



INTERNATIONAL
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INSTITUTESM

LIVING BUILDING CHALLENGE

Framework for Affordable Housing

*A Pathway to Overcome Social, Regulatory
and Financial Barriers to Achieving Living
Building Challenge Certification in
Affordable Housing*



Abstract: The affordable housing development community is uniquely situated to benefit from the philosophy and application of the Living Building Challenge in order to effectively accomplish its mission and goals. Living Buildings are designed to maximize the positive social and environmental potential of the built environment and serve as focal points for inspiration and education in their local communities. They are comprised entirely of healthy, low-impact building materials, harvest all their energy and water on-site, and place equity and social justice at the forefront of their design goals. As the world's most advanced and rigorous green building certification program, the Living Building Challenge can enhance the positive impact of affordable housing while mitigating the persistent inequalities often present in low-income communities.

Objective: To provide pathways and identify strategies to assist affordable housing developers in overcoming social, regulatory and financial barriers to achieving Living Building Challenge Certification.

Audience: Investors, developers, design and construction professionals, government officials, building product manufacturers and community groups interested in new construction of affordable multi-family housing in North America.

THE INTERNATIONAL LIVING FUTURE INSTITUTE

The mission of the International Living Future Institute (the Institute) is to lead and support the transformation toward communities that are socially just, culturally rich, and ecologically restorative. The Institute is a hub for visionary programs. The Institute administers the Living Building Challenge™, the built environment's most rigorous and ambitious performance standard. It is also the parent organization for the Cascadia Green Building Council, a chapter of both the United States and Canada Green Building Councils that serves Alaska, British Columbia, Washington and Oregon. In addition, the Institute is home to Ecotone Publishing, a unique publishing house dedicated to telling the story of the green building movement's pioneering thinkers and practitioners.

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EXECUTIVE SUMMARY



The Living Building Challenge Framework for Affordable Housing offers a pathway for multi-family affordable housing projects to achieve the Living Building Challenge, either as Petal or Living Certified. Every person, regardless of economic status, has a right to housing that is healthy, safe, affordable and environmentally sound. Therefore the intent of this Framework is to create more affordable housing projects that are socially just, culturally rich and ecologically restorative.

Truly sustainable, resilient housing will have a substantially positive effect on some of our most vulnerable populations. Freedom from monthly bills for water, heat and electricity will not only improve the financial health of struggling families, but also improve project economics. Further, low-income families, who disproportionately suffer negative health effects from poor air quality and exposure to high levels of toxins, will benefit from the Challenge's high standards for both air quality and healthy building materials. A safe, healthy home that offers resilience and adaptability in the face of global climate change through the Living Building Challenge offers a platform for community development and economic empowerment.

To understand the potential of the Living Building Challenge to transform affordable housing projects, the Institute has been collaborating over the past three years with a stakeholder group of leading North American affordable housing developers and organizations. Together, the group identified key social, regulatory and financial barriers to Living Building Challenge certification and explored opportunities to overcome these barriers in the affordable housing market. The Institute has provided technical assistance to three Living Building Challenge registered pilot projects. These pilot projects and the lessons learned are explored through in-depth case studies in this report.

Based on this collaborative effort, key pathways to achieve the Living Building Challenge for a number of climate zones across North America are identified. The most challenging Petals—Energy, Water and Materials—are each addressed in depth. Opportunities for achieving the remaining four Petals, each of which align well with established goals of many affordable housing developers, are also analyzed.

During the analysis of barriers, it is identified that the first costs associated with the Net Positive Energy and Water requirements of the Challenge can be significant due to the requirement to generate energy and treat water on-site. However, as energy and water costs rise and solar technologies become more efficient and affordable, this paradigm is changing. The lack of energy and water bills for Net Positive Energy and Water projects offers occupants true long-term affordability. The market is shifting quickly, and Red List compliant products are emerging at competitive prices.

For the Materials Petal, the stakeholders identified persistent first cost concerns and other barriers to meeting the requirements of this Petal. An integrated materials research and selection process is critical to address many of these logistical and financial barriers that continue to impede healthy materials selection. Sample specifications and a standard list of Red List compliant materials, many of which are cost competitive, are provided as a resource to reduce the research time and expense necessary for future projects pursuing the Challenge.

For the Energy, Water and Materials Petals, strategies and techniques necessary to move beyond best practice to achieve the performance-based requirements of the Challenge are identified. Net Positive Water and Energy strategies have been modeled using location-specific climate data. The modeling results demonstrate the feasibility of meeting the Challenge in various climate zones and suggest climate-specific strategies for each region.

KEY FINDINGS

- The rigid financing structure in the affordable housing industry has impeded Living Building Challenge innovations that require a financial system that can overcome first cost by capturing long-term economic benefits. However, the success that Enterprise has had incorporating Green Communities Criteria in state financing agencies' allocation requirements offers a model for transforming the current financing paradigm to recognize the long-term benefits of sustainable design.
- While Net Positive Energy is possible within each region modeled in this report, there remains a significant difference in the strategies and level of financial investment across different climate zones. Regions like San Jose and Austin already have Net Positive Energy within reach, while projects in other climates with more extreme temperature swings and limited solar resources, like Minneapolis, do not.
- Regulations that prevent rainwater reuse and on-site water treatment and infiltration are a barrier to meeting the Living Building Challenge. Pilot projects that advocate for distributed water are creating regulatory change.
- On-site black water treatment or composting toilets are challenging for multi-family affordable housing projects due to a number of financial, regulatory and social barriers. Therefore, the Institute has created a new temporary alternate compliance path for multi-family affordable housing projects three stories or greater that allows black water to be sent to a municipal sewer system.
- Net Positive Water is achievable for multi-family affordable housing with reasonably sized cisterns, if water consumption is reduced to around 20 gallons/capita/day (gcd). This can be accomplished by using ultra-high-efficiency fixtures and a combination of rainwater harvesting, grey water recycling and/or composting toilets. Some climate zones analyzed in this report can reach Net Positive Water without using advanced grey water harvesting or composting toilets.
- While meeting the Materials Petal is critical to protecting occupant health and supporting local economic development, the additional soft costs for research and hard costs for replacing specific materials, compared to a low-cost affordable housing baseline, continue to make meeting the Petal difficult in the current market. As more projects adopt healthy materials and pursue the Materials Petal while sharing information across the industry, costs will continue to decline, bringing the Petal within reach.
- The Place, Health & Happiness, Equity and Beauty Petals offer important opportunities to increase the social and environmental benefit of a project with limited additional cost.

- Targeted foundation support will continue to be important to overcome persistent financial barriers in the short term. In the long term, coordinated advocacy is required to convince state housing agencies to modify the allocation system for affordable housing tax credits in order to incentivize truly sustainable, regenerative design.

Next Steps

To build on the work in this report, the Institute continues to work with a group of North America's leading affordable housing developers to catalyze change in the market and demonstrate new models of regenerative design. The Institute will select five affordable housing projects to serve as Living Building Challenge pilot projects over the next year and will provide in-depth technical assistance to build upon current success. In addition, the Institute will continue to work with Enterprise Community Partners to share lessons learned across the industry and push for regulatory change and affordable housing financial reform.



Photo: Martin Tessler

BACKGROUND

Over the last decade, leading affordable housing developers have been aggressively pursuing sustainable building strategies in projects across the United States. Increasingly, the industry is recognizing that sustainable design yields higher quality projects that are better homes for residents, with improved long-term economics and reduced environmental impact.

In 2004, Enterprise Community Partners (Enterprise) created the Green Communities Criteria, the first holistic framework for promoting smart growth, public health, energy and water conservation and efficient operations in affordable housing. Since then, they have supported more than 550 housing organizations across the country to create and rehabilitate more than 37,000 green, healthy, affordable homes for low-income people. To better understand the financial impacts of this work, in 2012, Enterprise and third-party consultants Davis Langdon released *Incremental Costs, Measurable Savings Update*¹, an exposition of the return on investment for green design within affordable housing. Developers can now use the Enterprise Green Communities Criteria as a tool and the report as a financial rationale for creating deep green affordable housing projects with clear and measurable financial and social benefit.

However, despite the commitment and dedication demonstrated by leading practitioners, the overall market has made limited progress. The general belief within the affordable housing community is that the critical limiting factor is the rigid financial and regulatory structure of the Low Income Housing Tax Credit (LIHTC), which inhibits innovation by placing an unrealistically high emphasis on first costs, discounting the long-term benefits that projects could realize over time².

Over the past three years, the International Living Future Institute (the Institute) has researched the financial barriers to advanced green building. Though many of these barriers are based on perceived rather than real constraints, some strategies do represent additional first costs. In such circumstances, the initial capital outlay can be justified by the long-term social, environmental and economic benefits that result. Overall, however, *The Living Building Challenge Financial Study*³ found that some types of Challenge projects incur only minor cost increases compared to equivalent projects built using more conventional techniques⁴.

To demonstrate that achieving the Living Building Challenge in affordable housing is possible in even the most difficult conditions, the Institute partnered with the Aleutian Housing Authority to create the Living Aleutian Home Design Competition in 2012. The housing authority was first attracted to the Living Building Challenge because the cost of generating heat and electricity in the Aleutian Islands brought the economic benefits of Living Building Challenge projects into high relief. The Institute invited the world's most talented architects and engineers to design an affordable single-family residence capable of achieving the Living Building Challenge in Alaska. Over 100 entries were

1 Enterprise Community Partners. Enterprise Green Communities Criteria: Incremental Cost, Measurable Savings Update.

2 Refer to Appendix A: An Introduction to Low Income Housing Tax Credits in the United States

3 Cascadia Green Building Council, Living Building Financial Study

4 Cascadia Green Building Council, Towards Net Zero Water: Best Management Practices for Decentralized Sourcing and Treatment

submitted, and the Aleutian Housing Authority is now exploring ways to incorporate the designs into its work with First Nations communities in some of the United States' most remote regions.

The Institute has also analyzed regulatory, financial and social barriers to achieving the Living Building Challenge and identified pathways to overcoming these hurdles. Across the country leading architectural firms and developers that specialize in affordable housing, as well as advocacy organizations such as Enterprise, have prepared the way for the Institute to embark on this targeted research and outreach project. This toolkit provides an actionable framework for affordable housing projects to leapfrog past conventional green performance and achieve the Living Building Challenge.

THE LIVING BUILDING CHALLENGE

The Living Building Challenge (the Challenge) is a philosophy, an advocacy tool and a certification program. Within the larger Living Future Challenge framework, a framework for the remaking of everything, the Living Building Challenge focuses on one of humanity's largest creations—its buildings. It is in essence a unified tool for transformative thought and action, allowing us to envision and work toward creating a future that is socially just, culturally rich and ecologically restorative.

Defining the most advanced measure of sustainability in the built environment, the Challenge acts to rapidly diminish the gap between current limits and end-game positive solutions. The Challenge aims to transform how we think about every single act of design and construction as an opportunity to positively impact the greater community of life and the cultural fabric of our human communities.

The Living Building Challenge is comprised of seven performance categories, or "Petals": Place, Water, Energy, Health & Happiness, Materials, Equity and Beauty. Each Petal is further subdivided into Imperatives; each Imperative focuses on a specific sphere of influence (see Figure 1). This compilation of Imperatives can be applied to almost every conceivable building project of any scale and at any location to advance their sustainability goals.

As of November 2014, over 231 projects have registered to use the Challenge worldwide and are in various stages of the certification pipeline. Of the 231 projects, 28% are residential, including 16 multi-family housing projects. The Institute eagerly anticipates the certification of the first-ever Living, Petal or Net Zero Energy multi-family residence that can serve as a model for change in the industry.

Certification paths

There are three pathways to certification under the Living Building Challenge, recognizing that the achievement of even a portion of the program is a significant step forward for the market. The three pathways are Living certification, Petal certification, and Net Zero Energy Building certification.

A project achieves full Living certification by attaining all Imperatives assigned to its Typology. Petal certification requires achievement of at least three of the seven Petals, one of which must be the Water, Energy or Materials Petal. Imperative 01, Limits to Growth, and Imperative 20, Inspiration and Education, are also required.

SUMMARY MATRIX

Imperative omitted from Typology
 Solutions beyond project footprint are permissible

		LIVING BUILDING CHALLENGE			
		BUILDINGS	RENOVATIONS	LANDSCAPE + INFRASTRUCTURE	
CASE STUDY	PLACE				01. LIMITS TO GROWTH
		SCALE JUMPING		SCALE JUMPING	02. URBAN AGRICULTURE
				SCALE JUMPING	03. HABITAT EXCHANGE
					04. HUMAN-POWERED LIVING
PILOT	WATER			SCALE JUMPING	05. NET POSITIVE WATER
PILOT	ENERGY			SCALE JUMPING	06. NET POSITIVE ENERGY
CASE STUDY	HEALTH & HAPPINESS				07. CIVILIZED ENVIRONMENT
					08. HEALTHY INTERIOR ENVIRONMENT
					09. BIOPHILIC ENVIRONMENT
PILOT	MATERIALS				10. RED LIST
					11. EMBODIED CARBON FOOTPRINT
					12. RESPONSIBLE INDUSTRY
					13. LIVING ECONOMY SOURCING
					14. NET POSITIVE WASTE
CASE STUDY	EQUITY				15. HUMAN SCALE + HUMANE PLACES
					16. UNIVERSAL ACCESS TO NATURE + PLACE
					17. EQUITABLE INVESTMENT
CASE STUDY	BEAUTY				18. JUST ORGANIZATIONS
					19. BEAUTY + SPIRIT
					20. INSPIRATION + EDUCATION

Figure 1: Living Building Challenge Summary Matrix

Net Zero Energy Building (NZEB) certification is the third pathway. It requires four of the Imperatives to be achieved: I-01, Limits to Growth, I-06, Net Positive Energy, I-19, Beauty + Spirit, and I-20, Inspiration + Education. The requirement for I-06, Net Positive Energy, is reduced to 100% on-site production, and no on-site storage is required.

Regardless of the pathway pursued, certification is based on actual, rather than modeled or anticipated, performance. Therefore, projects must be operational for at least 12 consecutive months prior to certification.

SECTION 1

GATHERING STAKEHOLDERS + INFORMATION



INITIAL RESEARCH + THE FORMATION OF THE AFFORDABLE HOUSING NETWORK

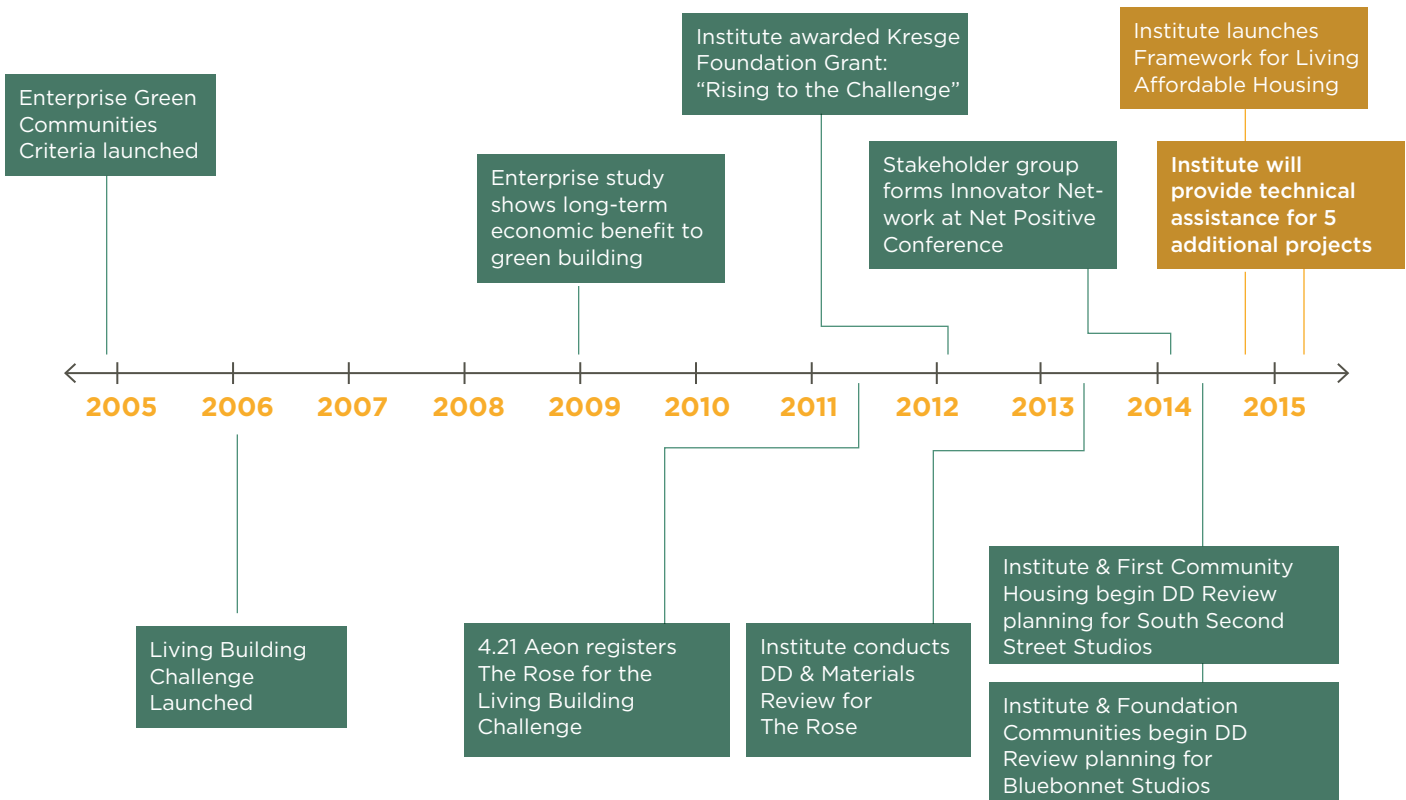
The Living Building Challenge Framework for Affordable Housing began with a review of the most innovative cost-saving strategies currently being employed in Living Building Challenge projects. The Institute surveyed all active registered Living Building Challenge project teams, asking them to identify both cost-saving best practices and hidden expenses associated with pursuing high-performance design. Subsequently, the Institute, with assistance from Enterprise, convened a group of key affordable housing developers who have either pursued or investigated the use of the Living Building Challenge on their own projects.

WORKSHOP ONE

On February 4, 2014, the Institute conducted a workshop with this newly formed stakeholder group during the Net Positive Conference in San Francisco, CA. The purpose of the workshop was to identify financial, regulatory, and social challenges and opportunities to achieving the Living Building Challenge in multi-family affordable housing projects. The group identified potential strategies that could break the perceived and real barriers involved in making the Living Building Challenge feasible for projects and began discussing a framework for how the group could collaborate to push the industry toward regenerative design.

Figure 2: Timeline of Living Affordable Housing

TIMELINE OF LIVING AFFORDABLE HOUSING





THE INNOVATOR NETWORK

Following the first workshop, Enterprise Community Partners proposed the creation of a group, later known as the Living Affordable Housing Innovators Network (the Innovator Network), to support the affordable housing industry in achieving new levels of performance in sustainable design. This group, represented in Figure 3, includes some of the leading developers and designers of affordable multi-family housing currently pursuing regenerative deep green projects, such as Net Zero Energy or Net Positive Energy buildings, Living Building Challenge “ready” buildings, or Petal certification under the Living Building Challenge program.

PILOT PROJECTS

One of the first tasks after the Innovator Network was formed was to identify pilot projects that the Institute would work with to test processes and strategies for overcoming barriers and capitalizing on opportunities to achieving the Living Building Challenge. Three pilot projects were identified: the Rose in Minneapolis, MN, South Second Street Studios in San Jose, CA, and Capital Studios in Austin, TX. Over nearly two years, beginning in December 2013, the Institute provided a variety of technical assistance to these projects including materials consulting and design development reviews⁵. The Institute continues to provide technical assistance to guide these projects on a pathway to meet the Living Building Challenge.

⁵ Refer to Appendix B: Sample Integrated Design Charrette



Flickr: Frans Persoon



*denotes pilot firm

Figure 3: Living Affordable Housing Innovators Network

= developer

= partner

Living Affordable Housing Innovators	Description	Innovator Leaders
Aeon* Minneapolis, MN Climate: Cold	Aeon develops, owns and manages high-quality affordable apartments and town homes that serve more than 3,500 people annually in the Twin Cities.	Gina Ciganik VP Housing Development
Community Housing Partners Christiansburg, VA Climate: Hot dry	CHP develops, designs, manages and sells affordable housing and delivers energy conservation training and contracting across the southeastern US.	Joshua Galloway Project Manager
First Community Housing* San Jose, CA Climate: Warm Temperate	First Community Housing designs, develops and manages affordable housing for low-income households.	Jeff Oberdorfer Executive Director Hilary Noll Enterprise Rose Fellow
Foundation Communities* Austin, TX Climate: Hot Humid	Foundation Communities provides first class, affordable homes and free on-site support services for thousands of working families with kids, as well as veterans, seniors, and individuals with disabilities.	Sunshine Mathon Design & Development Director
Heartland Alliance Chicago, IL Climate: Cold	Heartland advances the human rights and responds to the human needs of endangered populations—particularly the poor, the isolated, and the displaced—through the provision of comprehensive and respectful services and the promotion of permanent solutions leading to a more just global society.	Hume An Director of Real Estate Development James Lewis Project Manager, Rose Fellow
New Buildings Institute* Vancouver, WA Climate: Temperate	NBI assesses technologies, promotes design approaches, and helps guide policies and programs that will significantly improve the energy performance of commercial buildings.	Ralph DiNola Executive Director
Center for Sustainable Building Research (CSBR), University of Minnesota Minneapolis, MN Climate: Cold	CSBR works to transform the built environment in ways that provide for the ecological, economic, and social needs of the present without compromising those of the future.	Billy Weber Lecturer and Senior Research Fellow
Enterprise Community Partners New York, NY Climate: Cold	Enterprise Community Partners creates opportunity for low- and moderate-income people through affordable housing in diverse, thriving communities.	Katie Swenson VP National Design Initiatives Yianice Hernandez Director, Green Communities Ray Demers Program Director
Farr Associates Chicago, IL Climate: Cold	Farr Associates is focused on effective design and planning strategies that are environmentally responsive to issues such as energy conservation, historic preservation and planning.	Doug Farr President and CEO Daniel Splaingard Architect



Pilot Project 1: The Rose

The Rose has 90 units (47 affordable and 43 market rate), including 12 units for formerly homeless families and individuals. This development is the final phase of the four-phase South Quarter development project. Phases one through three of South Quarter included Children's Village Center, the Jourdain, the Wellstone, and Pine Cliff Apartments, a modern rehabilitated building.

The goal of this project is to create a new model for practical and innovative community development based on the Living Building Challenge. By implementing a mixed-income development as a symbiotic relationship with environment, transit, health, employment and community, the project hopes to catalyze development in the neighborhood, establish long-term affordable housing in

a changing community and demonstrate that achieving the Living Building Challenge is possible in affordable housing.⁶

Though the original design of the Rose project targeted full Living Certification, the project team has encountered social, regulatory and financial barriers that prevented them from meeting that initial goal. Nonetheless, this project has surmounted many significant hurdles to achieve much higher levels of environmental performance and health than industry standard. Thus, it serves as a replicable model for high-performance design for future affordable housing projects.

⁶ A detailed case study article is available here: <http://www.mnshi.umn.edu/kb/casestudies/rose.html>



The Rose

Location: Minneapolis, MN

Developer: Aeon, in partnership with Hope Community

Project Size: 150,000 sf

Transect: L5 Urban Center Zone

FAR: 2.0

Total Units: 90

Cost: \$21.5 million

Cost/sf: \$148/sf

Construction Start Date: September 2014

Construction Completion Date: Summer 2015

Credit: MSR



Pilot Project 2: South Second Street Studios

South Second Street Studios is a five-story, 100,000-square-foot, mixed-use building that incorporates 79 efficiency units, 23 units for the developmentally disabled, 25 for the chronically ill, 6 one-bedroom units, 1 two-bedroom unit and 9,000 square feet of retail space in San Jose. This project is pursuing LEED Platinum, a standard practice for the integrated design and construction team at First Community Housing (FCH) and is on track to achieve Platinum certification under LEED for Homes: Multi-Family Mid-Rise California, v2010. The project team is using modular construction to reduce waste, improve efficiency and shorten the construction time-frame. The Institute worked with FCH to analyze the steps necessary to achieve the Living Building Challenge on this project, including determining the regulatory and financial barriers and

anticipated cost increases. This project is serving as a pilot for FCH (and for the larger community), and as a result, FCH has reframed their approach to sustainability on all their projects.



South Second Street Studios

Location: San Jose, CA

Developer: First Community Housing

Project Size: 91,021 sf Housing / 9,000 sf Retail /

35,400 sf Underground Parking

Transect: L5 Urban Center Zone

FAR: 2.0

Total Units: 134

Construction Cost: \$32 million

Cost/sf: \$350/sf

Construction Start Date: February 2016

Construction Completion Date: July 2017

Credit: Rob Quigley Architects



Pilot Project 3: Capital Studios

Capital Studios, a Single Room Occupancy (SRO) project, is the first affordable housing project to be built in downtown Austin in 45 years. The project has two key goals: first, to provide downtown workers with an opportunity to live where they work; and second, to provide individuals on fixed incomes with a place to live in the heart of the city, in fully accessible housing with robust transportation connections. The project offers 135 efficiency apartments for single adults. The project incorporates many green practices, including solar thermal integration for hot water, highly efficient wall construction, and the best and most efficient HVAC units that Foundation Communities has used to date. The project also has extremely efficient fixtures to significantly reduce water consumption. The project is built to the requirements of the Austin Energy Green Building Program and Enterprise

Green Communities Criteria. It used the Living Building Challenge for design inspiration.

In May of 2014, Foundation Communities partnered with the Center for Maximum Potential Building Systems and hosted a design charrette⁷ to explore a series of Living Building Challenge Petal-specific goals that they will implement in future projects. Since this charrette, Foundation Communities has registered two projects with the Living Building Challenge. The first is the shared community portion of Bluebonnet Studios, which is seeking Net Zero Energy Building certification. The second is community room of Lakeline Studios, which is seeking full Living Building Challenge Certification. Foundation Communities is using both of these projects as a

⁷ Refer to Appendix F: Building for People & Community



Capital Studios

Location: Austin, TX

Developer: Foundation Communities

Project Size: 78,045sf

Transect: L5 Urban Center Zone

FAR: 2.8

Total Units: 135

Cost: \$16 million

Cost/sf: \$205/sf

Construction Start Date: Fall 2013

Construction Completion Date: October 2014

Credit: Dick Clark Arch.



testing ground for new financing and construction techniques that they and others will use to inform future multi-family affordable housing projects. The Institute will provide technical assistance on both projects.

WORKSHOP TWO

During the Living Future unConference in Portland, OR, in May of 2014, the Innovators attended a second workshop to discuss the affordable housing barriers outlined in Workshop One, and to develop tools for addressing these barriers. The group determined the creation of a common language surrounding deep green affordable housing practices and tools for information sharing were critical to leverage each innovator's individual efforts to benefit the group as a whole. The group also agreed to identify five more affordable housing projects to register for the Challenge and committed to continued work together to identify funding sources to overcome financial barriers.

WORKSHOP THREE

On September 10, 2014, Aeon and Hope Community convened a group of stakeholders that included many members of the Living Affordable Housing Innovators Network to share and find ways to communicate the lessons learned from the first pilot projects. This workshop was held in Minneapolis and was called The Learning Laboratory: A Collaboration of the Innovators.

For this meeting, the Center for Sustainable Building Research (CSBR) at the University of Minnesota prepared an affordable housing survey that identified key energy, water, material and financial data for the Rose and other projects in Aeon's portfolio, and for key projects from the portfolios of other members of the Innovators Network, including some of the pilot projects. Deep analysis of the best practices in different regions, as delivered by this survey, the

Building Benchmarking Tool⁸, offers important lessons for future projects. During the workshop, the stakeholders agreed to develop the survey further to help projects understand and identify best practice energy and water strategies, to guide materials selection, and to provide a toolkit for designing high-performance projects and Living Buildings.

THE LIVING AFFORDABLE HOUSING PROJECT CHALLENGE

The formation of the Innovators Network has prompted leading organizations within the affordable housing industry to embrace the principles of the Living Building Challenge. By selecting a group of pilot organizations, analyzing the strategies necessary to meet the Challenge and testing these strategies through pilot projects, the Innovators Network and the Institute have been able to make significant progress toward redefining what is possible today in multi-family affordable housing. The Institute is now strategically adding Innovators to the group in order to further address multi-family housing projects in a wider variety of climate zones and housing categories.

With the exception of the Capitol Studios project, which is an SRO, this report is focused on multi-family affordable housing since dense multi-functional housing in city centers that include a diversity of incomes aligns with the Institute's mission to support equitable, vibrant and livable cities. However, a wide variety of affordable housing categories exist,⁹ providing homes for a range of populations through different financing schemes. These include: Mixed-Use, Senior Housing, Multi-family, Social & Supportive

⁸ Refer to Appendix D: CSBR Building Benchmarking Tool

⁹ U.S. Department of Housing and Urban Development. "Affordable Housing." The definition for affordable housing varies widely by local jurisdiction. The widely accepted definition provided by The HUD defines affordable housing as housing for which the occupant(s) is/are paying no more than 30 percent of his or her income for gross housing costs, including utilities.






Housing, Single Room Occupancy (SRO) and Townhomes & Co-Housing¹⁰. To create a robust affordable housing supply serving all sectors of society, each category of housing must be addressed in all climate zones. As of November 2014, the Innovators have investigated three locations, and the Innovator Network includes

19 of the 36 possible combinations of affordable housing type and climate zone (see Figure 4). Ultimately, the Institute’s goal and the challenge we hope to meet is to have an example of a certified Living Building Challenge project in all seven of the major North American climate zones, for each of the six main affordable housing categories.

¹⁰ Single family housing is not addressed in this report.

Figure 4: Living Affordable Housing Challenge

	MIXED	MULTIFAMILY	SENIOR	SOCIAL AND SUPPORTIVE HOUSING	SRO	TOWNHOMES, COOPERATIVES, COHOUSING
HOT HUMID	Foundation Communities	Foundation Communities		Foundation Communities		
MIXED HUMID	Aeon	 Aeon Heartland Alliance	Aeon Heartland Alliance	Aeon Heartland Alliance	Aeon Heartland Alliance	
HOT DRY						
MIXED DRY		Community Housing Partners	Community Housing Partners	Community Housing Partners	Community Housing Partners	Community Housing Partners-
TEMPERATE	 First Community Housing	First Community Housing	First Community Housing	First Community Housing	First Community Housing	
COLD						
VERY COLD / SUB ARCTIC						

SECTION 2

IDENTIFYING STRATEGIES

PATHWAYS TO CERTIFICATION

The strategies necessary to achieve the most difficult Petals in the Challenge (Energy, Water and Materials) are discussed in depth in this section. Each of these Petals poses a significant challenge but also offers an important opportunity to improve the quality, as well as the social and environmental impact, of a project. The remaining Petals (Place, Health & Happiness, Equity and Beauty), while still rigorous, are typically achievable with limited additional cost from the project team. They are also particularly well aligned with the typical goals of affordable housing projects and provide significant benefit to both tenants and their communities.

An aerial photograph of a city skyline, likely San Francisco, with various skyscrapers and buildings. In the foreground, there is a large array of solar panels on a rooftop, with a grid pattern of yellow and blue panels. The sky is blue with light, wispy clouds.

ENERGY

“Low-income tenants deserve freedom from energy bills: a Net Positive Energy strategy offers a realistic solution for affordable housing in an age of energy volatility and climate risk.”

I. ENERGY

IMPERATIVE 06 | NET POSITIVE ENERGY

One hundred and five percent of the project's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion. Projects must provide on-site energy storage for resiliency.

—Living Building Challenge 3.0

PETAL INTRODUCTION

As the cost of living rises in most North American urban centers and income inequality grows, it is critical that we achieve price stability in housing to maintain a livable standard for all economic classes. The US Department of Housing and Urban Development (HUD) reports that 9.8% of American households pay more than 50% of their annual income on housing, and low-income families spend 17% of their income on utility bills.¹¹ According to HUD, homeowners and tenants should hope to pay at most only one-third of their income on housing to keep from being financially burdened.¹²

Utility bills remain an inconsistent variable in many family budgets. This causes significant stress for some of the most vulnerable communities: low-income, under-employed, and those with disabilities. As we continue to deplete our store of fossil fuel resources, energy prices will rise in the long term, while prices for renewable energy systems, especially photovoltaic panels and energy storage systems, will decline.¹³ In fact, a Deutsche Bank report published in October 2014 found that rooftop solar electricity is on track to be as cheap or cheaper than utility

electricity prices in 47 US states by 2016, up from only 10 today.¹⁴

Affordable housing tenants will find significant relief from insecurities that come with rising energy bills by meeting the Energy Petal. On-site energy generation through photovoltaic panels paired with storage capacity increases a community's resilience during times of disaster or energy price spikes. Solar energy and other renewable energy options also provide local jobs through on-site installation and maintenance, while creating the potential for regional manufacturing. Low-income tenants deserve freedom from energy bills: a Net Positive Energy strategy offers a realistic solution for affordable housing in an age of energy volatility and climate risk.

OVERALL APPROACH

An integrated design process is critical to meeting the Net Positive Energy Imperative. Most affordable housing projects are designed to a building code, following a prescriptive set of design strategies and construction details. In contrast, each Living Building project develops a place-based solution determined by the climate and the solar carrying capacity of the site. Living Building projects must analyze the available renewable energy resources on the project site

11 Walsh, Bryan. Building Green Houses for the Poor

12 U.S. Census Bureau. <http://www.census.gov/hhes/www/housing/special-topics/files/who-can-afford.pdf>

13 Rocky Mountain Institute. http://www.rmi.org/electricity_grid_defection

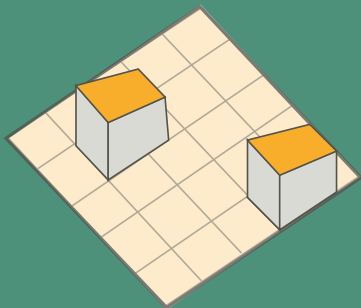
14 Randall Tom, Bloomberg.com, <http://www.bloomberg.com/news/2014-10-29/while-you-were-getting-worked-up-over-oil-prices-this-just-happened-to-solar.html>

and then work in an integrated process with multiple disciplines to optimize building form, daylighting, construction assemblies and system design to reduce energy consumption to levels that are often much lower than best practice.

If a project team is not able to meet the projected energy demand through the placement of photovoltaic panels on the project's roof or site, it can also consider a Scale Jumping strategy. However, Scale Jumping must not be used to simply enlarge the energy footprint of a project, but instead must result in a net benefit, including one or more of the following:

- Higher net efficiency
- Preservation of existing trees/habitat
- Lower net cost
- Placement within a larger infrastructure strategy
- Energy and/or thermal sharing¹⁵

¹⁵ Refer to the Energy Petal Handbook, p. 14



SCALE JUMPING

Living Building Projects have their own “utility,” generating their own water and processing their own waste. The ideal scale for solutions is not always within a project's property boundary. To address these realities, the Living Building Challenge has a Scale Jumping overlay to allow multiple buildings or projects to operate in a cooperative state—sharing green infrastructure as appropriate.

NET POSITIVE ENERGY MODELING

To determine the feasibility of meeting the Energy Petal on multi-family affordable housing projects in a number of North American regions, the Institute modeled Net Positive Energy in each region represented by members of the Innovator Network. The analysis determines the amount of energy that can be produced by a typical affordable housing based on its roof and site area and then calculates the energy

reductions versus standard practice necessary to achieve Net Positive Energy. The results show that Net Positive Energy is feasible in each of the regions studied, but the degree of difficulty varies greatly depending on the climate and available solar resources.

The Net Positive Energy modeling is based on a typical sample building with the following basic specifications:

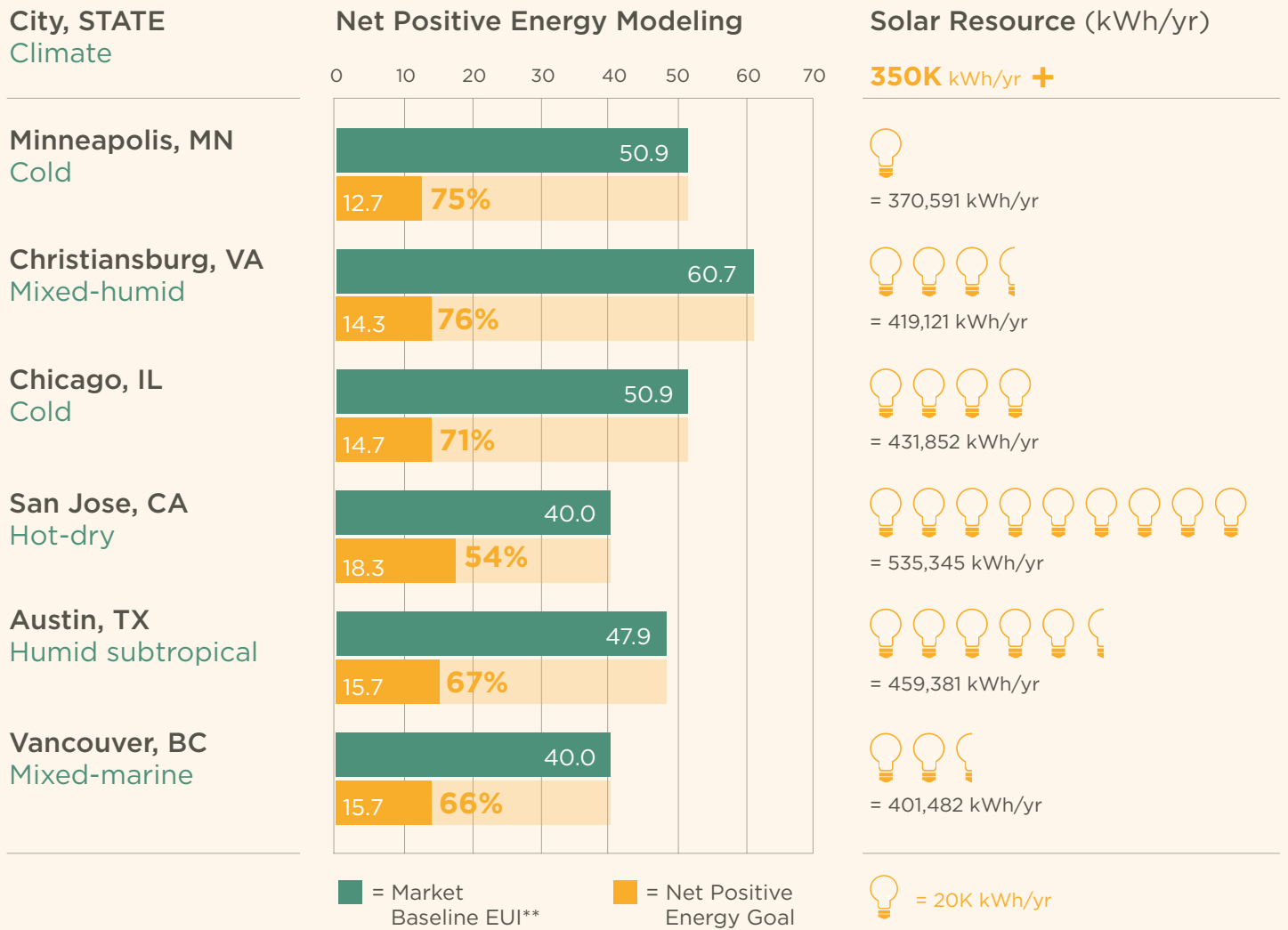
- 100,000 gross square feet
- Four stories
- Roof canted at a 10-degree angle
- Photovoltaic array installed with another 10-degree tilt (20-degree angle total)

For simplicity, 100% of photovoltaic roof coverage was considered for this model, which would require additional structure to support the solar panels and provide roof access. These calculations were completed using the PVWatts Calculator. The calculation methodology is explained further in Appendix E.¹⁶

¹⁶ Alliance for Sustainable Energy, LLC and National Renewable Energy Laboratory. <http://pvwatts.nrel.gov/>. Refer to Appendix H: PVWatts Calculator Directions.

Net Positive Energy Modeling by Location, 100% PV Coverage*

Figure 5: Net Positive Modeling by Location



* Calculations based off of 100% roof coverage by photovoltaics (PV). The maximum possible PV coverage would be 80% without building additional structure due to set back and fire access limitations.

MODELING CONCLUSIONS

The Net Positive Energy model above uses multi-family housing Energy Usage Intensity (EUI) baselines established by the 2030 Challenge for various climate zones across the US. The baselines range from 40 kBTU/sf/yr in the West to 60.7 in the Northeast.

As evident in the analysis, achieving the Energy Petal and its single Imperative, Net Positive Energy, will first require deep energy reduction versus standard practice. Affordable housing projects must strive for an EUI between 14 and 20 to keep the building's energy demand within the available solar resources. This represents a 49-73% reduction versus standard practice. High energy consumption is a challenging variable in high-density housing, particularly affordable housing that can have a greater numbers of occupants in each unit. However, from large commercial buildings to single-family and multi-family residential buildings, groundbreaking Living Building Challenge projects across the world are demonstrating that previously unheard of levels of energy efficiency are possible today.

For example, the Bullitt Center, a building seeking Living Building Challenge certification in Seattle, WA, has a measured EUI of around 12.1. This is a 93% energy reduction compared to an EUI of 92, the average for commercial office space in the US.¹⁷ The Bullitt Center also uses less than half the energy of a LEED platinum project that maximizes all energy credits. zHome, a Net Zero Energy Building and Energy Petal Certified multi-family project in Issaquah, WA, has an EUI of 21.1, less than half the energy consumption of a code-standard project.¹⁸

¹⁷ Bullitt Foundation. <http://www.bullittcenter.org/>

¹⁸ International Living Future Institute. <http://living-future.org/case-study/zhome>

This modeling also shows that in climates such as those found in Minneapolis, MN, and Christiansburg, VA, limited solar resources and high baseline EUIs make achieving the requirements of the Imperative a serious challenge. For example the modeling show, one of the pilot projects, the Rose, which attempted but did not yet succeed in meeting the Net Zero Energy Imperative under v2.1 of the Challenge, is in one of the most difficult climates to meet the Energy Petal.¹⁹ The Rose has a design EUI of 31.8, which is a 72% reduction versus a code baseline of 119 for this project type. However, in sunnier and more temperate climates like San Jose, CA, and Austin, TX, a 49% reduction in EUI would bring the Net Positive Energy Imperative within reach.

REDEFINING BEST PRACTICE

Enterprise has already been successful in pushing the market forward and reducing energy consumption in affordable housing through the development and implementation of the Enterprise Green Community Criteria. These guidelines require a 15% reduction in energy use versus a code baseline, through the incorporation of best practice measures such as improved insulation and windows and ENERGY STAR lighting and appliances. A report by Enterprise shows the cost for these upgrades is approximately \$0.85 per square foot, or \$1,000 per unit, with a payback of five years or less.²⁰

As shown from the modeling exercise described above, achieving the Living Building Challenge will require significantly greater energy reductions than the best practices demonstrated by Enterprise Green Communities projects. Since the Living Building Challenge is a performance-based standard that demands

¹⁹ Refer to Appendix I: The Rose Energy Diagram

²⁰ Enterprise Community Partners. <http://www.enterprisecommunity.com/servlet/servlet.FileDownload?file=00P3000000DTX16EAH>



place-based solutions determined by a region's climate and solar resources, it is difficult to provide specific guidance for how each climate zone must address energy efficiency. The most cost-effective solution depends on detailed energy modeling and a careful cost-benefit analysis of various design decisions to find the sweet spot between additional efficiency upgrades and long-term payback.

Key strategies that should be explored by affordable housing projects seeking the Living Building Challenge include:

- Climate-specific, detailed energy modeling
- Building form and orientation that maximizes solar access and limits heat loss
- Design for passive solar heating
- Effective solar shading
- Increased wall and roof insulation
- High-efficiency triple glazed windows
- Thermal mass
- Design to maximize daylighting
- Reduced air infiltration rate
- High efficiency heating and cooling systems, such as centralized VRF
- Natural ventilation to eliminate air conditioning
- Dedicated outside air system (separate heating and cooling from ventilation)
- Ground source heat pumps
- Solar hot water
- High-efficiency appliances, including induction cooktops
- Attractive and easily accessible stairways that reduce the use of vertical transportation



Flickr: stereotyp

BARRIERS & SOLUTIONS

There are unique barriers to achieving Net Positive Energy in affordable housing projects. This section explores the key social, regulatory and financial barriers and offers possible solutions to each.

SOCIAL BARRIERS

Affordable housing projects tend to have higher energy loads than typical multi-family projects due to increased occupant density. It is not uncommon for multi-generational families to live in one apartment, which increases energy consumption making it more difficult to achieve Net Positive Energy.

SOCIAL SOLUTIONS

To overcome the issue of high energy use intensity that comes from higher occupant density, it is important to sub-meter the energy consumption of individual units, providing a financial incentive for tenants to limit their energy consumption. Educational programs that emphasize conservation and the correct way to operate the building and the heating and cooling systems in different weather conditions can also help to reduce tenant energy consumption.

REGULATORY BARRIERS

There are two significant regulatory barriers to achieving Net Positive Energy for affordable housing projects. The first is that many utilities do not allow net metering or do not have policies in place to accommodate it. Because the utility grid serves as the energy storage device, net metering is an important strategy for keeping the costs of an on-site renewable energy system down by eliminating on-site energy storage. Net metering is also an important strategy for realizing the financial benefit of on-site energy production for grid-tied projects because it allows the producer to receive full retail prices

for the energy they produce. While net metering is increasingly common across North America, it is not allowed in all jurisdictions.

The second significant regulatory barrier to achieving Net Positive Energy is utility regulations that limit the size of photovoltaic installations and/or offer incentives only to small-scale installations. Both of these policies can make it difficult to develop a system large enough to serve all of a large multi-family project's needs. For example, incentives are limited to photovoltaic installations of 50 kW and smaller in Minnesota, and to 200kW in Austin. However, the Net Positive Energy modeling results indicate that a 300-400 kW installation would be required for a four-story multi-family project, dependent on climate zone.

REGULATORY SOLUTIONS

Political advocacy and legislative change are needed to overcome the barriers to net metering. Individual affordable housing developers can work in their local communities to bring about the necessary change, but it may be more effective to coordinate efforts within and across regions. Affordable housing developers would benefit from partnering with groups focused on promoting net zero energy. Net metering policies would benefit all utility customers so the base of support for such change is potentially very large. Advocacy is needed to encourage individual utility companies to change policies, and legislative change is necessary at the state and federal government level. Organizations like the Alliance for Solar Choice (TASC) founded by rooftop solar companies are working both nationally and state-by-state to promote net metering policies.²¹

21 The Alliance for Solar Choice. <http://allianceforsolarchoice.com/>




In jurisdictions where net metering is allowed, developers may want to consider tying net metering technology to sub-metering technology in order to maximize financial benefits and give tenants feedback on their energy consumption, which can reduce energy usage. Sub-metering in this context refers to the installation of utility meters on each dwelling unit to measure consumption by that dwelling unit as opposed to total consumption by the whole building. Some jurisdictions actually require sub-metering in multi-family housing projects so that landlords or billing companies cannot overcharge tenants for utilities. Developers can consider tying portions of the renewable energy system to individual net meters for each dwelling unit so that each tenant is credited a portion of the energy produced. The same result could be accomplished by prorating a portion of the overall energy produced on-site to each unit through “virtual sub-metering.”²²

zHome, a ten-unit townhome project in Issaquah, WA, employed the strategy of tying specific photovoltaic panels to each unit and net metering each unit. This approach provides tenants with information about their consumption habits and energy production patterns throughout the year. It also directly incentivizes positive environmental action, because the more each tenant reduces energy consumption, the less they pay for utilities. This strategy does require additional metering (which may already be required by your jurisdiction anyway) and additional wiring.

²² Virtual Net Energy Metering (VNM) is a tariff arrangement that enables a multi-meter property owner to allocate a solar system’s energy credits to other tenants.



Photo: zHome



In jurisdictions where regulations either prohibit or incentives discourage photovoltaic installations that are adequately sized to meet the needs of an affordable housing project, Scale Jumping can be employed. Scale Jumping could take the form of smaller photovoltaic arrays located on neighboring buildings. It could also take the form of a community solar garden or a community shared solar array with grid-connected subscribers that receive a credit as if the panels were on their own roof. New legislation and pilot projects in a number of states, including Colorado, Utah, California, Florida and Massachusetts, are showing how community solar gardens can be a viable and beneficial pathway to achieving Net Positive Energy.²³

FINANCIAL BARRIERS

There are two significant financial barriers to achieving Net Positive Energy on affordable housing projects. The first is the focus on first costs that is typical in the design and construction process. This focus on first costs can make it difficult for developers to integrate on-site renewable power generation, which has an added first cost, even if the long-term economics make sense.

A connected issue is that natural gas cannot be used by Living Building Challenge projects, which is often less expensive than electricity for providing heating, cooling and cooking, because combustion is not allowed as it represents a transitional strategy instead of an end-game strategy for a renewably powered future.²⁴ Low natural gas prices and concerns about keeping utility costs low can make it economically difficult for affordable housing developers to switch to all-electric heating, cooling and cooking. In this scenario, a focus on reducing energy demand by selecting energy-efficient

appliances, generating electricity on-site, and passing the financial benefits on to tenants through net metering can mitigate the impact of higher electricity prices.

The second significant financial barrier to achieving Net Positive Energy is that most affordable housing projects cannot take advantage of tax credits or incentives tied to photovoltaic panels. Multi-family residential projects generally cannot take advantage of the Residential Renewable Energy Tax Credit since that credit is only for dwelling units located in the United States that are owned and occupied as a residence by the taxpayer. In most multi-family affordable housing units, the residents are renters, not owners, so the tax credit does not apply.

In addition, a number of factors prevent affordable housing projects from taking advantage of utility-based or federally funded residential or commercial incentive programs, depending on the kind of incentive program. First, utility-based residential incentive programs tend to be directed toward small-scale installations that serve single-family residences, not multi-family residences. Second, affordable housing developers cannot take advantage of federally funded commercial incentive programs because the incentive comes in the form of a tax credit and non-profit affordable housing developers don't pay federal taxes. Third, many commercial incentives are production based which means that the financial incentive is paid over time based on the amount of energy produced—this approach provides financial benefit over the life of the project, but does not offset higher first costs.

FINANCIAL SOLUTIONS

Both of the financial barriers identified above relate to the increased first cost associated with photovoltaic systems. A variety of solutions are available to affordable housing developers to

²³ Solar Gardens Community Power. <http://www.solargardens.org/>

²⁴ McLennan, Burning Questions



address this issue. One option is to lease the project's roof space to a solar leasing company. In this scenario, a solar leasing company pays for the solar installation and either keeps the tax or other incentives for themselves or sells them on to an equity investor. The economic benefit of the solar panels is shared between the project owner and the solar leasing company, and typically, ownership of the panels reverts back to the affordable housing project owner after a period of time.

Another option, developed and implemented by one of the Innovators, Foundation Communities, is to capture the commercial federal tax benefits as well as local production incentives by leveraging the Low Income Housing Tax Credit financing model. Foundation Communities developed a program that requires the purchasers of the Low Income Housing Tax Credits they offer on the market to also purchase the tax incentives for the solar installation. Through this model, the full value of the tax incentives comes as cash to the affordable housing developer to offset the initial cost of the photovoltaic system. This results in a better return on investment than a leasing arrangement since there is no third party.

A third option is for funders, such as foundations, to provide targeted financial support for the incorporation of photovoltaic systems into affordable housing projects with the understanding that this support will help to create long-term financial stability for residents and non-profit developers.

CONCLUSION

As fossil fuel resource availability declines and energy prices rise, a focus on renewable energy generation becomes imperative especially for lower-income populations. Through an integrated design processes focused on energy efficiency, the EUI of projects can be greatly reduced,



which in turn reduces the required amount of photovoltaic panels and therefore the first cost. To be able to implement on-site renewable energy systems on a widespread basis and to fully realize the long-term financial benefits, new policies, legislation, and programs are needed that allow affordable housing projects to make use of current best practices in design, technology and financing.

Location, and specifically climate, impacts a project's ability to effectively reduce its EUI through efficient design. In certain markets and climate zones like San Jose and Austin, Net Positive Energy is more easily within reach. In more extreme climates like Chicago, Minneapolis and Christiansburg, it takes greater effort and bigger arrays to achieve Net Positive Energy. However, regardless of location, new policies and programs could bring the Energy Petal within reach.

If projects simply cannot reach Net Positive Energy due to regulatory and financial hurdles, developers should design "Net Positive Ready" projects that already incorporate deep energy reduction strategies and have roof structures that can easily integrate photovoltaic panels as the economics of distributed power generation improve.

Energy Pilot Project 1

The Rose

Innovator Organization: Aeon
 Minneapolis, MN

DESIGN APPROACH TO ENERGY REDUCTION

Reducing the overall energy use, and thereby long-term costs for the developer, was a primary goal for the project, and also a primary challenge given the climate, project type and regula-

tory environment. The project faces what some have referred to as the perfect storm: long, cold winters and hot, humid summers; high energy use intensity driven by tenant behavior; low regional energy prices; and regulatory barriers to large solar arrays.

To reduce energy use, the team relied heavily on energy modeling to inform the design. The team used early energy modeling to examine the impact of six different massing schemes

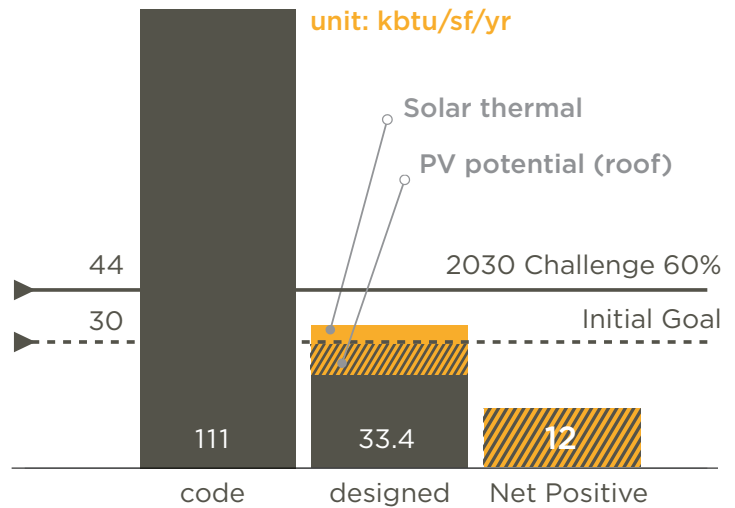
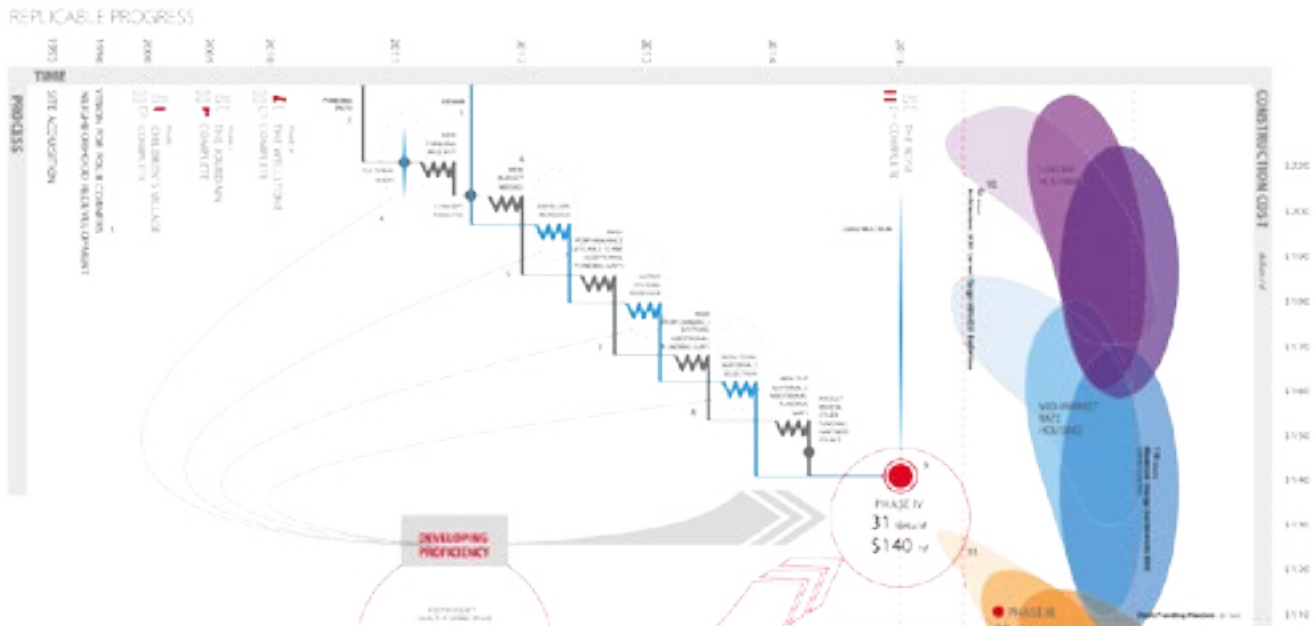


Figure 6: Energy Usage Intensity (EUI) Comparisons

Figure 7: Solar Resource Graph



on heating and cooling loads. The site plan, consisting of two buildings oriented along the east-west access, is a direct result of this exercise. The orientation allows desirable solar gains in the winter when heating demand is the greatest and limits solar gain along the eastern and western exposures during the hot summer afternoons when cooling demand is the greatest. The spacing between the buildings is also optimized to allow sun penetration into the first floor south-facing apartments of the north building during the winter.

For the building envelope and the space conditioning, the project team modeled multiple options before deciding on a solution that meet both the energy target and the budget. See the sidebar for detailed information on the building envelope and systems. It should be noted that the project team also considered adding a ground source heat pump, which would have further reduced the project's EUI. However, the depth of the bedrock is too high in this location, and the city of Minneapolis only allows two ground water source wells, which would be insufficient for this scale of project.

Lighting power densities will be reduced throughout the building. LED lighting will be used in common areas and for exterior lighting. Daylighting controls and occupancy sensors are used throughout the common areas. All appliances in the building will be verified to be ENERGY STAR labeled.

With these improvements in design, systems and materials over standard construction practice, the Rose has been able to reduce their design EUI to 31.8 if solar hot water is utilized, a 72% reduction versus a code-compliant baseline of 111. While the project did not meet its goal of an EUI of below 30, it is very close.



The Rose: Building Envelope + Systems

Building Envelope:

- Spray foam insulation for exterior walls
- Ground Floor Walls: R-39.5
2 x 6 16" O.C. wood construction clad with Enduramax masonry insulated units
- Upper Floor Walls: R-31.5
2 x 6 16" O.C. wood construction clad with Nichiha fiber cement panels.
- Roof: R-80
- Floor: R-15 at Garage Foundation, R-10 below the slab
- Windows: Pella Impervia
U-value: 0.34 U
Solar Heat Gain Coefficient (SHGC): 0.29
Visible Transmission: 0.55
- Window-Wall Ratio: 24%

Space Conditioning and Domestic Hot Water:

- HVAC: Mitsubishi R2 Variable Refrigerant Flow (VRF) system
IEER: 17.9
COP: 3.4
- Fresh Air: central dedicated outdoor air system (DOAS) with heat recovery
- Domestic Hot Water (DHW): 16 Kingspan Thermomax DF100 solar thermal panels (800 sf) located on the south facade of each building.
Provides for 34% of project's hot water needs. Remainder is supplied by 97%



PATHWAYS TO NET POSITIVE ENERGY

To achieve Net Positive Energy on this project, based on an EUI of 31.8, a 720 kW photovoltaic array would be required. This capacity array would consist of roughly 1,767 panels totaling 74,000 SF. The current roof will only accommodate between 306 panels (using a simple installation) and 442 panels (with the construction of a solar hat). To accommodate the remaining panels, the project team is looking at two different Scale Jumping options. The first option is to utilize rooftop area on neighboring buildings in the Aeon and Hope Community portfolio. The second option is to collaborate with other groups to develop a community-scaled Solar Garden in the neighborhood that would serve this and other projects.

BARRIERS & POSSIBLE SOLUTIONS TO NET POSITIVE ENERGY

Other than the high EUI, the main barrier to achieving Net Positive Energy on this project is financial. The developer does not have the additional funds needed to purchase the large photovoltaic array, and existing incentives from the local utility limit the size of photovoltaic installations to 40 kW, a fraction of what would be required for this project. In Minnesota, project teams that wish to install larger arrays must negotiate individual contracts without guaranteed power purchase agreements which means that large systems carry a high financial risk with a lower financial return for power generated. The Minnesota legislature is looking into providing new incentives for arrays up to one megawatt in size with compensation for up to 120% of their annual usage. Barring the development of new incentive programs for large-scale arrays, the developer could also consider partnering with an investor with a longer-term payback or pursue foundation funding to offset the initial costs.

CONCLUSION & LESSONS LEARNED

At present, the Rose is designed to be Net Positive Ready, which means that it will be built utilizing all the energy reduction strategies described, but without the photovoltaic array. During and after construction, the developer will continue to explore options to finance and build the necessary photovoltaic array on the Rose and/or neighboring sites.

The significant reduction in energy consumption achieved by the Rose can serve as a model to other affordable housing projects. A 72% reduction in EUI in a cold climate helps demonstrate that Net Zero Energy is within easy reach for other projects in more temperate climates that have greater on-site solar resources.

The significant reduction in energy consumption achieved by the Rose can serve as a model to other affordable housing projects. A 72% reduction in EUI in a cold climate helps demonstrate that Net Zero Energy is within easy reach for other projects in more temperate climates that have more on-site solar resources.



Photo: Flickr Stuart / Budding Entomologists

Energy Pilot Project 2

South Second Street Studios

Innovator Organization: First Community Housing
San Jose, CA

DESIGN APPROACH TO ENERGY REDUCTION

First Community Housing is using this project as a pilot to assess the feasibility of achieving Net

Positive Energy for multi-family housing in the San Jose region and to analyze and quantify the related additional costs so that they can begin applying Net Positive Energy strategies to future projects. Building orientation, thermal envelope, solar shading and floor plan/unit layouts have all been designed to maximize energy performance and meet both Enterprise Green Communities Criteria as well as LEED for Homes: Multi-Family Mid-Rise California, v2010 criteria.



unit: kbtu/sf/yr

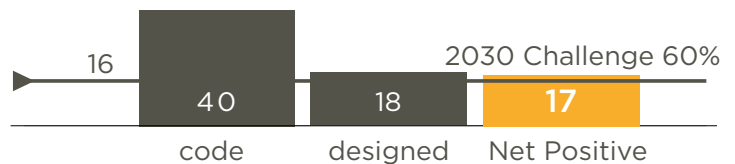
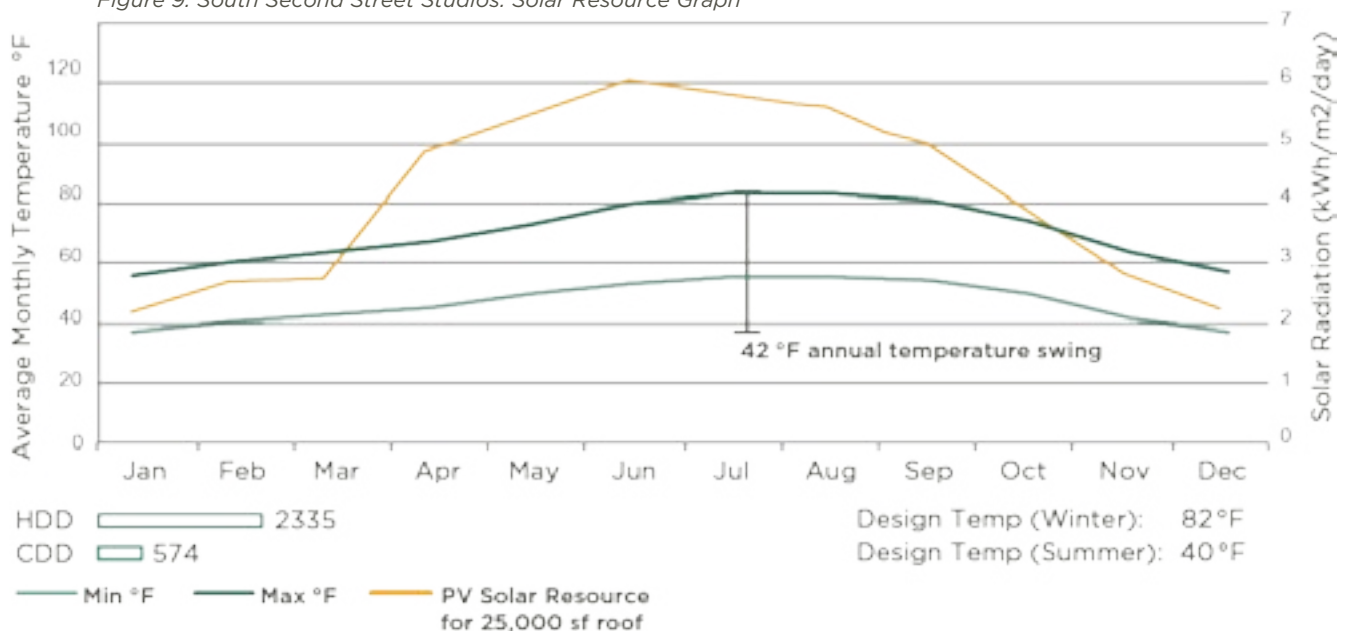


Figure 8: South Second Street Studios: Energy Usage Intensity Comparisons

Figure 9: South Second Street Studios: Solar Resource Graph



Despite other new approaches to the design, the project team has elected to use their traditional heating and cooling strategy. See the sidebar for detailed information on the building envelope and systems.

PATHWAYS TO NET POSITIVE ENERGY

Based on the modeling results, achieving Net Positive Energy on this project is within reach with minor additional upgrades to the design. The current EUI is anticipated to be 18 kBtu/sf/yr, and the target EUI is 17. The Institute suggests two possible ways to meet this target EUI. The first is reducing or eliminating air conditioning while increasing natural ventilation. Residents could still have access to air conditioning in communal areas on very hot days when natural ventilation is not sufficient. The project could also explore a high-efficiency building VRF system that would have significant energy reduction over individual PTAC units, as well as material upgrades to the envelope and windows.

With these or other similar upgrades, a photovoltaic array on the roof would be sufficient to meet the building's energy demands. At present, the project is designed to be photovoltaic ready. The team is also considering incorporating photovoltaic array on the awnings.

BARRIERS AND POSSIBLE SOLUTIONS TO NET POSITIVE ENERGY

The structure of California's sub-metering requirements is the main obstacle in this project's pursuit of Net Positive Energy. California regulations do not allow projects to have whole-building meters in addition to tenant sub-meters. Whole-building metering is necessary to get the most benefit from a large solar photovoltaic array through net metering, while sub-metering is critical to ensuring that tenants are aware of their energy consumption and have incentives to reduce their demand.



South Second Street Studios: Building Envelope + Systems

Building Envelope:

- Walls: R- 17.8
2x6 wood construction with R-21 batt and 0.5" polyiso continuous rigid insulations
- Roof: R-30 (before the green roof is applied which will increase the R-value)
Wood construction with batt and polyiso insulations
- Floor: Modular construction above concrete podium
- Windows: Milgard double-hung double-pane vinyl with Low-E Solarban 70XL

Space Conditioning and Domestic Hot Water:

- HVAC: Individually packaged terminal air conditioners (PTACs) in the units and stand-alone VRV units in common spaces.
- Domestic Hot Water (DHW): Considering solar thermal

Virtual sub-metering laws in California can help overcome this financing barrier. Virtual sub-metering allows the rooftop array in a multi-metered building to be fed directly to the grid and the benefit to be distributed to all the tenants evenly by the utility company through energy bills. In fact, California provides a capacity-based incentive of \$1.90/watt for energy that serves common areas and an even higher incentive of \$2.80/watt for solar power that directly benefits tenants.²⁵ While the higher incentive for energy that reduces residents' energy bills can help to

25 State of California, California Energy Commission and California Public Utilities Commission, <http://www.gosolarcalifornia.org/affordable/mash.php>



Photo: First community housing

mitigate a solar array's first costs, this approach does not provide much incentive for developers to invest additional funds up front because the benefits accrue to the tenants, not the developer.

Another barrier is that California building codes limit the options for natural ventilation. A minimum ventilation rate is required for each unit, making it difficult for the project to eliminate air conditioning, since the PTAC units that provide ventilation to each unit can also provide air conditioning for minimal additional cost. So little incentive exists to eliminate air conditioning.

Furthermore, according to Title 24, public quarters must be air-conditioned, so the double-loaded corridors in many First Community Housing projects become a large energy consumer. One way to overcome this barrier is for multi-family project to use courtyard designs with exterior public passageways that eliminate double loaded corridors and allow cross-ventilation.

CONCLUSION & LESSONS LEARNED

While regulatory and financial challenges still remain, South Second Street Studios case study demonstrates that for San Jose, Net Positive Energy is within reach, especially when compared to other more challenging regions throughout the country.

Energy Pilot Project 3

Capital Studios

Innovator Organization: Foundation Communities
Austin, TX

DESIGN APPROACH TO NET POSITIVE ENERGY

Capital Studios represents a culmination of Foundation Communities' best-to-date envelope

and mechanical systems design to reduce energy consumption. Primarily an SRO, the project has a design EUI of 29, a 40% reduction from code. The project incorporates:

- High-performance wall assemblies that eliminate thermal bridging
- The highest efficiency windows used on Foundation Communities' projects to date
- VRF air source heat pump
- A flat plate collector solar thermal array on the roof that supplies 50% of hot water demand

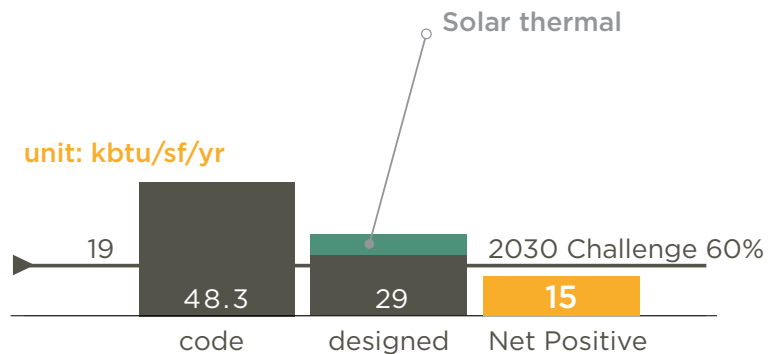
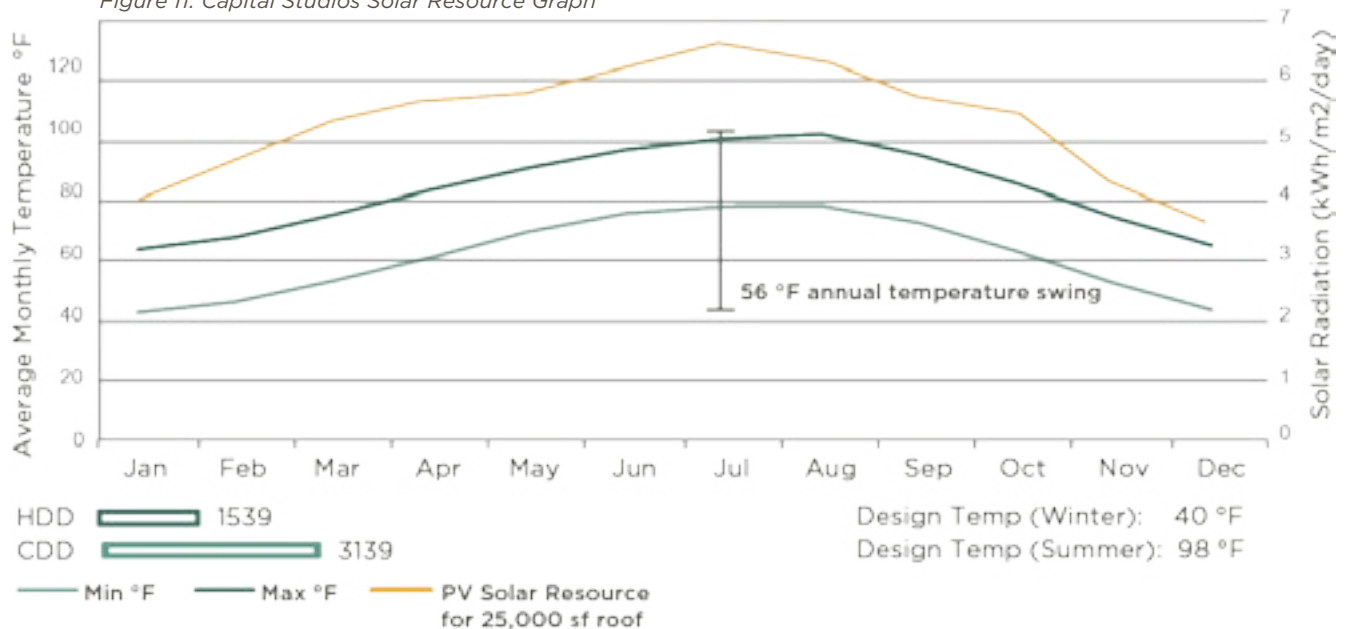


Figure 10: Capital Studios: Energy Usage Intensity Comparisons

Figure 11: Capital Studios Solar Resource Graph





PATHWAYS TO NET POSITIVE ENERGY

Since this project is already constructed, achieving Net Positive Energy is not possible without a retrofit and addition of a large solar array. However, using Capital Studios as a case study the Net Positive Modeling shows that Foundation Communities will need to continue to bring down energy consumption to from 29 to 15.4 EUI to achieve the Energy Petal for a typical project in the region.

The Net Positive Energy modeling suggests that a system of 371 kW would be necessary to provide enough energy for a typical project in Austin with an EUI of 15.4. However, Austin utility regulations also limit the size of solar arrays. While significant production-based incentives exist, they are capped at a 200 kW system. Given these utility limitations, projects should consider a Scale Jumping strategy that takes advantage of the rooftops of neighboring buildings in order to meet the full demand of the project.

CONCLUSION & LESSONS LEARNED

Foundation Communities has successfully incorporated on-site solar thermal panels and/or photovoltaic panels on their projects, including Capital Studios, based on three key factors. First, Austin is a good climate and utility environment for on-site solar. Since the developer's first installation in 2014, they have seen the payback of solar drop from over fifteen years to fewer than six years under current incentive programs. Austin also benefits from a very low installed cost for solar, around \$2.70/watt versus \$4/watt in places like Minnesota. Lastly, Foundation Communities ties the sale of the Low Income Housing Tax Credit to the federal Renewable Energy Tax Credit, which helps to offset the Installation cost.



Photo: First community housing

ENERGY RESOURCES

ACCA: The Indoor Environment & Energy Efficiency Association

Design standards for maintenance, installation, testing and performance of indoor environment residential and commercial systems.

acca.org/standards/technical-manuals

American Solar Energy Society: Solar Home Basics

An organization aiming to provide solar professionals and advocates access to current events, developments and resources. Basic solar hot water, solar electric, wind, energy efficiency and ground source heating and cooling design guides are included.

ases.org/solar-home-basics

Air Conditioning Contractors of America, Manual J: Residential Load Calculation

MJ8 produces equipment sizing loads for single-family-detached homes, small multi-unit structures, condominiums, townhouses and manufactured homes. This new version incorporates the complete MJ8-AE volume in a user-friendly format.

acca.org/technical-manual/manual-j/

Building Energy Data Book (2011)

The most comprehensive statistics for baseline energy consumption comparisons. Section 2.7, “Multi-Family Housing,” offers the most relevant data for research pertaining to affordable housing.

buildingsdatabook.eren.doe.gov

California Advanced Homes Program (CAHP)

Provides financial incentives and green guidance for California projects.

californiaadvancedhomes.com/about-cahp/financial-incentives

Database of State Incentives for Renewables & Efficiency (DSIRE)

The most up-to-date database of incentives and policies that support renewables and energy efficiency in the United States.

dsireusa.org

ENERGY STAR Score for Multi-Family Housing in the United States

An assessment of the energy performance of multi-family homes, taking into account the climate, weather, and business activities at the property.

energystar.gov/buildings/tools-and-resources/energy_star_score_multifamily_housing_united_states

Enterprise Green Communities Criteria

The principal set of design guidelines for US affordable housing development types (single-family and multi-family) and construction types (new construction, rehabilitation), which provides a methodical checklist of cost-effective strategies. Depending on the jurisdiction, projects meeting the 2011 Criteria may meet certain requirements for approval of tax incentives. See the Energy Efficiency section on pages 55-74.

enterprisecommunity.com/solutions-and-innovation/enterprise-green-communities/criteria

Green Communities Criteria: Incremental Cost, Measurable Savings Update

This resource illustrates the cost effectiveness of the Enterprise Green Communities Criteria in delivering health, economic and environmental benefits to developers and residents of green affordable housing.

enterprisecommunity.com/resources/ResourceDetails?ID=67812.pdf

International Energy Conservation Code (IECC) Climate Zone Map (2009)

Details climate zones by state and county, as well as minimum shell R-values and U-factors specific to the location.

energycode.pnl.gov/EnergyCodeReqs/

PlanLED

Human-centric LED lighting design solutions and products.

planled.com

PV Watts Calculator

Refer to Appendix H of this report for directions on using this calculator to estimate solar production.

pvwatts.nrel.gov

Solar Ready Buildings Planning Guide

A document that gives solar installation guidance throughout the design and construction process.

nrel.gov/docs/fy10osti/46078.pdf

Sun, Wind, and Light: Architectural Design Strategies, 3rd Edition

By Mark DeKay and G.Z. Brown A comprehensive guide to passive design.

Available on wiley.com or amazon.com

US Department of Energy, Air Sealing, Technology Fact Sheet

Analysis and guidance on the importance of sealing air leaks and providing controlled ventilation in single-family residences.

nhpci.org/images/Air_and_Duct_Sealing.pdf

Zero Net Energy Design Fundamentals

A two-page exposition on the implementation of integrated design in zero-net energy construction. This paper highlights the DPR Construction Office, certified under the Living Building Challenge's Net Zero Energy Building Certification.

newbuildings.org/sites/default/files/ZNE_DESIGN_FUNDAMENTALS_v1.pdf

A dark, high-contrast photograph of a water fountain. The water jets are illuminated, creating a shimmering effect against the dark background. In the foreground, the silhouettes of people are visible, some appearing to be playing or running through the water. The overall mood is dynamic and energetic.

WATER

“As global climate change and urbanization continues to add new stresses to our aging infrastructure, a new and more resilient system for affordable housing is necessary to ensure that we can meet our communities’ long-term water needs.”

I. WATER

IMPERATIVE 05 | NET POSITIVE WATER

Project water use and release must work in harmony with the natural water flows of the site and its surroundings. One hundred percent of the project's water needs must be supplied by captured precipitation or other natural closed loop water systems, and/or by recycling used project water, and must be purified as needed without the use of chemicals.

All stormwater and water discharge, including grey and blackwater, must be treated on-site and managed either through re-use, a closed loop system, or infiltration. Excess stormwater can be released onto adjacent sites under certain conditions.

—Living Building Challenge 3.0

PETAL INTRODUCTION

The catastrophic 2014 droughts in California and Texas have highlighted the risks of our current wasteful water practices and the substantial water insecurities that many communities face. In July 2014, the US drought monitor reported that over 81% of California is experiencing an exceptional drought.²⁶

In addition to the issue of water shortages, pollutants are degrading the water that is available and causing broader environmental impact. Traditional stormwater infrastructure allows toxic chemicals from streets and buildings to be washed into waterways and oceans, causing pollution with bio-accumulative potential to impacts human and ecosystem health. Water reuse, stormwater management and infiltration at the project scale can eliminate these environmental impacts while restoring a healthy hydrological cycle to a site.

In an age of climate change and in light of these significant issues, the benefits of a new decentralized approach, where buildings operate within the carrying capacity of their site, are becoming increasingly clear. In addition, decentral-

ized water systems typically reduce greenhouse gas emissions compared to centralized systems because on-site systems eliminate the energy expended to pump water and waste over long distances. In fact, a report by the Institute found that 44% of the energy used by an area's water system is for conveyance alone.²⁷ Small-scale decentralized systems also add adaptability and resilience, especially in times of drought, to our aging and outdated water infrastructure.

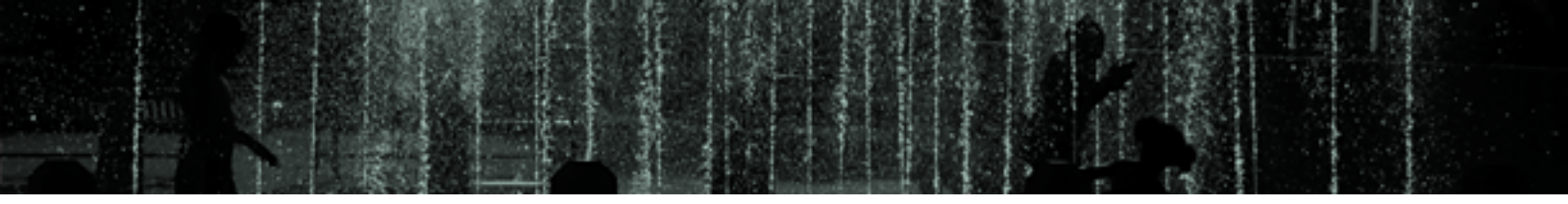
The Net Positive Water Imperative offers a new vision for distributed water systems that treat water as a precious resource and reconnects our buildings and communities with natural hydrological flows in harmony with the environment.

OVERALL APPROACH

Meeting the Net Positive Water Imperative in affordable housing requires careful design of three distinct but interrelated systems: water supply, stormwater management and wastewater treatment. While the Living Building Challenge is intended to inspire change and push the industry as far as possible while providing pathways to certification that recognize leadership, the market, particularly as it relates to water

²⁶ National Integrated Drought Information System (NIDIS), <http://drought.gov/drought/>

²⁷ Cascadia Green Building Council, <http://living-future.org/sites/default/files/reports/clean%20water-%20healthy%20sound.pdf>



regulation, is lagging behind the requirements of the Challenge. Therefore, for each of the main requirements of the Water Petal, the Institute has established temporary exceptions that make achieving Water Petal certification possible despite regulatory barriers. The first two temporary exceptions relate to all project types. The third is for affordable housing projects only. These temporary exceptions will be removed as alternative water system technology becomes more commonplace and as projects are successful in overturning outdated water regulations.

EXCEPTIONS

The Living Building Challenge program recognizes that some state health departments and utility regulations will not allow the capture and recycling of rainwater for potable use. In this case, the team can use the **Municipal Potable Water Supply Exception** (below) after they have advocated to the jurisdiction for regulatory change.

I05-E1 4/2010 Municipal Potable Water Supply²⁸

If health or utility regulations require a project to use municipal potable sources, it is allowed, but only for potable uses including sinks, faucets, janitorial uses, and showers. Non-potable uses such as toilet flushing, clothes washing, and equipment uses must use water sourced from the project site. While it is not required, the project is encouraged to include full rainwater harvesting capacity in anticipation of future regulatory acceptance of additional rainwater. To use this Exception the project team must exhaust all regulatory appeals short of legal appeals. In addition, the team must demonstrate through design drawings and calculations how the project is designed to meet the requirement for 100% site-sourced water.

A connection to a municipal stormwater system is generally not allowed under the Water Petal, except in the dense L5 and L6 transects where all opportunities for on-site have been exhausted, including infiltration, evapotranspiration and beneficial reuse in the project. In this case, projects can use the **Transect L5 and L6 Municipal Stormwater Connection Exception** (below).

I05-E4 4/2010 Transects L5 and L6 - Municipal Stormwater Connection²⁹

For Building projects in Transects L5 or L6, and where there is no adjacent downstream habitat supported by the water from the site, there is a conditional exception allowing the use of public storm sewers. In this instance, the project team may propose managing less than 100% of water on site by demonstrating that all possible

- *pathways of beneficial use of the stormwater have been exhausted, including:*
 - Evaporation/Evapotranspiration: Show that all areas for water uptake by plants or other means have been fully utilized (i.e., living walls, green roof, on-site or off-site vegetation, cooling tower make-up, irrigation for urban agriculture, etc.).*
 - Infiltration: Show that both shallow and deep*
- *infiltration have been investigated and utilized to the greatest extent possible.*
 - Beneficial Reuse: Show that no additional beneficial reuse of the stormwater is possible for either potable or non-potable use on or off the project site (i.e. potable or non-potable uses on neighboring buildings or properties, water features, etc.).*

Under the Net Positive Water Imperative, all wastewater, including grey water and black water, must be treated on-site without the use of chemicals. There are a number of different technologies available to meet this requirement, including composting toilets, trickling bio-filters, membrane bioreactors, constructed

²⁸ Refer to the August 2014 Water Petal Handbook, p. 10.

²⁹ Refer to the August 2014 Water Petal Handbook, p. 11.

wetlands and treatment lagoons. The most cost-effective strategies employed to meet this Imperative tend to be a combination of grey water treatment through constructed wetlands or subsurface irrigation, and composting toilets to treat black water.³⁰ Technologies such as membrane bioreactors or living machines tend to be significantly more expensive and require a large amount of energy, putting achievement of this Imperative in potential conflict with the Net Positive Energy Imperative.

Given the unique financial limitations of multi-family affordable housing projects that are three stories or greater and the ongoing maintenance expense for on-site black water treatment, the Institute has established an exception for this particular requirement of the Water Petal for affordable housing projects. Based on feedback from the pilot projects and the Innovator Network, this exception acknowledges current financial and regulatory barriers while rewarding projects that meet the other requirements of the Water Petal with a certification pathway.

IO5-E6 11/2014 Black Water Treatment for Multi-Family Affordable Housing

Multi-family affordable housing projects of three stories or more are allowed to connect to a municipal sewer system for black water treatment. All project grey water must be treated onsite or by Scale Jumping to adjacent sites.

NET POSITIVE WATER MODELING

The Institute modeled Net Positive Water strategies in each region that the developers in the Innovator Network represent in order to determine the feasibility of meeting the Water Petal for multi-family affordable housing projects in a number of North American climates. The modeling utilized local rainfall data and water balance calculations for each region. Results show that

Net Positive Water is attainable using existing exceptions for all the locations modeled, utilizing appropriate strategies for each climate,

The Net Positive Water modeling is based on same typical building used for the Net Positive Energy modeling. The basic specifications are:

- 100,000 square feet
- Four stories
- 100 units (135 occupants³¹)
- Roof sloped to collect water from the entire roof square footage

Three different scenarios were modeled, each of which meets the requirements of the Water Petal. Each scenario utilizes different systems to take advantage of different exceptions if needed given a project's specific regulatory or financial barriers.

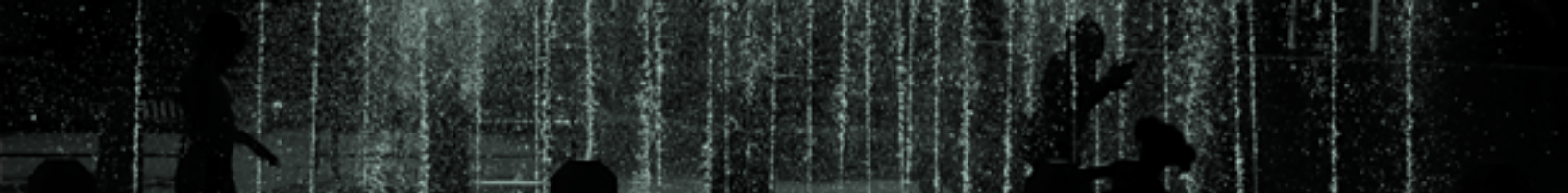
³¹ Calculations based on 135 occupants: 50 studio/efficiency units (50 people); 40 one-bedroom units (60 people); 10 two-bedroom units (25 people)



flickr: Luke stearns

³⁰ International Living Future Institute, Case Studies.

<http://living-future.org/casestudies>



Scenario 1: Closed Loop System with Rainwater Supply

Scenario 1 is based on the assumption that all project water (both potable and non-potable) is supplied by collected rainwater. Rainwater is captured from the roof and stored in a collection cistern. The cistern size has been modeled based on the rainfall data for each location.

In this scenario, grey water is managed through a constructed wetland and/or subsurface irrigation system. Black water is managed through an on-site composting toilet system, which helps reduce water demand to 15 gallons per capita per day (gcd).

The modeling results show that in all but one of the locations, a typical project can only source

roughly 50% of its water needs from rooftop rainwater collection. For the remaining 50% of the water needs, a project would have to Scale Jump to utilize a nearby building's roof of equal or greater size. In the sixth location, semi-arid San Jose, CA, the typical project could only meet 25% of its water needs from on-site rooftop rainwater collection. To meet the project's full water demand, three additional similarly sized rooftops would need to be added through a Scale Jumping strategy, requiring a cistern of 135,000 gallons. Harvesting rainwater from neighboring buildings could have the added benefit of addressing excess stormwater from those neighboring projects.

This scenario does not make use of any of the exceptions noted above.



flickr::Permario

SCENARIO 1. CLOSED LOOP SYSTEM WITH RAINWATER SUPPLY

15 gallons/per capita/day (gcd)

FIGURE 13: Water Scenario 1 Water Use Pie Chart

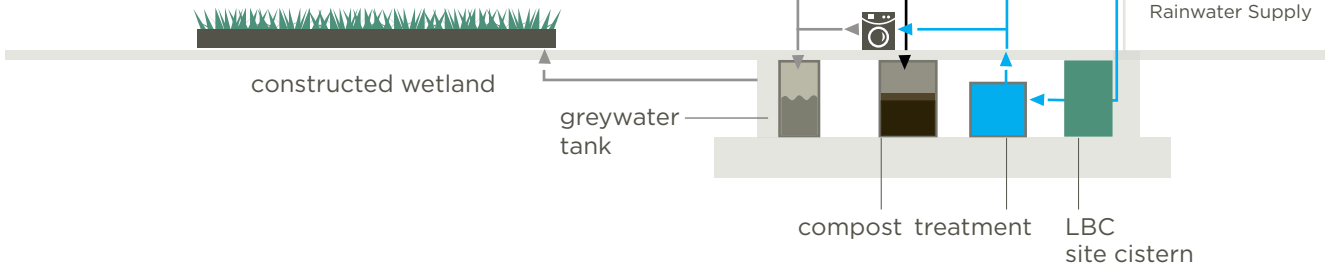
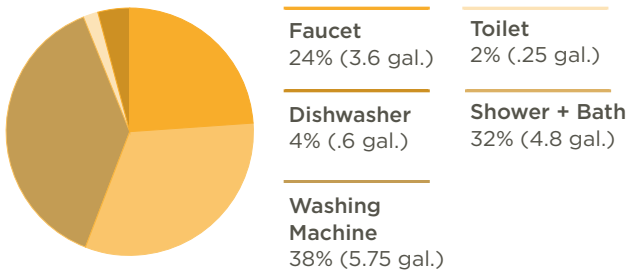


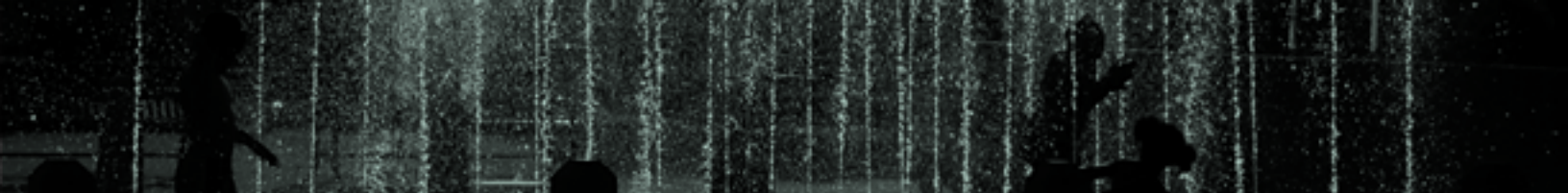
FIGURE 12 Water Scenario 1: Closed Loop System with Rainwater Supply

FIGURE 14 Water Scenario 1: Partner Location Cistern Sizing Table

Partner Locations	Catchment Area (sq ft)**	Rain Collection Resource (in/yr)	Cistern Size (gal)	Cistern Dimensions if 10ft tall
Minneapolis, MN	50,000	32.16	180,000	49'x49'
Christiansburg, VA*	50,000	40.73	20,000	16'x16'
Chicago, IL*	50,000	37.96	40,000	23'x23'
San Jose, CA	100,000	15.82	305,000	64'x64'
Austin, TX*	50,000	34.89	50,000	26'x26'
Vancouver, WA	50,000	41.63	135,000	42'x42'

*Scenario best suited for the following partner locations

**Required catchment area to meet 100% of water demand in modeled project.



Scenario 2: Municipal Potable Supply with Composting Toilets

In Scenario 2, regulatory barriers prevent rainwater collection for potable use; therefore, the Municipal Potable Water Exception is being used. Under this exception, municipal water provides all potable water use. Rainwater is captured from the roof, held in a cistern and filtered to an intermediate quality, sufficient for irrigation and laundry. Composting toilets reduce water demand for toilet flushing and maintain project water consumption at 15 gcd, as in Scenario 1.

The modeling results show that in all but one of the locations, a typical project can achieve Net Positive Water when the Municipal Potable Water Exception is used. The cistern size depends on the specific climate, but for all locations it is within a reasonable size range of 18,000 to 56,000 gallons.

Due to the limited water resources in the region, San Jose is again an outlier in this scenario. The typical project can only meet 45% of its water needs from on-site rooftop rainwater collection. Meeting the remaining water needs would require Scale Jumping. In addition, a fairly large cistern of 160,000 gallons is required. Given that water shortages are already occurring and expected to grow in this region, developers may want to consider other strategies for reducing water by reducing project size or occupant density so that the project fits within the carrying capacity of the site. Other strategies to meet the water demand in a dry climate include a community-scale rainwater catchment system and capturing and reusing other site water, such as grey water, as in Scenario 3B described below.



flickr: 55Laney

SCENARIO 2. MUNICIPAL POTABLE SUPPLY WITH COMPOSTING TOILETS

Rainwater used for 100% of greywater use

15 gallons/per capita/day (gcd)

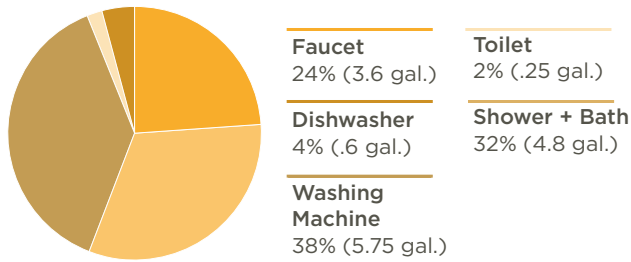


FIGURE 16 Water Scenario 2: Water Use Pie Chart

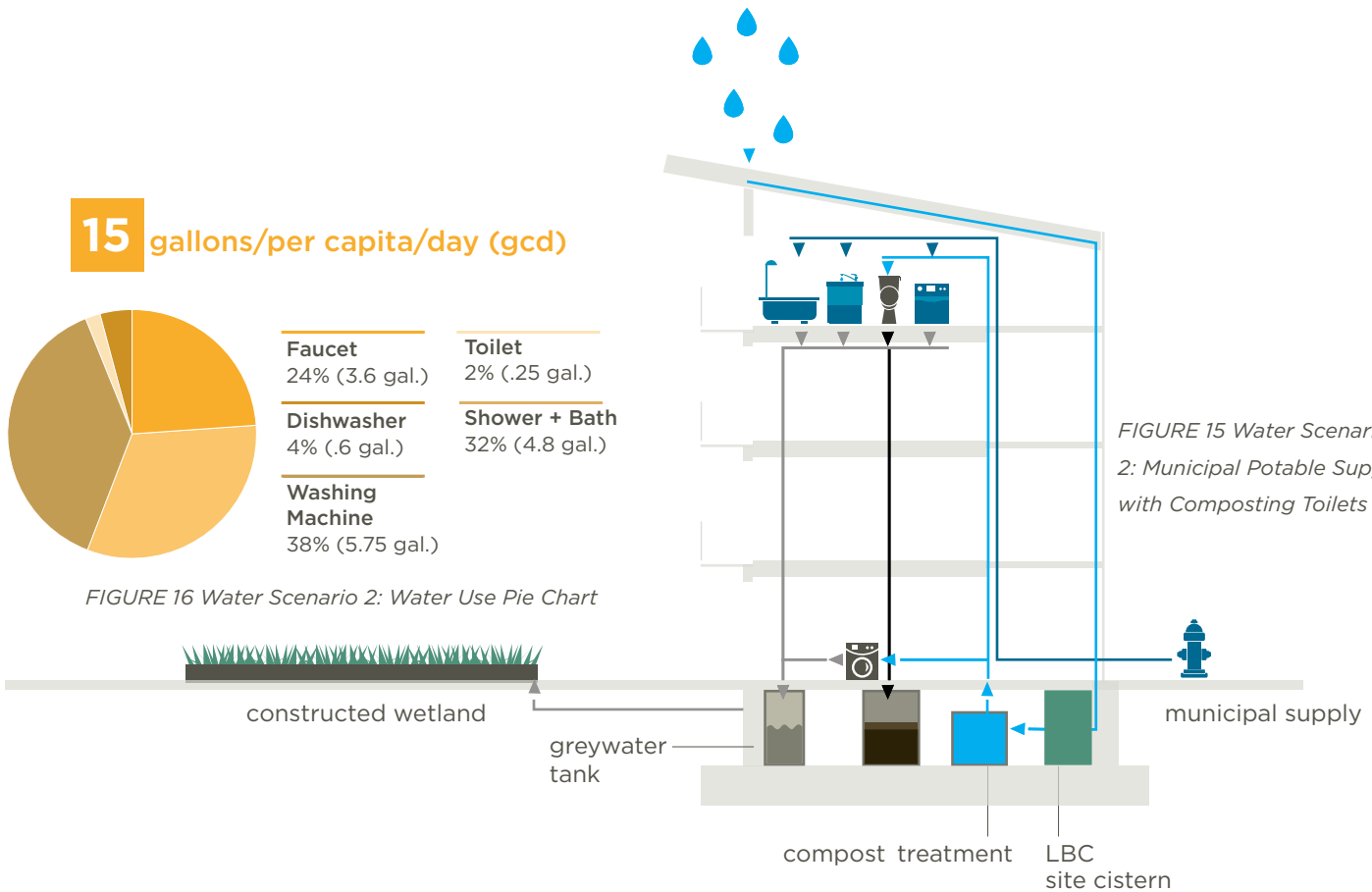
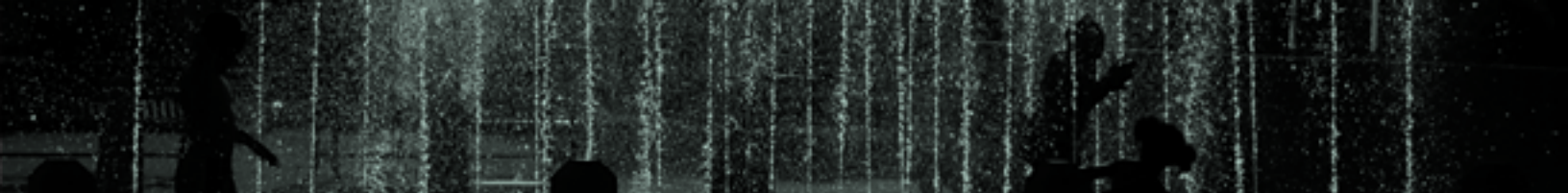


FIGURE 17 Water Scenario 2: Partner Location Cistern Sizing Table

Partner Locations	Catchment Area (sq ft)	Rain Collection Resource (in/yr)	Cistern Size (gal)	Cistern Dimensions if 10ft tall
Minneapolis, MN	25,000	32.16	56,000	27'x27'
Christiansburg, VA	25,000	40.73	20,000	16'x16'
Chicago, IL	25,000	37.96	18,000	16'x16'
San Jose, CA	55,000	15.82	160,000	46'x46'
Austin, TX	25,000	34.89	4,000	7'x7'
Vancouver, WA	25,000	41.63	41,000	23'x23'



Scenario 3A: Municipal Potable Supply with Harvested Rainwater Used in Low-Flow Toilets

Scenario 3A assumes that regulatory and/or social barriers prevent the use of composting toilets, so the project has elected to utilize the Black Water Treatment for Multi-Family Affordable Housing Exception. Harvested rainwater is used for flushing toilets, irrigation and laundry. Using low-flow toilets instead of composting toilets will increase daily water consumption per person per day to 20 gpd.

Modeling results show that in four of the six modeled climate zones (Christiansburg, Chicago, San Jose and Austin) rainfall does not provide sufficient supply to meet the water demand for non-potable uses in a typical project. If water-consuming toilets are used in these climates, Scale Jumping will be required to access additional rainwater or other on-site water, such as grey water, will need to be recycled. Minnesota and Vancouver can meet the requirements most easily and without the use of composting toilets or grey water recycling.



Flickr: stereotyp

SCENARIO 3A. MUNICIPAL POTABLE SUPPLY WITH HARVESTED WATER USED IN LOW-FLOW TOILETS

Rainwater used in washing machines and toilets

20 gallons/per capita/day (gcd)

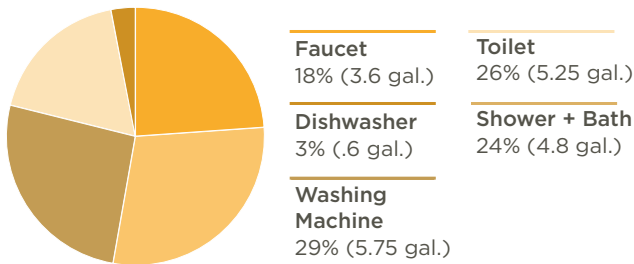


FIGURE 19 Water Scenario 3A: Water Use Pie Chart

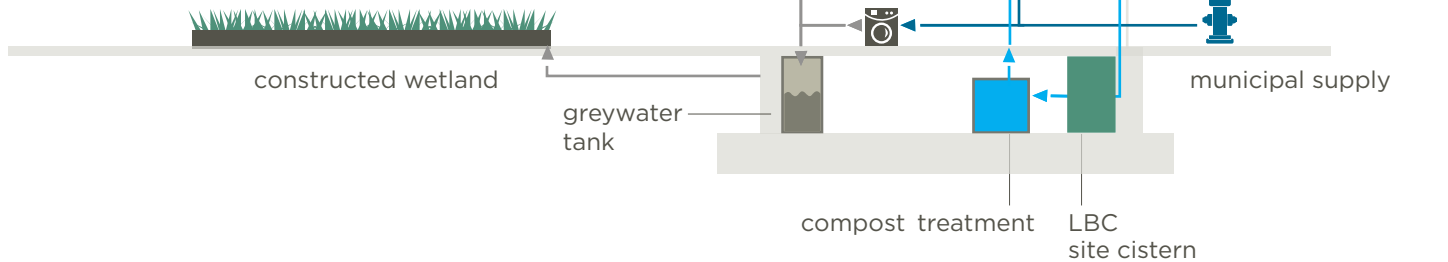
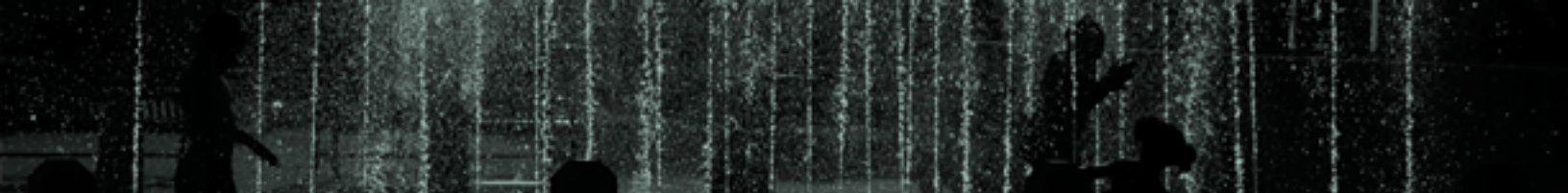


FIGURE 18 Water Scenario 3A: Municipal Potable Supply with Harvested Water Used in Low Flow Toilets

FIGURE 20 Background Scenario 3A: Municipal Potable Supply with Recycled Grey Water Used in Low Flow Toilets

Partner Locations	Catchment Area (sq ft)	Rain Collection Resource (in/yr)	Cistern Size (gal)	Cistern Dimensions if 10ft tall
Minneapolis, MN	25,000	32.16	135,000	42'x42'
Christiansburg, VA	25,000	40.73	20,000	16'x16'
Chicago, IL	25,000	37.96	24,000	18'x18'
San Jose, CA	55,000	15.82	103,000	37'x37'
Austin, TX	25,000	34.89	24,000	18'x18'
Vancouver, WA	25,000	41.63	208,000	53'x53'



SCENARIO 3B. Municipal Potable Supply With Greywater Recycling in Toilets

Scenario 3B also assumes that regulatory and/or social barriers prevent the use of composting toilets, so the project has elected to utilize the Black Water Treatment for Multi-family Affordable Housing Exception. In this scenario, grey water from laundry and janitorial uses is reused to flush toilets, and harvested rainwater is used for irrigation, janitorial uses and laundry. Using low-flow toilets instead of composting toilets will increase daily water consumption per person per day to 20 gcd.

In scenario 3A, Net Positive Water is achievable in Minneapolis and Vancouver with the use of large cisterns, 135,000 and 208,000 gallons respectively. In other locations, as modeled in Scenario 3B, grey water will need to be recycled from showers and laundry for toilet flushing in order to ensure that rainfall is sufficient to meet non-potable demand. This approach will greatly reduce the size of the cistern required to 25,000 gallons. Even with grey water recycling, San Jose will require at least an additional 30,000 square feet of roof area for rainwater collection, as well as a 103,000 gallon cistern.



Flickr: Seth

SCENARIO 3B. MUNICIPAL POTABLE SUPPLY WITH GREYwater RECYCLING IN TOILETS

Rainwater used first in washing machines and then used in standard low-flow toilets

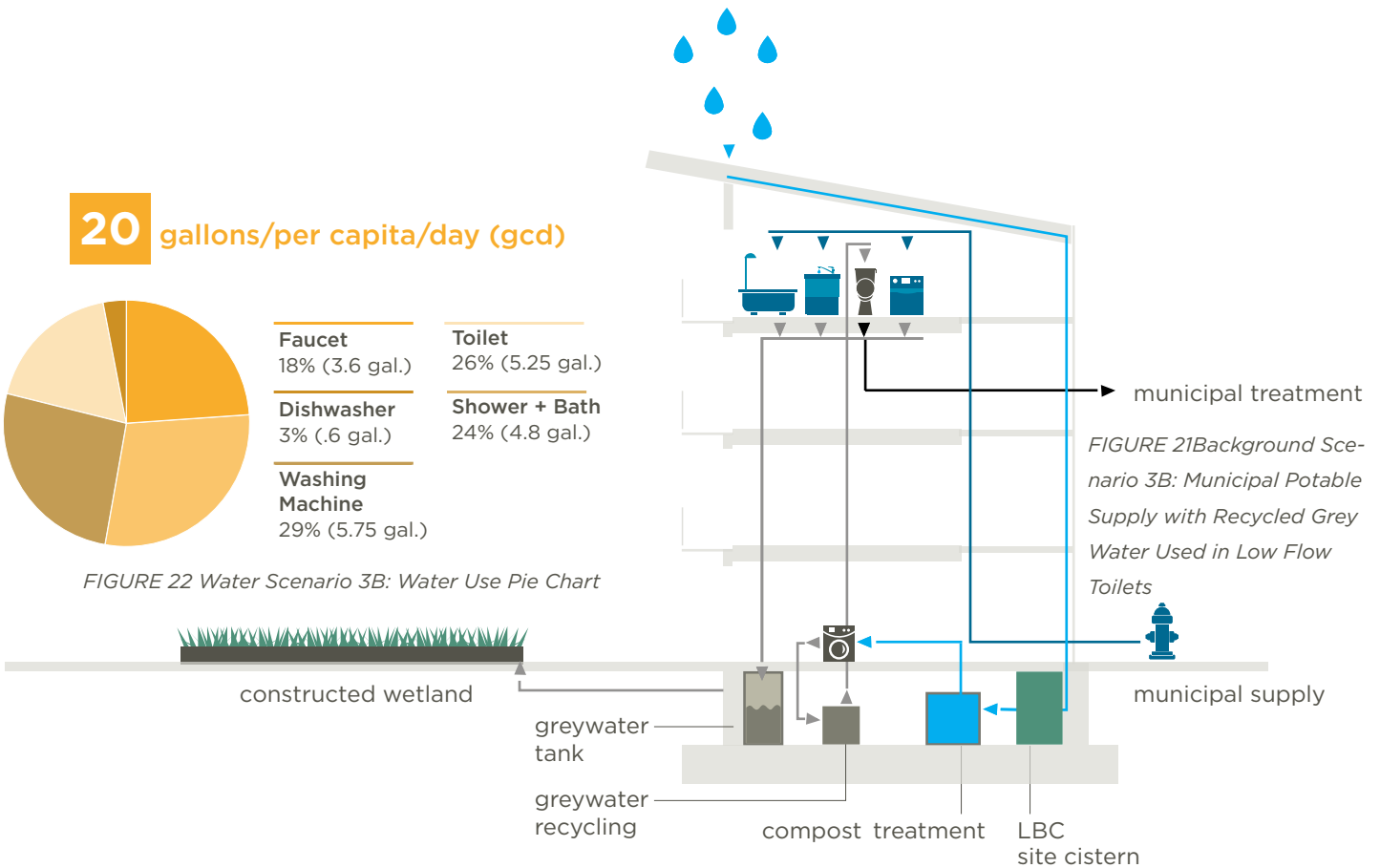


FIGURE 23 Water Scenario 3A + 3B: Partner Location Cistern Sizing Table

Partner Locations	Catchment Area (sq ft)	Rain Collection Resource (in/yr)	Cistern Size (gal)	Cistern Dimensions if 10ft tall
Minneapolis, MN	25,000	32.16	135,000	
Christiansburg, VA	25,000	40.73	20,000	
Chicago, IL	25,000	37.96	24,000	
San Jose, CA	55,000	15.82	103,000	
Austin, TX	25,000	34.89	24,000	
Vancouver, WA	25,000	41.63	208,000	

MODELING CONCLUSIONS

To achieve the Water Petal and its single Imperative, Net Positive Water, affordable housing projects must reduce water consumption to 15-20 gcd. This will require innovative water reduction strategies and, in some cases, tenant education about and acceptance of composting toilets. The 15-20 gcd may sound extreme, especially considering that most US multi-family apartments are designed to consume 40 gcd or 30 gcd if low-flow fixtures are specified.³² However, there is a precedent for this reduced level of water consumption. In fact, the team at Foundation Communities in Austin, TX, routinely specifies extremely efficient fixtures in their developments, which reduce water consumption to 20 gcd. An affordable housing community in San Juan County, WA, has a measured water consumption of around 20 gallons per day per resident.³³ In both cases, the incorporation of composting toilets could drive these numbers down to approximately 15 gcd.

While different system designs and cistern sizes are required for the various climate zones, the modeling shows that there is a pathway to meeting Net Positive Water in each of the six climate zones of the Innovator Network.

REDEFINING BEST PRACTICE

Many water conservation strategies are already common in green affordable housing projects. The Enterprise Green Communities Criteria includes specifications for high-efficiency fixtures, low-flow or dual-flush toilets, and efficient appliances that can reduce water consumption from a code baseline of 70 to around 30-40 gallons per capita per day (gcd). But as the Net Positive Water modeling shows, in order to meet the

³² Grondzik, Walter T., Alison G. Kwok, Benjamin Stein, and John S. Reynolds. *Mechanical and Electrical Equipment for Buildings (MEEB)*. Eleventh ed.

³³ Refer to Appendix G: Water Statistics & Specifications

requirements of the Net Positive Water Imperative, project teams will need to strive for deeper conservation measures and capture and utilize on-site rainwater or grey water. Some of the highest performing affordable housing projects today already collect rainwater and grey water for toilet flushing and irrigation. These practices and more will need to be incorporated to meet Net Positive Water.

The first step toward meeting the Net Positive Water Imperative and keeping costs down is reducing consumption. Project teams can perform a water balance calculation to compare estimated water consumption to the collection area and rainfall patterns in the location in order to determine an appropriately sized cistern for the climate zone. While the amount of rainwater supply will vary depending on the climate, generally projects will need to greatly reduce water consumption in order to ensure that usage is within the carrying capacity of the site.

As demonstrated in the Net Positive Modeling, the specific strategies used will depend on the climate zone, rainwater resources and other particulars of the project. However, key water reduction strategies that should be explored by affordable housing projects seeking the Living Building Challenge include:

- 0.8 gpf toilet
- 1.0 gpm showerheads
- 0.2 gpm bath faucet
- 0.7 gpm kitchen faucet
- ENERGYSTAR and water sense certified dishwashers (3 gallons/use)
- ENERGYSTAR and water sense certified clothes washers (14 gallons/use)
- Composting toilets with maximum of .03-.06gpf
- Rainwater harvesting and reuse
- Grey water harvesting and reuse
- Treatment: ultra violet (UV), reverse osmosis, membrane filtration or sand filters
- Condensate capture and reuse
- Purple pipe main for irrigation or non-potable uses

BARRIERS & SOLUTIONS

Social Barriers

Many people have concerns about the use of treated rainwater and grey water even though the treatment technologies are proven and established. In addition, non-traditional means of treating waste, such as composting toilets, are perceived by some to be unclean or unhealthy and can be associated with less modern ways of living. It is important that residents of affordable housing projects receive facilities that are on par with market rate housing.

Social Solutions

In recent years, composting toilet systems and alternative water treatment systems have made great strides in terms of quality and convenience. These systems are safe and compare favorably to the look, feel and functionality of traditional systems. A single affordable housing project that incorporates these systems successfully will go a long way in changing the market and residents' minds. Just as people who visit the Bullitt Center's composting toilet system³⁴ are impressed by its cleanliness and ease of use and in turn reevaluate whether a system like that could work for their project, the installation of such systems in even one affordable housing project will change the way the market views alternative water treatment systems—inspiring a new generation of integrated water system designs for multi-family housing.

Regulatory Barriers

jurisdictions simply do not allow potable water to be supplied from rainwater, let alone grey water, in public buildings. In addition, building an on-site wastewater treatment system can also be a regulatory challenge. Utilities often require projects to

³⁴ <http://www.bullittcenter.org/building/building-features/waste-not/>



PROJECT HIGHLIGHT: BRIGHT 'N GREEN & COMPOSTING TOILETS

Bright 'N Green in Brooklyn, NY, a registered Living Building and a five-story, multi-family speculative condo development has implemented an innovative water system that is overcoming common concerns about the health and practicality of alternative water systems. The project collects all the water for toilet flushing and irrigation from rainwater from the roof, and has implemented a composting toilet system using the Aquatron Composting System³⁵, which separates solids and liquids through centrifugal force and then send the solids to a worm bin, generating usable compost. This project demonstrates that a market-based speculative project can attract purchasers in trendy areas of Brooklyn while using a composting toilet system. In fact, the developer uses the composting toilet system as a marketing tool, and the project has been featured in numerous New York media outlets.³⁶

connect to the municipal sewer system and pay a service fee even if the project does not actually use the connection.

³⁵ Aquatron, <http://www.rosiesnaturalway.com/aquatron.html>

³⁶ http://ny.curbed.com/archives/2014/10/24/excrementeating_worms_star_at_new_green_brooklyn_building.php



Regulatory Solutions

Long-term coordinated advocacy will be critical to overcoming persistent regulatory barriers to decentralized water systems. To meet this challenge the International Living Future Institute has convened a key group of leaders in sustainable design and construction to conduct bio-regional advocacy through the Living Future Congresses. The first congress will be formed in the Cascadia bioregion (including Washington, Oregon, BC and Alaska) and the program will be expanded across the US and Canada through 2015. Changing outdated water regulations will be a key focus of these Congresses.

In addition, the Institute requires advocacy whenever one of the exceptions is used. This advocacy is an important aspect of the Challenge, since each Living Building Challenge project that advocates for alternative water systems in its jurisdiction will help to change regulations, in time leading to wider acceptance and use of alternative water systems.

Some states, such as Massachusetts, are taking a leadership role and can serve as great examples for other locations. Three projects targeting the Living Building Challenge, including the Kellogg House at Williams College, the Kern Center and the Hitchcock Center for the Environment both at Hampshire College, have recently overcome regulatory and social hurdles to rainwater recycling systems. Their jurisdictions have approved the installation of rainwater harvesting systems for 100% of each project's water needs, including potable water. All three projects also manage grey water and black water on-site through a combination of composting toilets and constructed wetlands. These projects are breaking through regulatory hurdles and demonstrating that closed loop water systems are practical and feasible for public projects.

Financial Barriers

There are two interrelated financial challenges that make it difficult for affordable housing projects to meet the Water Petal. First, decentralized water infrastructure, treatment, and storage systems have greater up-front cost when compared to a connection to the municipality's existing infrastructure, which is subsidized by taxpayers. Unfortunately, our current regulatory and utility paradigm externalizes almost all of the cost of water supply and treatment to the municipality, and the true costs are spread among the taxpayers, making water very inexpensive to project owners. Compared to on-site energy generation, there is little payback for on-site water systems.

Further, in wet climates, where large storm events can exceed a cistern's storage capacity, a larger on-site stormwater management system can entail significant up-front costs. While on-site stormwater management has significant benefits to the environment and community infrastructure, there are limited economic incentives for the owner or the residents.

The second major financial barrier is that on-site water treatment has significantly higher maintenance costs than traditional systems do. Many affordable housing projects operate with very little or negative cash flow, and maintenance of an alternative water system may not be financially feasible over the long run.

Financial Solutions

In recognition of the significant first cost and ongoing maintenance costs for on-site black water treatment in multi-family affordable housing, the Institute established an alternative compliance path to allow affordable housing projects to utilize a municipal sewer under a temporary exception. Projects are also allowed to use the municipal storm sewer in dense

urban environments, where on-site management can be difficult.

Foundation funding will continue to be important to address the issues of first cost for alternative water systems. In the long term to achieve all the Water Petal requirements to treat and manage all water on-site, there will need to be significant changes to utility regulations and incentive programs as well as to the Low Income Housing Tax Credit allocation system. While water prices remain very low in many areas of the US, global climate change and continuing drought in the American West are likely to push prices higher as sources of potable water are depleted. A 2013 report by the Pacific Institute, *California 2030: An Efficient Future*, recommends immediate action to reform the current rate structure for water with increased prices to encourage efficiency and to ensure that water supply can meet future water demand in drought-stricken California.³⁷ Future rate increases will improve the financial feasibility of alternative water systems, and water efficiency measures will mitigate the risk of rising utility bills for low-income tenants.

CONCLUSION

As global climate changes takes hold and water resources become increasingly stressed, particularly in regions prone to drought, there is a growing need for decentralized, resilient water infrastructure. Net Positive Water modeling suggests that meeting the Water Petal is feasible in a variety of climate zones across North America if water demand is reduced through the use of high-efficiency fixtures, appliances, and potentially composting toilets. However, there are different technical challenges in each of the climate zones modeled that demand a place-based approach.

While the technical challenges are surmount-

able, financial and regulatory barriers persist and prevent the widespread adoption of innovative, regenerative water systems. The Institute will continue to pursue coordinated action and advocacy to overcome regulatory barriers to pave the way for decentralized water system adoption.

The demonstration of a single project adopting a comprehensive approach to achieving Net Positive Water should not be underestimated. An affordable housing project that is able to show that a Net Positive Water strategy is practical and feasible, while meeting tenant needs, could have a transformative effect on the industry and inspire other developers to adopt innovative systems.



Flickr: Jonathan Petit_Opera Garnier

³⁷ http://www.pacinst.org/wp-content/uploads/sites/21/2013/02/ca_water_20303.pdf (page 7)

WATER PILOT PROJECT 1

The Rose

Innovator Organization: Aeon
Minneapolis, MN

DESIGN APPROACH TO WATER REDUCTION & STORMWATER MANAGEMENT

Through the use of water-conserving fixtures, the project team on the Rose has been able to reduce water use by 50% from the baseline for

the building. On-site condensate from the project's VRF system will be used to provide water for a centralized water feature. The project is also considering using harvested rainwater for irrigation of the urban agricultural areas. The water would be collected from rooftops and filtered through rain gardens before being stored for use in a storage cistern.

The current stormwater strategy is designed to exceed the City of Minneapolis' stormwater



unit: g/c/d

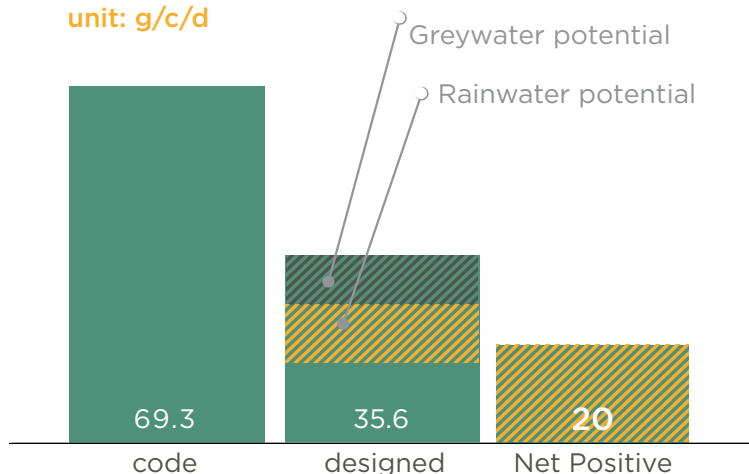
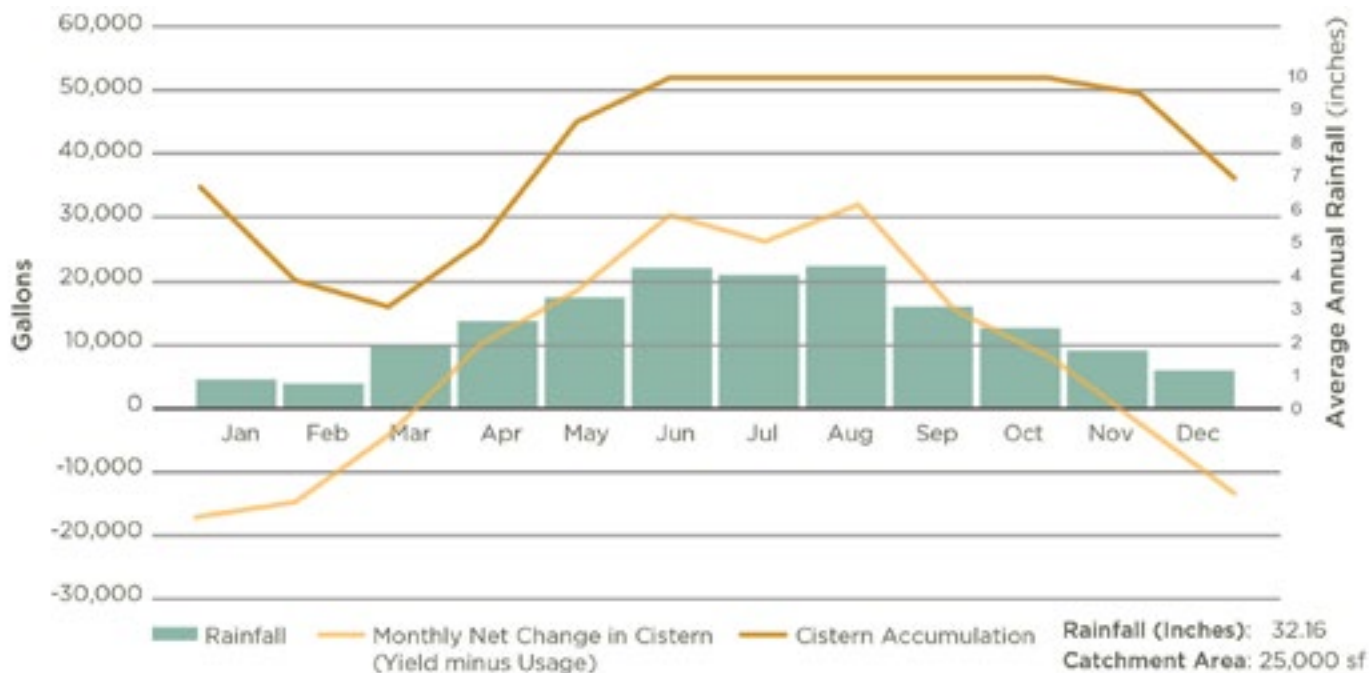


FIGURE 23 The Rose: Water Use Comparisons



standards. The site design utilizes rain gardens and a large underground storage and infiltration system to reduce the quantity and improve the quality of water leaving the site. Three rain gardens, with a total capacity of 26,000 gallons, capture water from the east quarter of the building roofs. The underground retention system will receive the remainder of the water and has a capacity of 48,500 gallons. A water quality unit will remove sediment and oil from water before it filters into the soil or enters the city's stormwater system, which empties into the Mississippi River.

- Water supply–Building Interior:** Municipal
- Water supply–Irrigation:** Rainwater collection
- Water supply–Water Feature:** Condensate from VRF system
- Grey water treatment and reuse:** None
- Black water treatment and reuse:** None
- Stormwater management:** Surface rain gardens, underground retention system before flowing to city stormwater system

PATHWAYS TO NET POSITIVE WATER

As designed, the project is not meeting the Net Positive Water Imperative. Significant changes would need to be made in order to reduce water consumption and capture and reuse on-site water. Looking at building water use according to the Net Positive Modeling results, however, this goal is feasible in Minnesota without the use of exceptions through the use of composting

BY THE NUMBERS: THE ROSE

FIXTURE TYPE	AS DESIGNED
Toilets	1.28 gpf
Kitchen Faucet	1.5 gpm
Bath Faucet	0.5 gpm
Shower	2 gpm
Bath	--
Clothes Washer	27 g/use
Dishwasher	7 g/use
	36.6 gcd

toilets and the integration of grey water and black water systems such as constructed wetlands. Making use of current exceptions, the project would need to capture all rainwater on-site and install a collection cistern to provide for all the non-potable water uses in the building. Grey water would also have to be treated through constructed wetlands or subsurface irrigation.

In terms of stormwater management, the project would need to retain and treat more water on-site. This could be accomplished by greatly increasing the amount of pervious surfaces on the site, scaling up the size of the rain gardens, and/or adding injection wells.

BARRIERS AND POSSIBLE SOLUTIONS TO NET POSITIVE WATER

Financial and regulatory challenges prevented this project from meeting their goal of Net Zero Water under the 2.1 version of the Challenge. In terms of water supply, regulations at the City of Minneapolis severely limit grey water collection, which meant the project could not collect enough water to meet demand.

Managing all storm water on-site was another significant barrier. Expanding the capacity of the project's stormwater management system to a 10-year event would require 2.5 times the planned capacity. To eliminate all runoff would require 3.5 times the capacity. In addition to the estimated \$1,000,000 in additional costs, expansion of the systems would reduce courtyard functionality and nearly eliminate all tree planting on site.

Finally, the project found that integrating a grey and black water system would be prohibitively expensive. They estimated construction would be \$2,000,000 with \$200,000 in yearly operating expenses.

CONCLUSION & LESSONS LEARNED

An important lesson learned from the Rose is that the water system design has to consider occupant behavior. The Wellstone project, another Aeon and Hope Community development adjacent to the Rose, had individual washers and dryers installed in each unit. Residents in this project began washing their neighbors' and friends' clothing since it cost very little for each additional load. As a result, water consumption was measured at over 70 gpd, much exceeding the projected estimates. Therefore, in the Rose, the project team designed a central laundry room where residents pay a fee for each use. They anticipate that this change will greatly reduce water consumption.

Based on feedback from early pilot projects, including the Rose, the Living Building Challenge requirements for managing stormwater have been updated in the 3.0 version of the Standard. Projects are now required to design their system to meet only a ten-year storm event, and for buildings in the L5 and L6 transect, there is a conditional exception allowing the use of the municipal storm sewer for overflow.

Feedback from pilot projects, including the Rose, has also led to the creation of the Black Water for Multi-Family Affordable Housing Projects exception. While the Rose would still face some additional cost associated with grey water treatment, making use of these exceptions would make the Water Petal attainable for future projects.

In compliance with the stormwater requirements of the Net Positive Water Imperative, the South Second Street Studios project team is implementing project-wide Low Impact Development (LID) strategies to manage 100% of stormwater on site through the use of a living roof and bioswales. The team is also exploring the potential for rainwater collection and reuse.

BY THE NUMBERS: SOUTH SECOND STREET STUDIOS

FIXTURE TYPE	AS DESIGNED
Toilets	1.28 gpf
Kitchen Faucet	1.5 gpm
Bath Faucet	0.5 gpm
Shower	2 gpm
Bath	--
Clothes Washer	27 g/use
Dishwasher	7 g/use



Photo: Chad Podoski_Ludwigia sedioides

WATER PILOT PROJECT 2

South Second Street Studios

Innovator Organization: Aeon
Minneapolis, MN

The technical challenges of meeting the other requirements of the Water Petal in this region are significant. Even by taking advantage of the Municipal Potable Water Exception, a project in this climate will have difficulty. According to the Net Positive Water modeling, a project in San

Jose would have to maximize on-site rainwater capture, install composting toilets and/or a grey water reuse system, and Scale Jump to neighboring buildings to collect enough rainwater and recycled site water to meet the project's water demand.

Water supply--All Uses: Municipal, exploring rainwater

Grey water treatment and reuse: None

Black water treatment and reuse: None

Stormwater management: 100% of stormwater to be retained on-site with green roof and bio swales

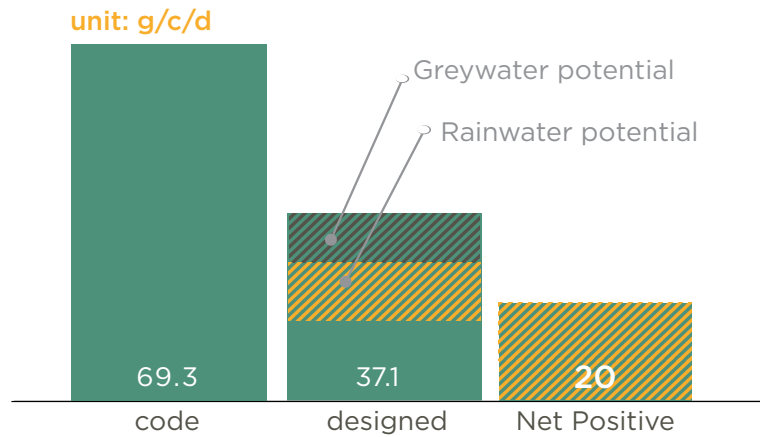


FIGURE 25 South Second Street Studios: Water Use Comparisons

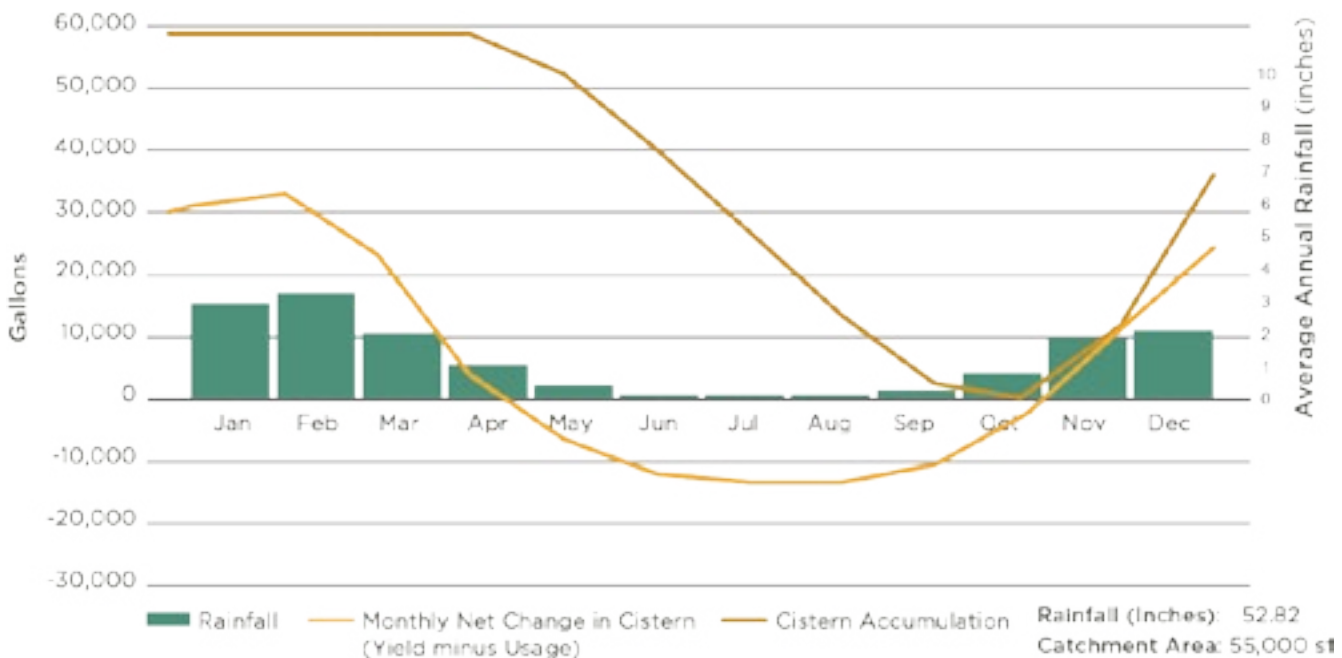


FIGURE 26 South Second Street Studios: Cistern Sizing Graph

WATER PILOT PROJECT 3

Capital Studios

Innovator Organization: Foundation Communities
 Minneapolis, MN

The Capital Studios project has prioritized water conservation and the use of extremely efficient fixtures. With this project and others, Foundation Communities has demonstrated that

a water conservation target of 20 gcd, which is necessary to meet the Net Positive Water Imperative for all the Innovator locations, is possible using current fixtures and technology. The project achieved these water consumption numbers without incorporating rainwater capture and reuse. According to the project team, the extremely efficient fixtures require a bit more attention to detail to make sure they operate correctly; each fixture has to be

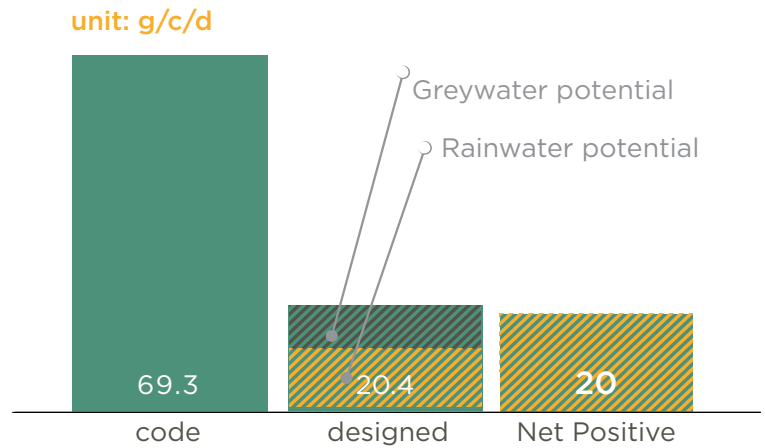


FIGURE 27 Capital Studios: Water Use Comparisons

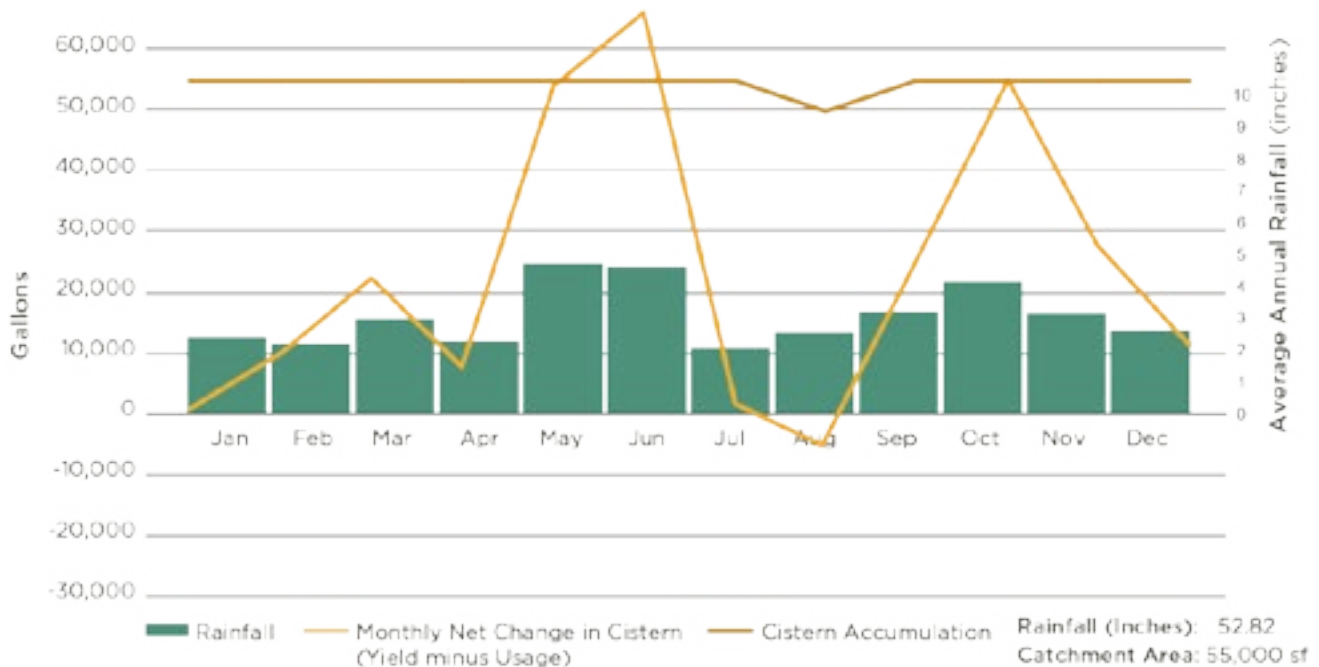


FIGURE 28 Capital Studios: Cistern Sizing Graph



calibrated to the water pressure of the unit in which it is installed. To meet the requirements of the Water Petal, the team would need to supply the required 20 gcd from captured rainwater or recycled site water, neither of which is currently planned for this project.

Foundation Communities is exploring meeting all requirements of the Net Positive Water Imperative on the Lakeline Studios project, in Austin, TX. This project is a stand-alone community center serving a number of affordable housing developments. Similar to their approach with the Net Positive Energy Imperative, the developer intends to use this smaller project to demonstrate that rainwater collection and on-site water treatment are possible. This is an effective strategy for developers to test out systems that they are unfamiliar with. Targeting a portion of a project or a single community building could be an effective gateway to Full Living Building Certification for future projects.

Water supply – All Uses: Municipal
Grey water treatment and reuse: None
Black water treatment and reuse: None
Stormwater treatment: 100% of stormwater to be retained on-site with green roof and bio swales

BY THE NUMBERS: CAPITAL STUDIOS

FIXTURE TYPE	AS DESIGNED
Toilets	0.8 gpf
Kitchen Faucet	1.5 gpm
Bath Faucet	0.5 gpm
Shower	1.0 gpm
Bath	--
Clothes Washer	14 g/use
Dishwasher	--
Leaks	--
Other	--
	20.4 gcd

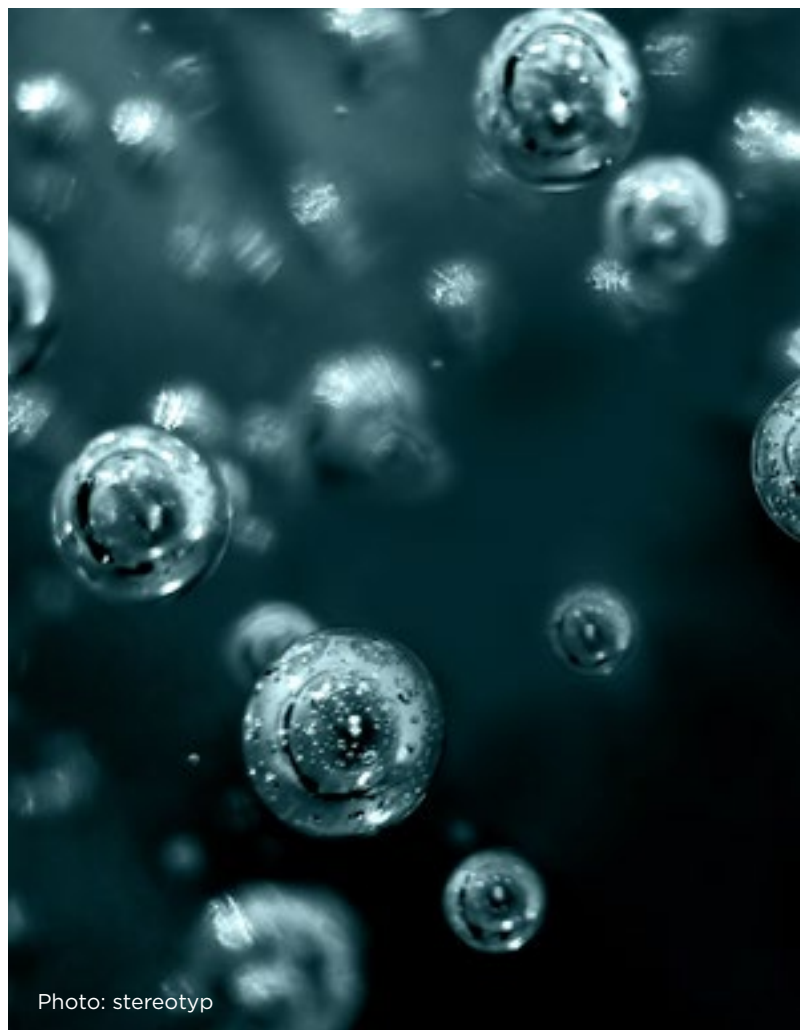


Photo: stereotyp

WATER RESOURCES

Achieving Water Independence in Buildings

Achieving Water Independence in Buildings, explains water reuse strategies and what current Oregon regulations allow. Their approach helped achieve statewide rainwater and greywater allowances in Oregon and may offer guidance for those in other states wishing explore the possibilities of water reuse in buildings and those wishing to reform limiting regulation.

living-future.org/includes/pdf/SustainablePath_MakingTheSwitch_Whitepaper8.pdf

American Water Works Association: Affordability Assessment Tool

This resource provides workbooks for comparing the affordability of water strategies. It considers maximum performance testing for water conservation and the impact of rising water bills on economically at-risk communities.

awwa.org/resources-tools/water-and-wastewater-utility-management/affordability.aspx

Clean Water, Healthy Sound

This study provides insight on the pros and cons of four commonly proposed decentralized and distributed treatment systems and how they relate to conventional practices at different density scales. Overall environmental impacts associated with each wastewater treatment system are compared and analyzed using Life Cycle Assessment (LCA). A separate conveyance analysis looks at how density relates to environmental impacts associated with moving wastewater from its point of generation to a central location, regardless of the treatment technology employed.

[living-future.org/sites/default/files/reports/clean water- healthy sound.pdf](http://living-future.org/sites/default/files/reports/clean%20water-healthy%20sound.pdf)

Enterprise Green Communities Criteria

Design guidelines for US affordable housing development types (single-family and multi-family) and construction types (new construction, rehabilitation), which provides a methodical checklist of cost-effective strategies. This Criteria delivers significant health, economic and environmental benefits to low-income families. Depending on the jurisdiction, projects meeting the 2011 Criteria may meet certain requirements for approval of tax incentives. See pages 42-54 for the Site Improvements section related to pre-development considerations related to water flow, as well as the Water Conservation section.

enterprisecommunity.com/solutions-and-innovation/enterprise-green-communities/criteria

Making The Switch

Utilizing best practice examples from around the globe and building on Cascadia's past research and engagement, this policy document seeks to assist decision makers and communities as they transition from conventional and expensive methods of water management to more distributed systems. The report highlights some of the risks of our outdated approach and encourages urgent change by putting forward 20 action items to address the persistent barriers that block our progress.

living-future.org/node/875



Maximum Performance (MaP) Testing

Since its launch in 2003, MaP has been a pioneer in improving toilet performance by scoring and testing over 3,500 tank-type toilet models, as well as over 450 bowl and valve combinations.

map-testing.com/map-search.html

Regulatory Pathways to Net Zero Water

Intended for projects pursuing net zero water strategies, this report describes obstacles present within current codes, identifies possible alternative pathways for seeking approvals, and provides guidance to Seattle-area design teams pursuing the goals of the Living Building Challenge.

living-future.org/sites/default/files/reports/RegulatoryPathwaystoNetZeroWater.pdf

US Environmental Protection Agency WaterSense Website

A comprehensive website to test your knowledge, calculate savings and find rebates related to water efficiency. An entire online community is available for builders and industry professionals who may need more technical information.

epa.gov/watersense



MATERIALS

“Small shifts in the standard specifications of the affordable housing industry can have ripple effects that spread across the building marketplace, transforming the US materials economy and providing safe, healthy affordable housing for all.”



III. MATERIALS

PETAL INTRODUCTION

The Materials Petal is one of the more challenging Petals within the Living Building Challenge because it requires more than a technical or engineering solution. It requires a change in the manufacturing industry overall to embrace transparency and toxic chemical avoidance. While challenging, meeting the Materials Petal is also critical to protecting occupant and environmental health. The requirements of this Petal are particularly important to meet in affordable housing projects, which have a long history of substandard materials that have a negative impact to occupant health.³⁸

Concerns about toxins in affordable housing continue today. Over one million children in the United States have lead levels in their blood that impact brain cognition and development. Lead-based paint and other building materials are significant contributing factors.³⁹ Further, a recent report from the Healthy Building Network identified a number of common building materials that have been connected to a growing epidemic of asthma in the US, with the greatest impact on low-income and minority populations.⁴⁰ While the Health and Materials requirements within the Enterprise Green Communities Criteria have already resulted in significant changes in the past decade, progress continues to be impeded

38 National Center for Biotechnical Research, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447157/>

39 National Center for Biotechnical Research, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447157/>

40 Lott, Full Disclosure Required: A Strategy to Prevent Asthma Through Building Product Selection

by a lack of transparency in the market and both perceived and actual increase in first costs for healthier materials.

The Materials Petal offers a framework to ensure healthy, non-toxic affordable housing projects. The Living Economy Sourcing Imperative of the Materials Petal also offers a platform for local economic development and empowerment that is in alignment with the long-term vitality of our communities and ecosystems. The Embodied Carbon Footprint Imperative inspires projects to reduce the amount of embodied carbon in their design and make a purchase to offset this impact. The Responsible Industry Imperative promotes transparency in the market while ensuring the sustainable harvesting and extraction of wood products. The Net Positive Waste Imperative significantly reduces the amount of construction debris that ends up in landfills while turning waste into a resource through a requirement for beneficial reuse of salvaged products.

The affordable housing industry presents a critical opportunity to affect large-scale change in the materials marketplace. Since its establishment in 1986, the Low Income Housing Tax Credit has resulted in the construction of more than 2.5 million units and produces as many as 100,000 jobs each year.⁴¹ In an era of increasing income inequality and urbanization, the number of affordable housing projects is likely to grow.⁴²

41 Healthy Building Network. <http://www.healthybuilding.net/uploads/files/full-disclosure-required-a-strategy-to-prevent-asthma-through-building-product-selection.pdf>

42 "America's Thorny Affordable Housing Crisis." Fortune. <http://fortune.com/2014/03/25/americas-thorny-affordable-housing-crisis/>



Since affordable housing projects tend to use similar designs and materials specifications to reduce soft costs and meet tight construction schedules, small shifts in the standard specifications of this industry can have ripple effects that spread across the materials marketplace, transforming the US economy and providing safe, healthy housing for all economic classes.

OVERALL APPROACH TO MATERIALS SELECTION AND SPECIFICATION

Achieving the Red List, the Local Economy Sourcing, and the Responsible Industry Imperatives requires thorough research and use of an integrated design process throughout all project phases. In a typical, linear design-bid-build process, the architect and consultants develop a list of materials in the project specifications and finish schedule, then hand the list off to the contractor in the construction documents for bidding and construction. The contractor will select materials based on the specifications and substitute out cheaper or more readily available materials through a submittal process with the architect in order to keep costs down. The nature of this linear process, as well as some contractors' desire to substitute materials to reduce costs, can make it difficult to achieve the Red List, Responsible Industry and Living Economy Sourcing Imperatives, since there is limited time during the construction process to conduct research without impacting the construction schedule and likely the budget.

In an integrated design process, the effort to research and vet materials is shared among a diverse range of stakeholders on the design and construction team. Each player in the process has specialized knowledge of their particular market. For example, while sub-contractors may not have a deep knowledge of material science, they will have specialized information about the availability and performance of the building materials for their trade. An integrated process

plays to the strengths of each party and reduces the research time necessary for a project. It also ensures the project team is not forced into last-minute substitutions or construction delays that negatively impact the project's schedule or budget.

The process would begin with a materials workshop during pre-design or schematic design. The focus of the workshop would be to develop a draft materials list appropriate for the region and climate. The draft materials list provided in Appendix H⁴³ of this report can serve as a starting point. During the workshop, the architect, consulting engineers and contractor should receive training on the materials requirements so that they can serve as the first line of defense in selecting compliant products. As the design develops, the architect and consultants should define the basic palette and begin identifying compliant materials. A project team might even consider bringing on a dedicated materials consultant and at minimum assigning a team member responsibility for healthy materials research and documentation.

During Design Development, all team members should work closely with the materials consultant to ensure that the materials they have selected are compliant or have compliant options. The team should take advantage of published compliant materials lists, the Declare program, and other resources as a starting point for materials research. The project team should also develop clear and concise templates to send to manufacturers and describe the specific information required to document the Red List, Responsible Industry, and Local Economy Sourcing Imperatives.

During Construction Documents, these three Materials Petal requirements should be included

43 "America's Thorny Affordable Housing Crisis." Fortune. <http://fortune.com/2014/03/25/americas-thorny-affordable-housing-crisis/>



in the project contract documents to ensure the contractor is legally obligated to comply. The most effective way to ensure that the project meets the Materials Petal requirements is to provide a proprietary specification where specific brands and materials are identified by the design team. However, it is impossible to identify every material within a project before construction. Therefore, the project team should also develop performance specifications for materials that they have not yet been able to identify. In public bid projects, a contractor is often allowed to make substitutions even if a material is identified. Therefore, the team may also need to develop a performance specification that identifies the materials requirements along with a list of materials that includes alternates. Sample Division 1 specifications, as well as example specific materials specifications, are available to registered Living Building Challenge project by request.⁴⁴

44 To request sample specification send an email to info@living-future.org

Prior to construction, the general contractor should hold a workshop to educate the subcontractors about the intent and requirements of the Materials Petal and ensure they do not bring products on-site that have not been vetted. Submittals and substitution requests should be vetted for compliance by the sub-contractors before they are sent to the architect or materials consultant. The architect or materials consultant should also visit the construction site regularly to spot check materials.

The difference between an integrated design process to meet the requirements of the Materials Petal and a conventional design-bid-build process is illustrated in Figures 29 and 30 below. The project team should take advantage of published resources and databases of healthy materials. For example, some Living Building Challenge projects have published the list of materials that they used in order to reduce research time and increase market transparency.⁴⁵

45 Materials list are available to registered project teams on the Project Team Community Brain Trust: <https://ilbi.org/action/community/brain-trust/lbc-project-materials-lists>

Figure 29. Traditional Design Process

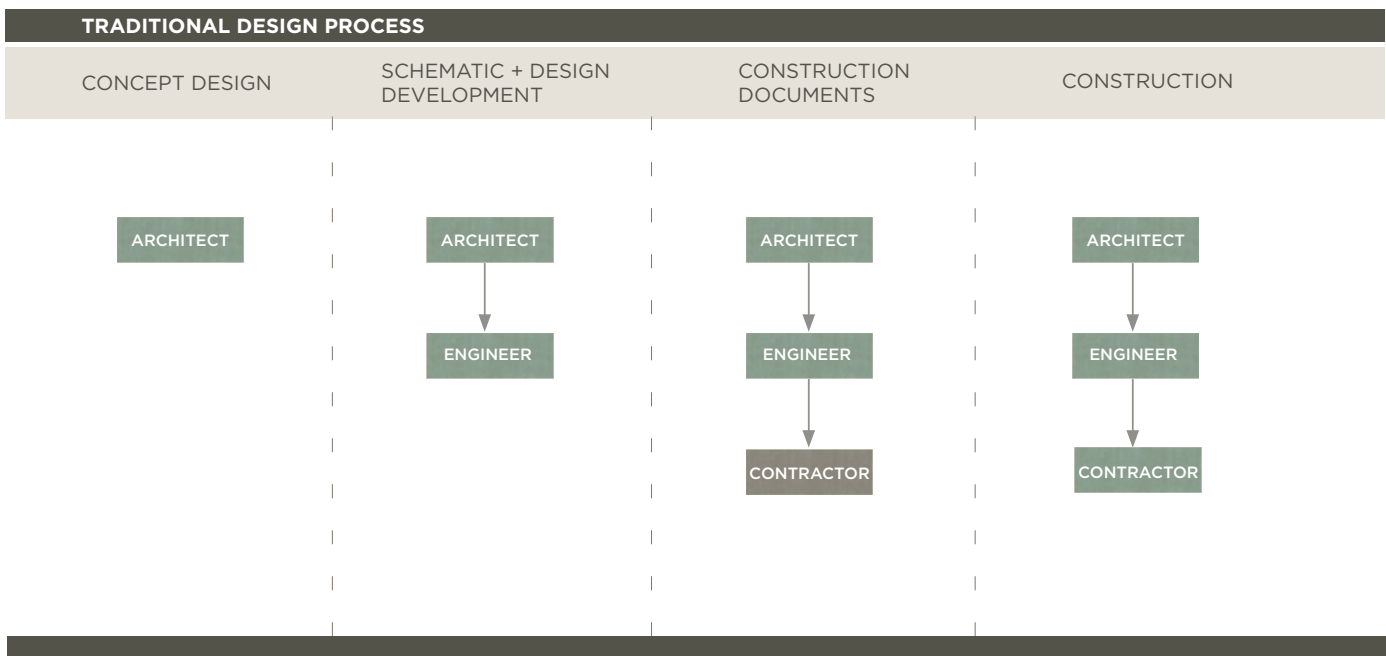
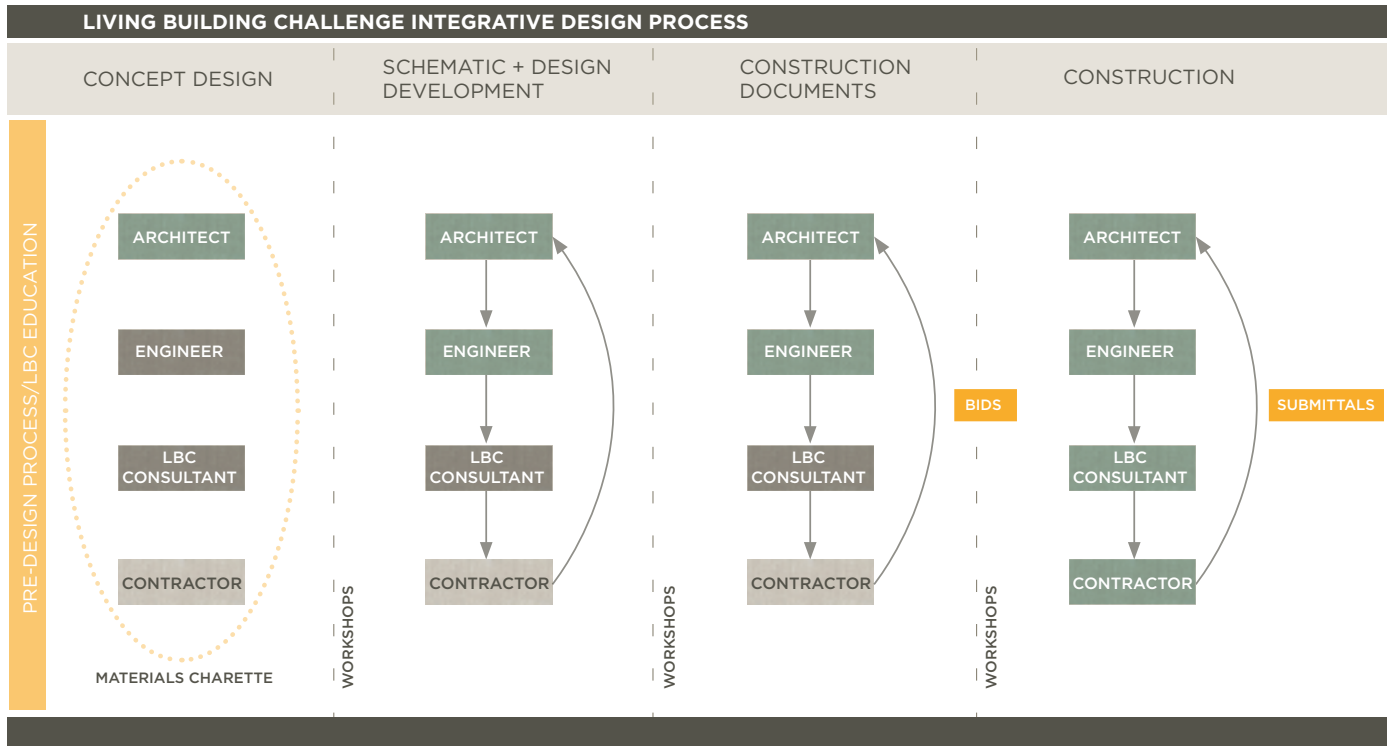




Figure 30. Living Building Challenge Integrative Design Process



IMPERATIVE 10 RED LIST

There are temporary exceptions for numerous Red List items due to current limitations in the materials economy. Refer to the Materials Petal Handbook for complete and up-to-date listings. The project cannot contain any of the Red List materials or chemicals.

—Living Building Challenge 3.0

Other helpful resources to use as a starting point for Red List compliant materials research include the Declare program,⁴⁶ Pharos⁴⁷, Greenspec⁴⁸ and Greenwizard⁴⁹.

⁴⁶ declareproducts.com

⁴⁷ pharosproject.net

⁴⁸ greenspec.buildinggreen.com

⁴⁹ greenwizard.com

Clear and concise templates letters to send to manufacturers that describe the specific information required to document the Red List. Early communication with manufacturers is critical to success in meeting this Imperative and to transforming the market.



IMPERATIVE 11 EMBODIED CARBON FOOTPRINT

The project must account for the total embodied carbon (tCO₂e) impact from its construction through a one-time carbon offset in the Institute's new Living Future Carbon Exchange or an approved carbon offset provider.

—Living Building Challenge 3.0

In order to minimize a project's embodied carbon footprint, which will reduce the cost of the offset purchase, project teams should conduct an embodied carbon charrette early in the design phase, looking at opportunities to reduce materials through structural efficiency and by using lower embodied carbon materials

such as wood instead of steel or concrete. Calculating carbon offsets and making a purchase is a relatively straightforward process and involves only a minimal amount of time from the design team with a relatively small additional investment.

IMPERATIVE 12 RESPONSIBLE INDUSTRY

The project must advocate for the creation and adoption of third-party certified standards for sustainable resource extraction and fair labor practices. Applicable raw materials include stone and rock, metal, minerals, and timber.

For timber, all wood must be certified to Forest Stewardship Council (FSC) 100% labeling standards, from salvaged sources, or from the intentional harvest of timber on-site for the purpose of clearing the area for construction or restoring/maintaining the continued ecological function of the on-site bionetwork.

All projects must use, at a minimum, one Declare product for every 500 square meters of gross building area and must send Declare program information to at least 10 manufacturers not currently using Declare.

—Living Building Challenge 3.0

Providing 100% FSC wood materials for an affordable housing project can be a logistical challenge with a significant impact to a project's hard cost. However, the growing market for FSC-certified products means that prices are decreasing while availability is increasing. The project team or materials consultant should identify the type of wood products required for the project early in the design process, so they can have enough lead time to research and identify FSC materials. Choosing salvaged or reclaimed materials that are not required to be

FSC is another effective strategy to limit impact of the potential upcharge for FSC.

At present there are no similar third-party standards governing the resource extraction and associated labor practices of other raw materials used in the building industry. Such standards would ensure the use of sustainable practices that are healthy for the environment, workers, surrounding community, and local economy. The Challenge, being as much an advocacy tool as a certification program, is designed to



transform the industry. As such, this imperative requires that advocacy letters be sent to industries governing the extraction of stone, rock, metals, and minerals.⁵⁰ Sample letter templates are provided to registered project teams. Currently there is a growing list of Declare products that make meeting the requirement to specify a Declare product for every 500 square meters of project area straightforward. For example, nearly every major carpet company is

⁵⁰ Refer to Appendix I: Sample Affordable Housing Materials Transparency Letter

participating in Declare, as well as many insulation and interior finish material companies. Affordable housing developers that intend to build multiple projects are also in a strong position to encourage manufacturers to list their products in the Declare database, making it easier and less time consuming for all project teams to identify compliant materials in the future.

IMPERATIVE 13 LIVING ECONOMY SOURCING

The project must incorporate place-based solutions and contribute to the expansion of a regional economy rooted in sustainable practices, products and services. Manufacturer location for materials and services must adhere to the following restrictions:

- *20% or more of materials construction budget⁵¹ must come from within 500 km of construction site.*
- *An additional 30% of materials construction budget must come from within 1000 km of the construction site or closer.*
- *An additional 25% of materials construction budget must come from within 5000 km of the construction site.*
- *25% of materials may be sourced from any location.*
- *Consultants must come from within 2500 km of the project location.*

—Living Building Challenge 3.0

Using the Living Economy Sourcing Calculator, a project team should begin building a conceptual cost estimate and materials list early in the design process to determine how close their design is to meeting this Imperative. This conceptual materials list and estimate will need to be updated as the design becomes more defined and as actual

costs are assigned for each material. An integrated design process that includes the contractor early on to ensure that the conceptual estimate is accurate and the team is on track to meet the requirements is critical to meeting this Imperative.

⁵¹ Materials construction budget is defined as all material costs and excludes labor, soft costs and land. Declare products and salvaged materials may be counted at twice their value. Certain natural building materials may include labor cost in their calculation. Refer to the August 2014 Materials Petal Handbook for more information, pp. 34-38.



IMPERATIVE 14 NET POSITIVE WASTE

The project team must strive to reduce or eliminate the production of waste during design, construction, operation, and end of life in order to conserve natural resources and to find ways to integrate waste back into either an industrial loop or natural nutrient loop.⁵²

All Projects must feature at least one salvaged material per 500 square meters of gross building area or be an adaptive reuse of an existing structure.

The project team must create a Material Conservation Management Plan that explains how the project optimizes materials in each of the following phases:

- *Design Phase, including the consideration of appropriate durability in product specification*
- *Construction Phase, including product optimization and collection of wasted materials*
- *Operation Phase, including a collection plan for consumables and durables*
- *End of Life Phase, including a plan for adaptable reuse and deconstruction*

For all project types, there must be dedicated infrastructure for the collection of recyclables and compostable food scraps.

A project that is located on a site with existing infrastructure must complete a pre-building audit that inventories available materials and assemblies for reuse or donation.

—Living Building Challenge 3.0

FIGURE 31 Imperative 14: Diverted Waste Percentage Requirements

During construction, the project team must divert wasted material to the following levels:	
Material	Minimum/Diverted Weight
Metal	99%
Paper & Cardboard	99%
Soil & Biomass	100%
Rigid foam, Carpet & Insulation	95%
All others- combined weighted average	90%

To meet the strict diversion rate requirements required by the Net Positive Waste Imperative, project teams will need to follow one of two best practices. The first is requiring on-site separation of waste materials and working creatively to limit leftovers and waste. The other is working with a local recycling hauler to collect comingled waste from the project site and do

the sorting at their facility without mixing it with waste from other projects. This will ensure that the team is getting project specific numbers and that their efforts to limit jobsite waste are accurately recorded. This second method for handling construction waste may be the best option for urban projects with limited site area. In either case, the contractor will either

⁵² Refer to the Materials Petal Handbook for calculation details, clarifications and exceptions.



need to maintain waste weight and tracking documentation themselves, or work with the materials consultant in order to document compliance with the Imperative.

The Material Conservation Management Plan should include a careful consideration of ways to reduce waste throughout all phases of a building's life. Many jurisdictions have required some level of construction waste management for years now, so that aspect of the requirement is more familiar, although the level of diversion required by this Imperative is high. Planning for materials optimization and waste reduction in the other three phases (design, operation, and end of life) is less common in the construction industry but an important step to reduce waste. Following an integrated design process is one way to ensure success with this requirement during the design phase. Bringing the architect, engineers (especially the structural engineer) and the contractor together early in the design process to consider ways to design the building to optimize material use is key. For example, ways to use the structure as finish can be explored, minimizing material use from the beginning. Optimal dimensioning of spaces can also be considered to limit the cutting of materials. One strategy currently employed by the South Second Street Studio pilot project is to use pre-fabricated assemblies to reduce on-site waste.

The requirement for salvaged materials should be seen as an opportunity to turn what is traditionally considered waste into a beneficial resource for the project. In addition, this may actually reduce project cost by limiting the amount of new material that needs to be purchased.

While the requirements are strict, a careful design process and a construction waste management plan that is diligently executed by the

contractor should make meeting this Imperative possible without significant additional cost in most markets.

BARRIERS & SOLUTIONS

Social Barriers

The largest impediment to meeting the Materials Petal is often a lack of understanding by the architecture, engineering and construction team. Project teams that are unfamiliar with materials research can be resistant to pursuing the Materials Petal because they are unsure how to estimate how much work is required, how to manage that work, and/or are concerned by the financial liability they may be taking on.

Social Solutions

To overcome this barrier, it is important to provide sufficient education to the project team to ensure all parties are familiar and comfortable with the materials requirements. If a project team is uncomfortable with the requirements of the Materials Petal, it is advisable to bring on an experienced materials consultant. The Institute can provide technical assistance if an experienced consultant is not available.⁵³

Regulatory Barriers

The traditional design-bid-build process and requirements that force teams to work with a low-bid contractor can be a significant impediment to achieving the Materials Petal. Since contractors involved in this process are generally not involved early in the design process, complying with The Challenge can be overwhelming. In this scenario, contractors have an incentive to substitute as many low-cost materials as possible to make a profit. In fact, in some states, such as Minnesota, contractors are legally allowed to make substitutions if they can prove they are choosing a more durable selection.

⁵³ International Living Future Institute, <http://living-future.org/living-building-challenge/tools-support/technical-assistance>



Regulatory Solutions

Bringing in the contractor early so that they are involved in the design process is a solution that will allow the contractor to be engaged with the Living Building Challenge philosophy and strategies as they are decided. It also gives the contractor a chance to bring their team up to speed with the goals of The Challenge. There are many construction contracting methods that allow the contractor to participate early in the design process such as construction management at risk or design-build contracting.

Financial Barriers

While it is often assumed that the Materials Petal will require an increase in material hard costs, it is the experience of many project teams that while the research does take more time and effort, hard costs are not necessarily increased. While replacing certain materials common to affordable housing such as laminate countertops (which currently contain formaldehyde), upgrading to FSC wood, or upgrading to fiberglass windows do involve additional costs, most other compliant materials are not any more expensive than their alternatives. The additional expense will be to fund either a dedicated materials consultant or to account for additional research time from the design team.

Financial Solutions

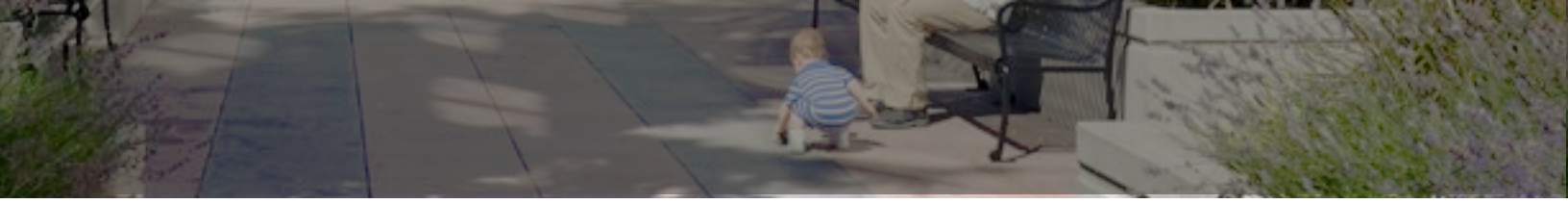
In the short term, targeted foundation support may be necessary to conduct the research necessary to identify compliant materials and overcome hard cost increases for specific items. However, one project conducting this research and then sharing it with the broader affordable housing community would significantly reduce research time for future projects. Overall advocacy from major players in the industry could also help to quickly change the marketplace because when more compliant products are available, less research is required to find them. Appendix I contains a template letter that any

affordable housing developer or architect can use to advocate to suppliers, letting them know that transparency and toxic chemical avoidance will determine their future material decisions. In this way, developers and project teams can leverage their purchasing power to have a significant impact on the market for healthy materials even if they are not actively engaged in a Living Building Challenge project.

CONCLUSION

Changing the materials marketplace and defining a new standard in affordable housing design that prioritizes human health, environmental benefit, and local economic benefit is critical for ensuring that healthy spaces are provided for affordable housing residents that benefit the local community. Pioneering Living Building projects across the world have already begun to make significant inroads in the market. Project teams report that the time to research and identify a compliant product has decreased from over twenty hours in 2010 to fewer than five hours per product today—and this number is continuing to decline. Public Living Building Challenge materials lists, as noted in the Materials Resource section and in Appendix H, are further driving down the research learning curve. Declare and other transparency programs are pushing manufacturers to change their product formulations and embrace transparency. The affordable housing industry has the potential to play a major transformative role in this process.

While hard costs and soft costs may be increased in the short term, a pioneering team could make a dramatic impact on this industry, ensuring healthy, safe homes for our communities' most vulnerable populations.



MATERIALS PILOT PROJECT

The Rose

Innovator Organization: Aeon
Minneapolis, MN

DESIGN APPROACH TO MATERIALS SELECTION

Aeon and Hope Community used Enterprise Green Communities Health criteria as the baseline in materials selection, with the Materials Petal of the Living Building Challenge as the ultimate goal. When it became clear that the project team did not have time or budget to meet all of the requirements of the Materials Petal, the development team decided to focus primarily on



Red List compliance of interior finish materials because they had the greatest potential impact on resident health. The team identified 41 potential materials and products to investigate for selection of Red List compliant alternatives. Items were ranked in order of magnitude of impact based on volume (drywall, for example, ranked high) and known toxicity (for example, paints and sealants ranked high because they typically contain high levels of VOCs). The Institute provided technical assistance and materials lists from other Living Building projects to assist the project team in their research process.

Some notable Red List compliant products specified in the Rose include:

- Paint (in dwelling units and common areas)
- Drywall
- Hallway carpet
- Common area light fixtures: LED
- Windows: Non-PVC fiberglass windows

Note: As of publication, the Rose was making final decisions regarding which materials to prioritize as Red List compliant.

BARRIERS & POSSIBLE SOLUTIONS TO RED LIST COMPLIANCE

As mentioned previously, some Red List compliant materials may have increased first costs due to actual higher prices or contractors raising prices to use materials they are unfamiliar with. Either way, the increased first costs can be hard for some affordable housing projects to incorporate. However, in the case of the Rose, Aeon received large grants from two foundations to support the incorporation of Red List compliant materials. Unfortunately, the project was bid during a very high volume construction period in Minneapolis, and the construction bid came back significantly higher than expected. The grants funds that were intended to cover the increase in materials hard costs associated with meeting the Red List were necessary for other items within the bid, in particular the advanced VRF system that was integral to the project's energy goals.

Below is a list of the cost premium associated with installing various Red List compliant materials instead of the lower cost baseline material per the construction bid that the Rose project team secured.

- Replacing laminate countertops with Ice-Stone: \$175,000/ with Caesarstone: \$120,000
- Replacing standard cabinetry with FSC-cer-



tified Columbia Forest Products Purebond: \$441,000 (due to an increase installation cost, not actual material hard costs)

- Replacing vinyl sheet flooring in bathrooms with tile: \$300,000
- Replacing vinyl composite tile throughout dwelling unit with Forbo Marmoleum: \$208,000
- Replacing standard wood for the structure for FSC-certified wood: \$850,000 (a significantly greater upcharge for FSC than reported by other construction markets)

In total, the cost premium for the Red List compliant materials versus a low-cost baseline in the bid was nearly \$3 million. Again, this was in an extremely busy construction market. The team believes that if the project had been bid two years earlier in a recession market, the \$3 million foundation grants would have been more than enough to cover the full cost of an upgrade to Red List compliant materials. The project team is still working hard through the construction process to include as many healthy materials as possible and plans to upgrade materials using the project's contingency as the budget allows. In fact, the project recently received another \$600,000 for products that do not have a cost-competitive option that comply with the Red List.

CONCLUSION & LESSONS LEARNED

The Rose has demonstrated that although Red List compliant materials are becoming more commonplace and cost-competitive, there are likely to be some hard and soft cost increases attendant to meeting the requirements compared to standard affordable housing design. Projects need to build these hard cost increases into their project budgets or continue to seek foundation support to offset hard cost increases

outside their budgets until these materials and practices become more standard practice across the industry.

Besides the health benefit of Red List compliant materials, many of the upgrades from a low-cost baseline also improve durability and performance. For example, fiberglass windows have a significantly longer life span than PVC windows, and solid surface countertops and linoleum are also more durable than laminate or VCT flooring.

Although this project will likely fall short of certification, by helping to develop a standard Red List compliant materials specification and identifying the significant cost drivers, the project has paved the way for the next pioneering affordable housing project to prioritize occupant health and eventually achieve the Materials Petal.



MATERIALS RESOURCES

Brain Trust

Publicly available materials list from Challenge projects are posted to the Brain Trust on the Living Building Challenge Community. A subscription to the Community is required to access the Brain Trust. ilbi.org/action/community/brain-trust/lbc-project-materials-lists

Declare

Declare™ is a “nutrition label” and online database for building materials, providing manufacturers with a clear, elegant and informative pathway for disclosing the ingredients within their products. Project teams are encouraged to select products through Declare to ensure they meet Living Building Challenge Materials requirements. If a suitable product cannot be found in Declare, project teams can streamline the process of materials research, selection, and documentation by requesting that a manufacturer list their products in Declare.

declareproducts.com/

BuildingGreen

BuildingGreen offers information and resources to help design and build construction projects from a whole-systems perspective and take an integrated design approach that minimizes ecological impact and maximizes economic performance. The BuildingGreen Website offers a wide variety of articles on the health and environmental impact of building materials.

.buildinggreen.com/

GreenSpec

BuildingGreen also operates GreenSpec, which lists over 2,600 green building products, selected by the editorial team based on our independent research assessing manufacturer claims. GreenSpec is a useful starting point for projects attempting the Materials Petal.

greenspec.buildinggreen.com/about/greenspec

GreenWizard

GreenWizard offers thousands of design and construction professionals a comprehensive product management workflow and tools for project collaboration. GreenWizard enables the design and construction community to better manage products and projects, collaborate and assess compliance with the Living Building Challenge, simplifying the process for building healthy, sustainable and efficient construction projects.

.greenwizard.com/

Pharos

The Pharos Project is an independent and comprehensive database for identifying health hazards associated with building products. Pharos has integrated the Living Building Challenge Red List so that a project team can identify Red List free products. This resource is a useful starting point for materials research.

pharosproject.net/dashboard/



PETAL OPPORTUNITIES





The remaining four Petals of the Challenge are less difficult to achieve than Energy, Water and Materials, and align closely with the values and goals of affordable housing projects in general. These four Petals offer opportunities to increase the social and environmental benefit of a project with limited additional cost and effort. As opposed to the technical nature of the Energy, Water and Materials Petals, the Place, Health & Happiness, Equity and Beauty Petals take a human-centered approach to how our health, behavior, local ecology and community are affected by the built environment.

These Petals reflect the necessity for humans to strengthen their relationships with the natural world and their communities.

The basic requirements of each Imperative within the remaining four Petals are explained below. In addition, one brief case study is included with each Petal to illustrate how meeting the Petal requirements can improve the quality and beneficial impact of a project for residents and the surrounding natural and human community.

PLACE PETAL

IMPERATIVE 01 LIMITS TO GROWTH

Projects may only be built on greyfields or brownfields.⁵⁴

IMPERATIVE 02 URBAN AGRICULTURE

The project must integrate opportunities for agriculture appropriate to its scale and density using the Floor Area Ratio (FAR) as a basis for calculation.⁵⁵

IMPERATIVE 03 HABITAT EXCHANGE

For each hectare of development, an equal amount of land away from the project site must be set aside in perpetuity through the Institute's Living Future Habitat Exchange Program⁵⁶ or an approved Land Trust organization.⁵⁷

IMPERATIVE 04 HUMAN POWERED LIVING

Each new project should contribute toward the creation of walkable, pedestrian-oriented community, and must not lower the density of the existing site.⁵⁸

—Living Building Challenge 3.0

⁵⁴ Refer to the August 2014 Place Petal Handbook, Imperative 01, for full requirements and clarifications, pp. 7-16.

⁵⁵ Refer to the August 2014 Place Petal Handbook, Imperative 02, for full requirements and clarifications, pp. 17-27.

⁵⁶ Refer to the August 2014 Place Petal Handbook, Imperative 03, for full requirements and clarifications, pp. 28-33.

More information on ILFI's Habitat Exchange Program can be found at www.living-future.org/exchange.

⁵⁷ Refer to the August 2014 Place Petal Handbook, Imperative 04, for full requirements and clarifications, pp. 7-16.

⁵⁸ Refer to the August 2014 Place Petal Handbook for information on Land Trusts, for full requirements and clarifications, pp. 30, 33.



The Limits to Growth Imperative represents the chance to rejuvenate an existing site and protect ecologically sensitive areas that are often affected by sprawl. Meeting the Urban Agriculture Imperative provides amenities for residents that promote community interaction while providing access to healthy, locally grown food. Residents will also benefit greatly from being located near basic amenities and services within a pedestrian-oriented community.

features include a 6,000 gallon cistern, a 32 kW photovoltaic array that is individually metered, permeable surfaces for water infiltration, and narrow units to maximize natural daylighting and operable windows.



PLACE CASE STUDY

Rag Flats
Philadelphia, PA

Completed in 2006, Rag Flats includes eleven dwelling units constructed on a greyfield in the heart of the Fishtown neighborhood of Philadelphia. Co-owners of Onion Flats, Tim and Pat McDonald, chose the abandoned site of an industrial rag company and envisioned a garden community that challenges the idea of private versus public space. Rag Flats has a Walk Score of 89 and a Bike Score of 93, providing access to the city's amenities through human-powered and public transportation. Some of the project's other green



HEALTH + HAPPINESS PETAL

IMPERATIVE 07 CIVILIZED ENVIRONMENT

Every regularly occupied space must have operable windows that provide access to fresh air and daylight.⁵⁹

IMPERATIVE 08 HEALTHY INTERIOR ENVIRONMENT

To promote good indoor air quality, a project must create a Healthy Interior Environment Plan that explains how the project will achieve an exemplary indoor environment.⁶⁰

IMPERATIVE 09 BIOPHILIC ENVIRONMENT

The project must be designed to include elements that nurture the innate human/nature connection. Each project team must engage in a minimum of one all-day exploration of the biophilic design potential for the project.⁶¹

—Living Building Challenge 3.0

Operable windows and other passive ventilation strategies do not just decrease HVAC energy use, they also improve occupant comfort by allowing occupants control over their environment. Occupant health and comfort are at the forefront of the Healthy Interior Environment Imperative. Zero- and low-VOC materials coupled with indoor air quality testing can reduce rates of

asthma and other airborne illnesses. Incorporating biophilic elements can reduce stress and improve brain function and productivity while promoting a greater connection to the natural world. The combination of these three Imperatives can significantly improve occupant health and well-being for our most vulnerable populations through intelligent design with limited additional cost.



HEALTH + HAPPINESS CASE STUDY

Jazz at Walter Circle East St. Louis, IL

Designed by Farr Associates, Jazz at Walter Circle is home to 74 affordable housing units for senior citizens. The ground floor features a grocery store, promoting community interaction and providing an important amenity for the aging residents. Each residential unit features an operable french door and planter boxes for in-unit resident gardening. By providing a large outdoor terrace space on each floor for large-scale gardening and community events, each floor acts as its own neighborhood, providing residents another opportunity to access fresh air and interact with their neighbors.

⁵⁹ Refer to the August 2014 Place Petal Handbook, Imperative 04, for full requirements and clarifications, pp. 34-39.

⁶⁰ Refer to the August 2014 Health & Happiness Handbook, Imperative 07, for full requirements, clarifications, exceptions and information regarding minimum requirements for windows, pp. 5-9.

⁶¹ Refer to the August 2014 Health & Happiness Handbook, Imperative 08, for full requirements, clarifications, biophilic workshop goals and tracking methods, pp. 20-23.



EQUITY PETAL

IMPERATIVE 15 HUMAN SCALE + HUMANE PLACES

The project must be designed to create human-scaled rather than automobile-scaled places so that the experience brings out the best in humanity and promotes culture and interaction. In context of the character of each Transect, there are specific maximum (and sometimes minimum) requirements for paved areas, street and block design, building scale and signage that contribute to livable places.⁶²

IMPERATIVE 16 UNIVERSAL ACCESS TO NATURE + PLACE

All primary transportation, roads and non-building infrastructure that are considered externally focused must be equally accessible⁶³ to all members of the public regardless of background, age and socioeconomic class—including the homeless—with reasonable steps taken to ensure that all people can benefit from the project's creation. The project may not block access to, nor diminish the quality of, fresh air, sunlight and natural waterways for any member of society or adjacent developments.⁶⁴

IMPERATIVE 17 EQUITABLE INVESTMENT

For every dollar of total project cost, the development must set aside and donate half a cent or more to a charity of its choosing or contribute to ILFI's Equitable Offset Program, which directly funds renewable infrastructure for charitable enterprises.⁶⁵

IMPERATIVE 18 JUST ORGANIZATIONS

The project must help create a more JUST, equitable society through the transparent disclosure of the business practices of the major organizations involved.⁶⁶

—Living Building Challenge 3.0

62 Refer to Living Building Challenge 3.0 for design guidelines, p. 53.

63 Refer to the future Equity Petal Handbook for requirements and a complete list of applicable infrastructure and exceptions that address issues of safety.

64 Refer to the Living Building Challenge 3.0 for the entire list of requirements

65 Note: Project cost includes land, soft costs, hard costs and FFE. The Charity must be located in the country of the project and be a registered charity or 501c3. Projects may choose to split the offset as desired between multiple charities or ILFI's offset program. Public agencies and charitable organizations are exempt from this requirement.

66 Refer to the Living Building Challenge 3.0 for JUST Label requirements, p. 57.



The Equity Petal is at the center of why achieving the Living Building Challenge for affordable housing is so critical to creating a just and equitable society. True sustainability can only be achieved if the movement embraces all sectors of humanity, no matter the background, income, age, class or race. Non-profit developers are excluded from the Equitable Investment requirement of the Equity Petal since their investments are already meeting the intent of the Imperative. In fact, the Institute's Equity Offset Program is intended to provide low-income housing developers with additional sources of financing for renewable energy infrastructure.

EQUITY PETAL CASE STUDY

McDermott Place Apartments Seattle, WA

Developed by the Low Income Housing Institute (LIHI), and designed by Schemata Workshop and Runberg Architecture Group, this 60,000-square-foot, six-floor, mixed-use building provides 76 units of housing for homeless veterans. Designed to be attentive to the occupants' needs, both social and mental health services are offered on-site. The Lake City Food Bank's queuing space is easily accessible through McDermott's parking garage. By siting the project within walking distance of 20 restaurants, and multiple parks, schools and grocery stores, the project promotes a healthy, active lifestyle and social interaction for residents.





BEAUTY PETAL

IMPERATIVE 19 BEAUTY + SPIRIT:

The project must contain design features intended solely for human delight and the celebration of culture, spirit and place appropriate to its function and meaningfully integrate public art.

IMPERATIVE 20 INSPIRATION + EDUCATION

Educational materials about the operation and performance of the project must be provided to the public to share successful solutions and to motivate others to make change.

—Living Building Challenge 3.0

The Beauty Petal serves not only to elevate the spirit and beauty of a particular place, but also to highlight the necessity of designing spaces that become cherished community resources. Thoughtful consideration to how every square meter of the project will elevate the human spirit will provide residents a sense of pride in and affection for the space. Education programs can expand the impact of the development to the broader community and turn each project into a center for inspiration and education about regenerative design.¹

BEAUTY PETAL CASE STUDY

zHome
Issaquah, WA

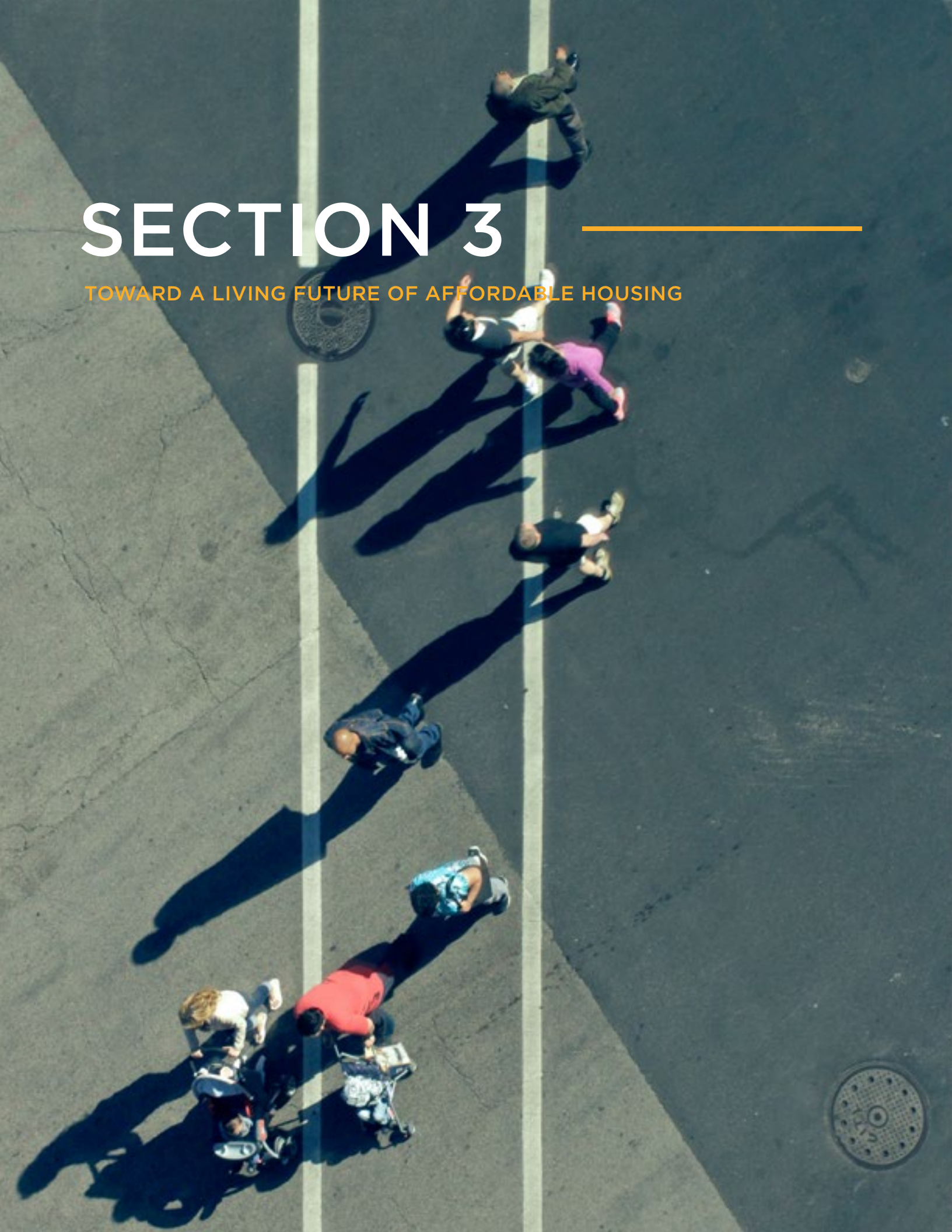
zHome is the first multi-family building to achieve the Net Zero Energy and Petal Certification. Developed by the City of Issaquah, the 10 townhouses offer many innovative strategies to reach Net Zero Energy and a 30% reduction in water use. To address Beauty, zHome seamlessly integrates rain gardens, seating and curved pathways into a landscaping plan with herbs and native species. The beautiful landscape design not only benefits the zHome residents, it is also an amenity for the neighboring YWCA Family Village, an affordable housing development comprising 146 permanent units. One of zHome's units also functions as an education facility offering regular tours. In the first year of occupancy more than 10,000 visitors toured and learned about the impact of zHome, an inspiring example of the possibilities of the Living Building Challenge in multi-family design.



¹ Philadelphia Generocity Blog, <http://www.generocity.org/raise-of-hope/>.

SECTION 3

TOWARD A LIVING FUTURE OF AFFORDABLE HOUSING





Affordable housing is a key leverage point in developing equitable and resilient communities in the face of climate change, growing income inequality and continued urbanization in North American cities. People from all income brackets should have access to safe, healthy and environmentally sound homes. The Living Building Challenge offers a clear framework to achieving these goals while enhancing a project's community and environmental benefit.

Through collaboration with the Living Affordable Housing Innovators Network, this report demonstrates a pathway for affordable housing projects to achieve the Living Building Challenge Full or Petal Certification in each of the climate zones presented, though significant challenges remain. This report concludes that the rigid financing structure of the affordable housing tax credit allocation system, which over-emphasizes first cost, continues to be the largest hurdle to the uptake of the Living Building Challenge in this market. Regulatory requirements, particularly energy regulations limiting the size of distributed power systems and water regulations preventing on-site water collection and treatment, also continue to impede progress. Overcoming these barriers will require a combination of innovative project-specific strategies combined with long-term and coordinated action by key partners in the industry.

ENERGY

The Net Positive Energy modeling presented in this report demonstrates that it is possible to meet the Energy Petal through deep energy reduction (49-73%) below the standard baseline for multi-family projects. Since energy efficiency strategies will be different in each region, climate-appropriate designs will need to be developed for each major climate zone. Meeting the Energy Petal offers an important opportunity to reduce tenant energy bills and improve their financial security as well as strengthen the cash flow of the developers. Unfortunately, first cost concerns and utility regulations continue to impede adoption of large-scale arrays while utility polices continue to prevent projects from capturing the full economic benefit of the energy they produce.

New financing models using solar leasing arrangements, net metering, or solutions that tie federal solar incentives to the Low Income Housing Tax Credit can help overcome the first cost barrier. Scale Jumping and community solar gardens are also effective solutions if utility regulations restrict an array's size. Developers that have been successful in overcoming financial barriers for solar integration should share their strategies across the industry to facilitate widespread adoption of distributed power generation. Further, coordinated action will be necessary to promote utility incentive programs and advocate for net metering so that projects can capture the full economic benefit of their on-site energy production. Distributed solar generation costs are decreasing rapidly, so projects that do not have the ability to incorporate on-site solar should be designed to be Net Positive Ready to take advantage of on-site solar as the economics improve.

WATER

The Net Positive Water modeling work presented in this report demonstrates that it is technically feasible for affordable housing projects to achieve the supply side requirements of the Net Positive Water Imperative by using a rainwater collection cistern sized appropriately for the climate zone and employing conservation strategies that reduce water consumption to 15-20 gcd. Since tenant wa-



ter consumption varies only slightly by climate zone, meeting this water reduction target should be possible in all climate zones.

However, regulatory as well as financial barriers continue to impede progress on achieving the treatment requirements of the Net Positive Water Imperative. Given the current financing and water utility paradigm, the Institute has created a temporary alternative compliance pathway that will allow affordable housing projects to connect to a municipal sewer for black water treatment. This compliance path acknowledges that on-site black water treatment is not currently feasible for affordable multi-family housing. It offers a pathway to certification for projects that rewards teams that push significantly beyond best practice and incorporate rainwater collection and reuse, as well as grey water recycling and treatment. Regulatory barriers that prevent rainwater collection and on-site grey water treatment will still need to be overcome in many jurisdictions. Each project's advocacy for the change of these regulations in their community will continue to be important tools to implement larger systemic regulatory reform.

MATERIALS

Meeting the Materials Petal will have important health benefits for affordable housing residents in an industry that has a history of substandard materials. Furthermore, given the huge volume of affordable housing projects produced each year, meeting the Red List Imperative in the affordable housing market has the potential to significantly reduce the overall amount of toxins released into the environment. However, the additional soft costs for research and documentation and the hard costs for replacing specific materials compared to a low cost affordable housing baseline continue to make meeting the Red List Imperative, and the Materials Petal overall, a challenge in the current market.

An integrated design process for the Materials Petal is critical to reduce impact on a project's construction schedule and budget. Standard materials lists that meet Living Building Challenge Red List requirements, such as the compliant list provided in this report, will reduce time and cost. Compliant materials lists should be shared across the industry to reduce research time for each project and build momentum and awareness for healthy sustainable building materials in the industry. Coordinated healthy material purchasing across the industry will also help to bring down the cost with the potential to transform the materials market overall.

PLACE, HEALTH & HAPPINESS, EQUITY AND BEAUTY PETALS

The remaining Petals within the Living Building Challenge are not only less difficult to achieve than the Energy, Water and Materials Petals, they offer important opportunities to elevate the social and environmental performance of affordable housing projects. These Petals take a human-centered approach to design and strengthen residents' relationships to each other, their broader community, and the natural world.



A PATH FORWARD

Developing groundbreaking models of regenerative design for the affordable housing industry should continue to be a primary goal of the Living Affordable Housing Innovators Network. One model project can have a large ripple effect in its local market and across the industry. The three pilot projects presented in this report have overcome significant challenges and demonstrated that previously unheard of levels of performance are possible today. These pilot projects serve as a pivotal step forward by sharing their deep green strategies and important lessons learned based on facts on the ground. The Institute will continue to support the industry by providing technical support to five additional affordable housing projects over the next year.

In the short term, targeted foundation support to overcome the first cost associated with on-site renewable energy, alternative water systems and additional materials costs may still be necessary. In the long-term, advocacy to retool the investment decision-making framework of the Low Income Housing Tax Credit system must be pursued to ensure that affordable housing financing is aligned with the long term social and environmental benefits of regenerative design. Just as Enterprise Community Partners was able to demonstrate the economic benefits of their Green Communities Criteria through their report, *Incremental Cost, Measurable Savings*, the Institute should begin to research and quantify the long-term social, environmental and economic benefits of regenerative design in affordable housing as more projects are developed that can be analyzed.

There is precedent for changing the affordable housing tax credit allocation system when a convincing argument is presented to state housing agencies. Green building criteria are now included in 75% of all housing agency's financing requirements, and over 20 states have adopted the Enterprise Green Communities Criteria. The hard work of Enterprise Community Partners and other green affordable housing organizations has now paved the way for future legislative changes that prioritize the regenerative design principles within the Living Building Challenge.

While the challenge is great, the opportunity is greater: Living Affordable Housing can be the foundation of our nation's transition to a truly sustainable, resilient and equitable society. The Institute urges all parties in the affordable housing industry to take advantage of the resources and tools provided by the *Living Building Challenge Framework for Affordable Housing* to encourage the creation of healthy, regenerative affordable housing projects that can serve as focal points for social, environmental and economic transformation in our communities.



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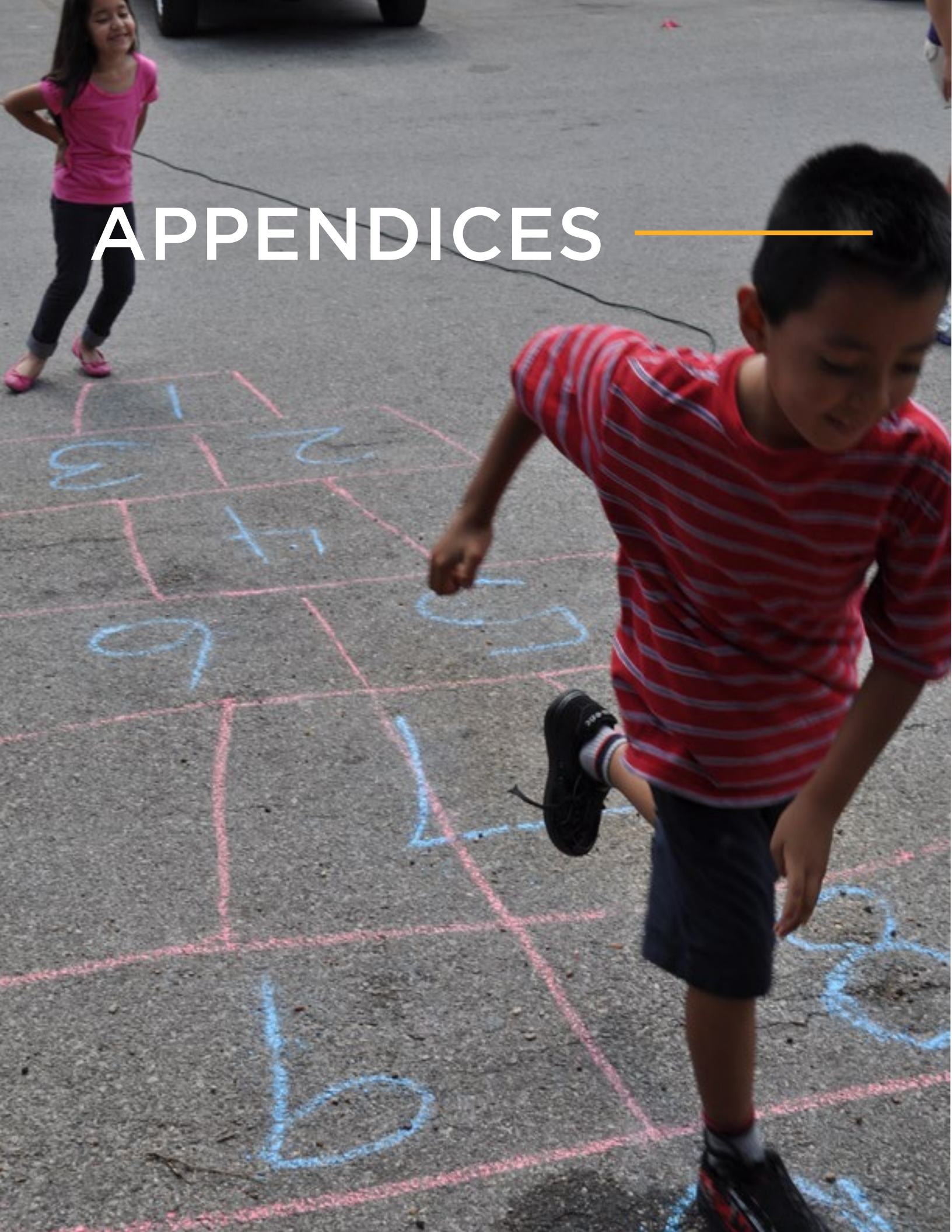
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APPENDICES





APPENDIX A

An Introduction to Low Income Housing Tax Credits in the United States

The United States Department of Housing and Urban Development (HUD) and a number of other governmental agencies provide financing for affordable housing and subsidies that are then used by a largely private group of affordable housing developers to provide a steady stream of subsidized housing. Low Income Housing Tax Credits now comprise over 90% of affordable housing created in the United States and are responsible for funding nearly all multi-family affordable projects. Most affordable housing projects also receive subsidies from other government programs. These include grants and below-market rate loans from state and local governments, as well as Section 8 housing vouchers that place additional regulatory restrictions on projects. Private foundations also offer affordable housing support, but to a lesser extent.

While nearly 75% of housing finance agencies require or incentivize green practices, this financing system generally places an emphasis on providing the greatest amount of affordable housing at the lowest cost. While implementation varies from state to state, these allocation systems tend to focus largely on first costs, rather than the long-term social, environmental and community benefits of a project. Further, the time limit on spending credits imposed on an affordable housing developer creates schedule pressures on projects that can make it difficult to follow an effective, integrated design process.

The structure of this incentives process, while very successful in creating a competitive, market-based solution for promoting the development of privately managed affordable housing, presents a unique challenge to achieving sustainability goals. However, since the affordable housing financing system exists outside normal market pressures of private development, it also presents an opportunity to retool the investment decision framework to work for long-term environmental and economic benefit. In fact, the Enterprise Green Communities Criteria have now been adopted by more than 20 states as requirements for allocation of Low Income Housing Tax Credits (LIHTCs). The work that Enterprise Green Communities has done to tie state incentives policies to their green building criteria can be a model for future work to break down financing barriers and encourage the creation of Living Buildings.

ALLOCATION

LIHTCs are allocated through a competitive process. In general, credits are allocated to projects that serve the most, lowest-income tenants, for the longest period of time. Projects are specifically evaluated through a “point system.” While lowest-income tenants provide the most points, there are other factors such as building methods, partnership characteristics, amenities (public transit, distance to schools, libraries, parks, etc.) and geographic distribution that can also contribute to overall points. There is also a certain percentage of “set-aside” tax credits (~10-30%) to be used only for certain groups such as non-profits, rural developments, or at-risk developments, but this varies state by state. Tax credits are awarded at different times of the project development stage depending on the state, but often not until completion of the project. In Virginia, credits can be awarded one to two years before project completion if requirements are met. In Minnesota, tax credits are not awarded until after evaluation of three stages: 1) time of initial application 2) acceptance of project 3) time project is placed in service.



APPENDIX B

Sample Integrated Design Charrette

SCOPE OF WORK:

- Facilitate and plan a one- or two-day charrette for up to 30 people.
- The goal of the charrette is to explore and understand potential issues and opportunities to achieve high environmental performance, and help to define strategic goals that can inform the fundamental direction for the project. The information shared and the understanding gained by the participants is the most important product of the day.
- An agenda is proposed below as a draft and can be modified by mutual agreement.
- Major charrette instruments (such as easel pads, markers, projector etc.) to be supplied by the project team. We will provide a list one week prior to the charrette.

SUGGESTED CHARRETTE AGENDA OUTLINE:

DAY ONE:

INTRODUCTION (30 MINUTES)

Welcome, introductions, agenda overview

REVIEW OF THE LIVING BUILDING CHALLENGE (1 HOUR)

A presentation about the philosophy of the program

PROJECT BACKGROUND (1 HOUR)

The project leaders present site context and the proposed team process for the project.

PETAL EXPLORATION (2 HOURS)

Interactive dialogue to assess and agree about the goals and intent for each petal.

CONVENING (2 HOURS)

Small breakout groups. Explore each petal in smaller circles to identify in greater detail how goals could be realized.

SHARING (45 MINUTES)

Reconvening of all participants to summarize the ideas and goals discussed during Convening.

NEXT STEPS (15 MINUTES)


List of next steps and responsibilities.

DAY TWO (OPTIONAL)

RECAP OF DAY ONE (15 MINUTES)

Opportunity to add goals, re-prioritize and offer fresh thoughts

STRATEGY DEVELOPMENT (3 HOURS)



Break into Petal groups and examine potential strategies around each goal and Imperative. Report back to the group.

IMPERATIVE ACTION STEPS (1 HOUR)

Develop as a group the tasks, timeline and responsibilities for each Imperative.

CLOSING (15 MINUTES)

Thoughts and reflections. Determine responsibilities.

SUGGESTED CHARETTE PREPARATION MATERIALS

Charrettes are most successful when teams have prepared information beforehand that can allow the charrette participants to come to informed conclusions. A suggested list follows:

- A complete eco-system study for a 1 km radius of the site that assesses existing and pre-development flora, fauna, geography, geology, microclimate and sensitive habitats.
- Site analysis diagrams that outline important site features.
- Soils analysis, percolation ability
- Solar and wind potential of the site
- Existing utilities/services information
- Site plans and images
- Proposed project space program or existing building analysis
- Site history from pre-human settlement to present day
- Neighborhood density and occupancy analysis for a 1 km radius.

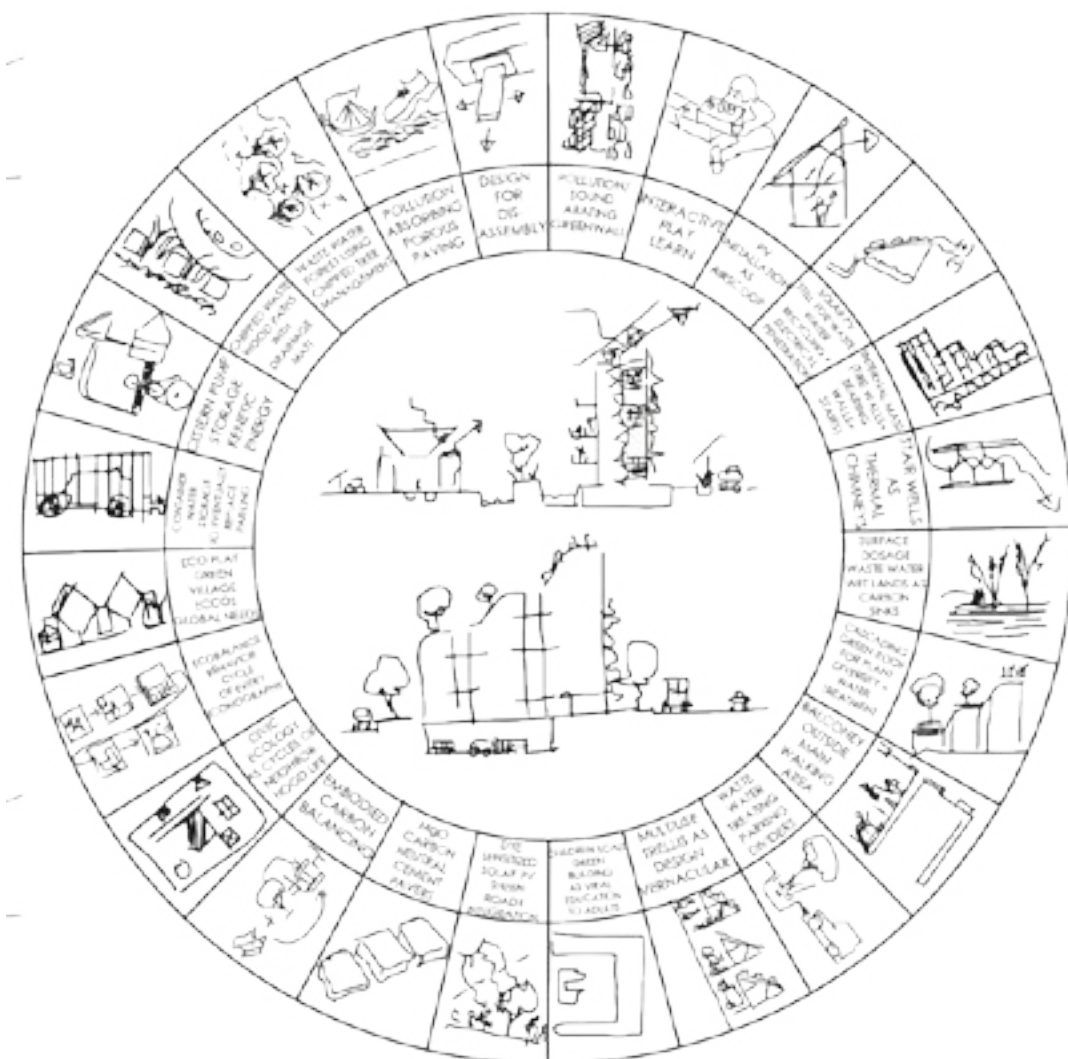
APPENDIX C

Building for People & Community Diagram

The Center for Maximum Potential Building Systems
Exploration of the Living Building Challenge
Austin, TX

The wheel below illustrates an approach to understanding all the interconnected elements and potential strategies of a multi-family building targeting the Living Building Challenge. Simple line sketches paired with descriptive verbiage have the potential to communicate clearly to the various different learning types on the project team, enhancing the whole-team understanding of an idea or process for a given strategy.

The Process Diagram (Courtesy of Pliny Fisk III, Center for Maximum Potential Building Systems)



APPENDIX D

CSBR Benchmarking Tool

A High Performance Sustainable Housing Survey 1.0 Pilot

Designed and tested by the Center for Sustainable Building Research (CSBR) at the University of Minnesota



Compare and share: What planning, design and programmatic strategies are contributing to the success of this project?



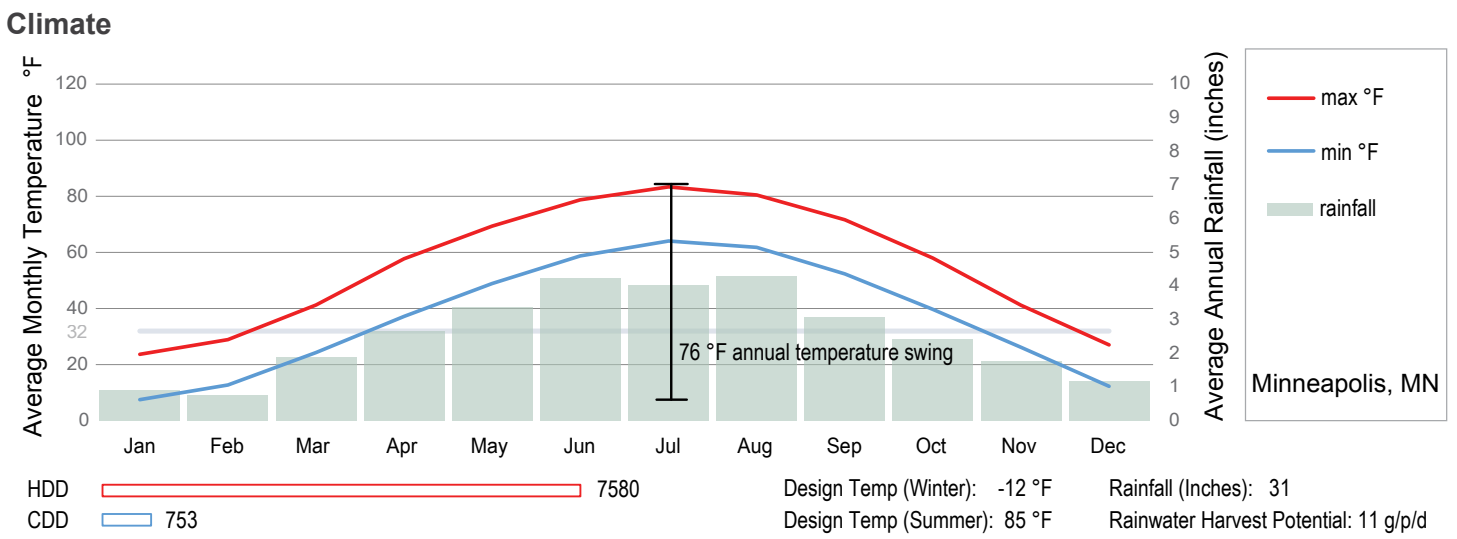
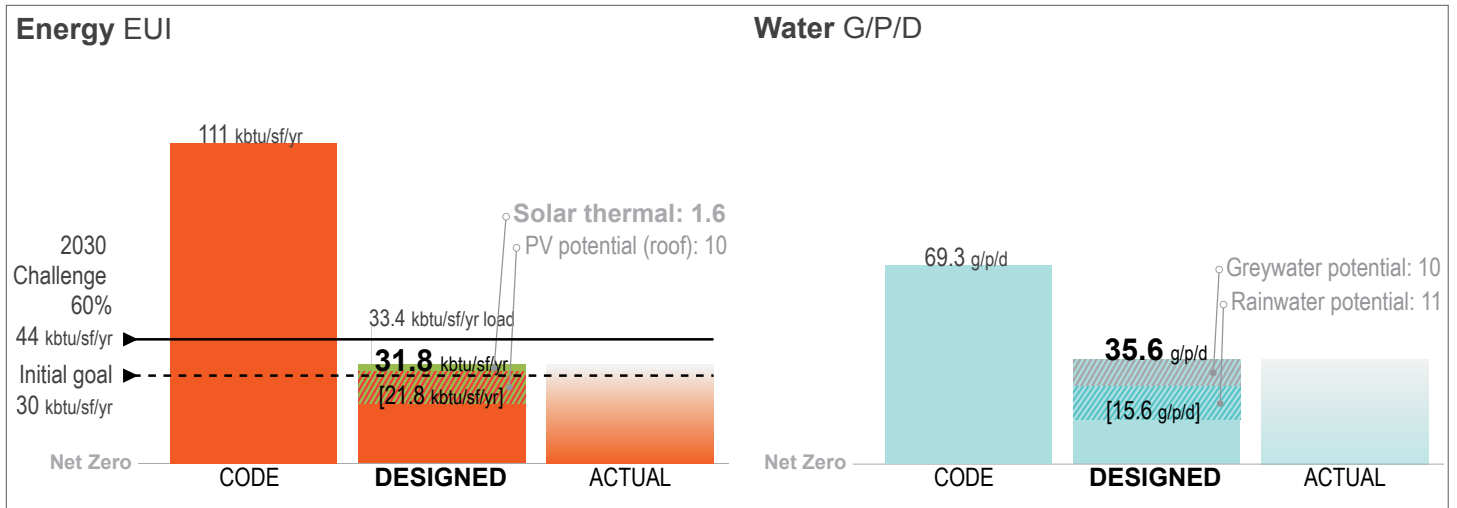
Minneapolis, MN
The Rose

Project Start: 2011
Construction Start: (Fall 2014)
Complete: (Summer 2015)

Developer(s): **Aeon**
Hope Community
Architect: **MSR**
GC: **Weis Builders**
Cost: **\$21.5 million**
Size: **150,000 sf**
Cost/sf: **\$148/sf**
Baseline: **\$110/sf**

Total Units: **90**
Unit Mix: **Studio, 30/60% AMI**
1-br, market
2-br, 30/50/60/market
3-br, 60% AMI
Parking: **Underground, surface**
FAR: **2.0**
Whole-building certification: **Living Building Challenge-inspired**

Target Population: **Families**
Public Funding Partners:
LIH Tax Credits 4%
LIH Tax Credits 9%
Community Dev Block Grant
Minnesota Housing Finance Agency



Energy

EUI per square foot: **31.8 kbtu/sf/yr**
per unit: **16,765 kbtu/unit**
PV potential of roof: **?**

Technologies: Solar thermal (50% of hot water load), VRF system

Priorities: Reducing heating/cooling costs, daylighting, solar control in habitable spaces (crucial), solar hot water, PV

Design Guide:

Equity Action: The goal is to lower the bills for residents while also saving the developer money. Focus on balancing indoor environmental quality better than code with overall cost was a success.

Notable Success: The building approaches the target set of 30 EUI by pairing conservation with an advanced VRF system. Solar thermal off-sets 1.6 kbtu/sf when modeled as a single action.

Water

G/P/D Indoor: 35.6 gal/person/day
Outdoor:

Technologies: Efficient fixtures, rain gardens and underground stormwater storage tubes with water filtration module to handle design 2-yr rain event of 2.75".

Priorities: Improving stormwater quality, reducing quantity of runoff

Design Guide: Enterprise Green Communities Site

Initial Goal: Original intent was to meet LBC Water Petal, but was limited by regulatory barriers regarding greywater collection and also prospect of first and ongoing maintenance costs.

Materials

Priorities: The team goal was to achieve a healthy IEQ by using materials that are non-toxic or less toxic wherever possible.

Design Guide: LBC Materials, Enterprise Green Comm.

Living Building Challenge: The approach to the Materials Petal focused primarily on interior finish materials with the greatest potential impact on resident health, including 41 potential materials and products investigated to find Red List Free alternatives. Items were prioritized based on volume (drywall, for example) and known toxicity (paint and sealants containing VOCs, millwork and countertops known to contain formaldehyde, etc). One intent of this approach is scalability--findings from this initial subset of materials can be incorporated and repeated throughout the entire building. Cost alternatives compared throughout specification process.

Health

Priorities: IEQ considerations in the use of materials; the location of the stairwell; other things like access to daylight, natural ventilation, etc.

Design Strategies: A centralized ventilation system feeds filtered fresh air into each unit. The site location at the junction of interstates I-94 and I-35W favored a central system that allows for better air quality control. Double-filtration system with MERV 8 and 11. Units have exhaust fans in the kitchen and the bathrooms. Building also addresses resident well-being through biophilic design elements. Feelings of personal safety are enhanced through the use of prospect & refuge in spatial configuration. The courtyard organizes the site formally and highlights the movement of light, air and water through site with seasonal variation. Designed for both children and adults, it utilizes natural forms and highlights the ecology of the site through the movement of water and variety of plantings.

Social Sustainability

Priorities: Key goals are redeveloping an urban infill site, close to a variety of neighborhood amenities and social services, with the intent of addressing concerns raised in the cultural audit --a community street-interview and photography project created by a journalist who was hired for the purpose--that was done before the project began.

Design Strategy: *What would be most useful?*

Demographic Information

<u>Neighborhood</u>	<u>City</u>
14%	17% ...single-parent households
10%	7% ...households; children under 6 yrs
6%	14% ...households with senior residents
x%	24% ...households; public assistance
x%	32% ...percent of residents "of color"
19%	x% ...percent residents with less than a high school degree
x%	x% ...percent of adults who are non-English speakers

Site

Priorities: Stormwater retention and filtration, and to some extent the use of native plantings.

Design Guide: Enterprise Green Communities Site

Design Strategies: Water quality is a big issue in MN, and stormwater retention can help with this. The City of Minneapolis has been working on a many-decade process of sewer separation to eliminate combined sewer overflow (CSO) into the Mississippi River during heavy rain events. However, due to difficulty and cost of replacement, eight CSO locations remain. The City is expanding storm sewer capacity. Building owners are required to disconnect any rainwater drainage into sanitary sewers and reroute water into onsite retention, infiltration, or on-street storm drains. Building owners are required to manage a 2.75" storm (or 2-year rain event) onsite.

Project Contact: Gina Ciganik, Vice President Housing Develop.
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Survey and project brief prepared by the Center for Sustainable Building Research, University of Minnesota. For more information contact William Weber, wwweber@umn.edu, (612) 625-0598



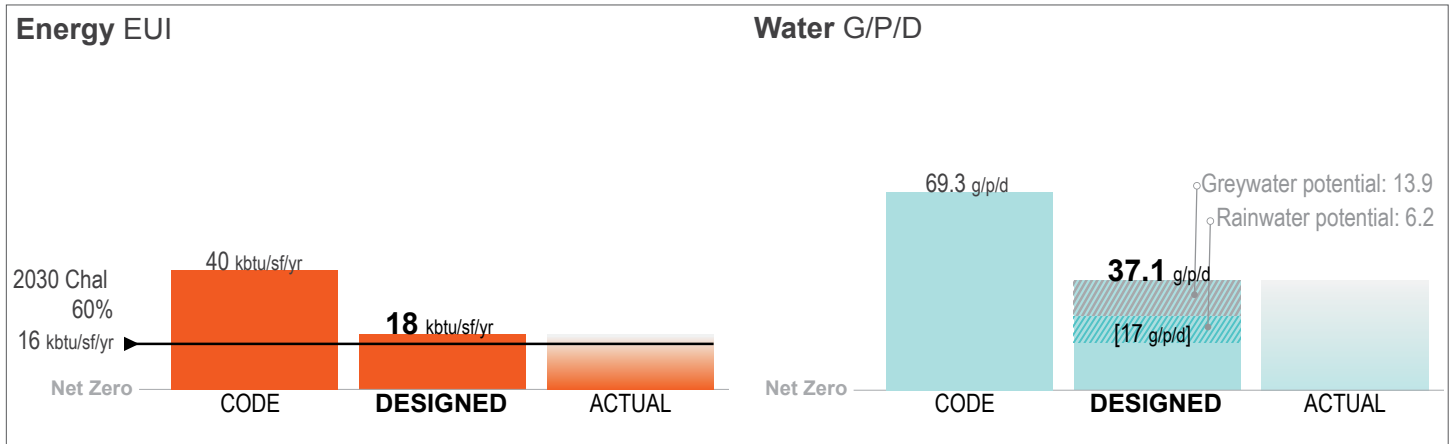
San Jose, CA
S. Second Street Studios

Project Start: 2008
 Construction Start: 2015
 Completed: 2016

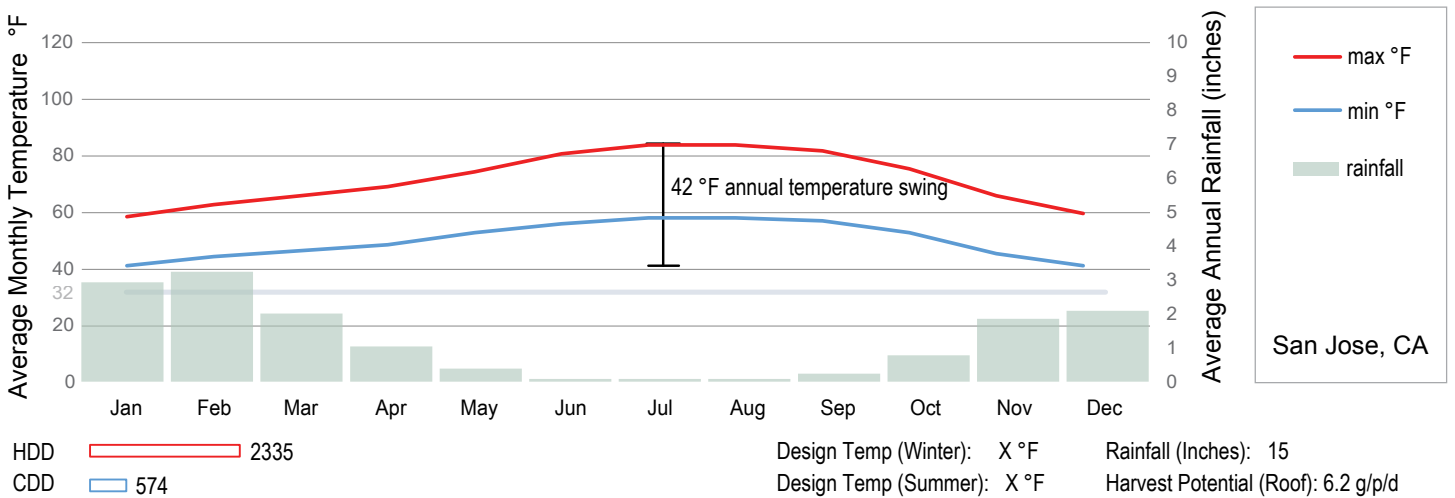
Developer: **First Community Housing**
 Architect: **Rob Quigley Architects**
 GC: **Branagh, Inc.**
 Cost: **\$32 million**
 Size: **91,021 sf**
 Cost/sf: **\$352/sf**
 Baseline:

Total Units: **135**
 Unit Mix: **1-br, 30/50/60% AMI**
2-br, 30/50/60% AMI
 Parking: **Underground**
 FAR: **1.80**
 Whole-building certification: **LEED for Homes Mid Rise: Platinum (target)**

Target Population: **SRO**
 Funding Partners:
 LIH Tax Credits 9%
 City of San Jose, AHP, IIG



Climate



Energy

EUI per square foot: **18 kbtu/sf/yr**
per unit: **12,136 kbtu/unit**
per bedroom: **204,797 kbtu/bedroom**
PV potential of roof: **?**

Technologies: Solar thermal(?) [Blower-door test, thermal bypass inspection]
Priorities: Reducing CO2 footprint, daylighting, orientation, solar control in habitable spaces, solar hot water
Design Guide: Net Zero Ready, HERS

Equity Action: Units are individually metered by the local utility, PG&E. Residents pay for their use and therefore directly benefit from the savings and reduced costs. We are investigating virtual net metering as an alternative pathway to distributing renewables to units as well as common areas (and bypass CA utility metering regulatory barriers).

Water

G/P/D Indoor: 37.1 gal/person/day
Outdoor:

Technologies:

Priorities: Stormwater runoff quality

Design Guide: LEED for Homes Mid Rise - Platinum

Design Strategy: 100% of stormwater retained on site (see Site)

Materials

Priorities: Life cycle impact, recycled content, human health, asthmagens, removal of VOCs

Design Guide: LEED for Homes CA 2010, LBC Materials

Living Building Challenge: The project's approach is more of a feasibility analysis of LBC certification for affordable multifamily rental housing. As such, we are seeking to be LBC "Ready"; we intend to meet whichever Imperatives possible, and deliver []

Equity Action: FCH has a long standing interest in the connection between green building and the health of residents, many of whom are most vulnerable to environmental health injustices. For instance, we have taken action to eliminate phalate exposure in units by using natural linoleum in place of VCT.

Health

Priorities: IEQ, asthmagens, pest management, controlling humidity, control of second-hand smoke

Design Guides:

-Biophilia informed one or more key aspects of the design

-The Center for Active Design's "Active Design Guidelines" informed one or more key aspects of the design

-The WELL Building Standard had a significant impact on design

Social Sustainability

Priorities: On-site and neighborhood amenities, mobility, safety, community identity, creating social networks, supporting social mobility

Design Strategy:

Demographic Information

<u>Neighborhood</u>	<u>City</u>
x%	x% ...households w/ senior residents
x%	x% ...households; children under 6 yrs
x%	x% ...households; public assistance
x%	x% ...percent of residents "of color"
x%	x% ...percent residents with less than a high school degree
x%	x% ...percent of adults who are non-English speakers

Site

Priorities: Native plantings, reduced irrigation, stormwater retention and infiltration, reduction of urban heat island effect

Design Guide: LEED for Homes Mid-Rise, LBC Site Petal SITES v2.0

Design Strategies: Living roof with native plants that attract pollinators; ornamental and permaculture/ productive foodscapes; drip irrigation, drought tolerant plants, passive harvesting; 100 percent stormwater retained on site; light roof, veg roof, light surfaces, street trees, living screens

Equity Action: Urban infill site with proximity to community services, transit lines, bike lanes, etc helps to reduce need for costly automobile ownership and maintenance.

Project Contact: Jeff Oberdorfer, Executive Director
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Survey and project brief prepared by the Center for Sustainable Building Research, University of Minnesota. For more information contact William Weber, wmweber@umn.edu, (612) 625-0598



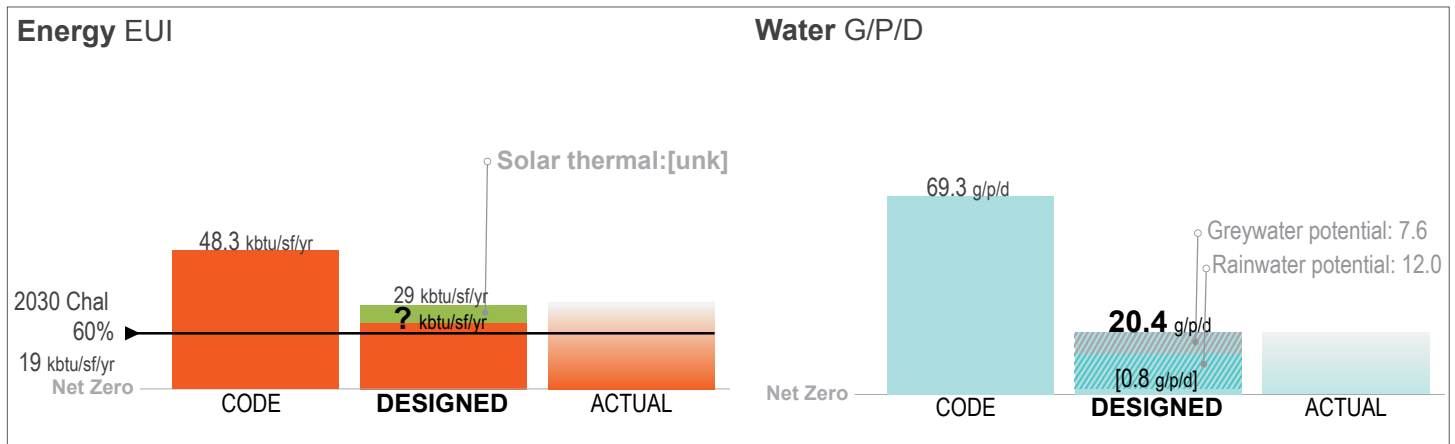
Austin, TX
Capital Studios

Project Start: 2012
Construction Start: 2013
Completed: 2014

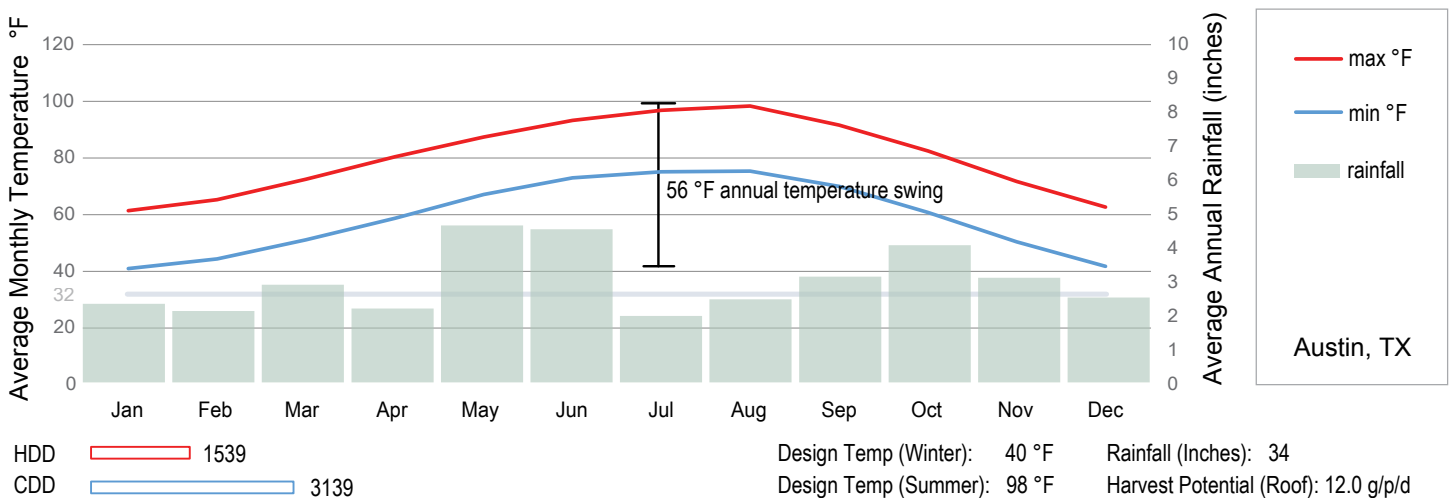
Developer: **Foundation Communities**
Architect: **Dick Clark Architects**
GC:
Cost: **\$16 million**
Size: **78,045 sf**
Cost/sf: **\$205/sf**
Baseline:

Total Units: **135**
Unit Mix: **Studio, 30/40/50% AMI**
Parking: **Structure, on-street**
FAR: **2.82**
Whole-building certification: **LEEDv4 for Homes Platinum (target)**

Target Population: **SRO**
Funding Partners: **LIH Tax Credits 9%**



Climate



Energy

EUI per square foot: **29 kbtu/sf/yr**
per unit: **16,765 kbtu/unit**
PV potential of roof: ?

Technologies: Solar thermal (50% of hot water load), VRF air-source heat pump system [Blower-door test, thermal bypass inspection]

Priorities: Reducing heating/cooling costs, daylighting, solar control in habitable spaces (crucial), solar hot water, PV

Design Guide: EnergyStar, Austin Energy Green Building

Equity Action: All savings on utility costs ultimately contribute to more robust social services (building is all-bills-paid).

Notable Success: These are the best walls we've built to date (lots of continuous insulation and best windows). Also the best designed and most efficient HVAC we've designed to date.

Water

G/P/D Indoor: 20.4 gal/person/day
Outdoor:

Technologies: Efficient fixtures (cisterns and connection to municipal "purple pipe" or recycled water main attempted but not feasible due to budget)

Priorities: Reducing potable water consumption

Design Guide: Enterprise Green Communities Site

Design Strategy: Connection to city purple pipe for irrigation. Use of highly efficient fixtures: 14 gal/use clothes washers, 0.8 gpf toilets, 1.0 gpm showerheads, no bathtub.

Materials

Priorities: Impact on human health, asthmagens, removal of VOCs, environmental toxicity

Design Guide: Green Communities, LEEDv4, LBC Materials

Living Building Challenge: Used LBC as an inspirational tool during the charrette.

Thresholds: VOCs, formaldehyde, etc. content were key determining factors.

Health

Priorities: 100% accessible apartments. Mitigating health concerns due to indoor air quality as much as possible. Attempt to get people outside and using the stairs.

Social Sustainability

Priorities: As the first affordable housing in downtown Austin in 45 years, there are two key goals. One, to provide downtown-centric workers an opportunity to live where they work. Two, to provide individuals with fixed-incomes a place to live in the heart of the city in fully accessible housing with robust transportation connections.

Design Strategy: *What would be useful on a summary sheet?*

Key Lessons: "Building downtown is hard! But hugely important."

Demographic Information

<u>Neighborhood</u>	<u>City</u>
x%	x% ...households w/ senior residents
x%	x% ...households; children under 6 yrs
x%	x% ...households; public assistance
x%	x% ...percent of residents "of color"
x%	x% ...percent residents with less than a high school degree
x%	x% ...percent of adults who are non-English speakers

Site

Priorities: Reduced need for irrigation, use of 100% native species

Design Guide: Enterprise Green Communities, Austin Energy Green Building

Equity Action: This site is a zero-lot line project located in downtown. Since there was not space for traditional landscape amenities we designed outdoor courtyards and a terrace into the center of the building to provide outdoor spaces for residents.

Project Contact: Sunshine Mathon, Design + Develop. Director
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Survey and project brief prepared by the Center for Sustainable Building Research, University of Minnesota. For more information contact William Weber, wmweber@umn.edu, (612) 625-0598



APPENDIX E

PVWatts Calculator Directions

www.pvwatts.nrel.gov

The National Laboratory of the U.S. Department of Energy, Office of Energy and Renewable Energy (Operated by the Alliance for Sustainable Energy LLC) has provided a free online calculator to estimate energy production and cost of energy of grid-connected photovoltaics. The update of this calculator was released in September of 2014. The Institute used this tool and the methodology below to determine the solar production for a typical affordable housing project and then to calculate an energy target that will allow the project to achieve Net Positive Energy.

Example Net Positive Calculation

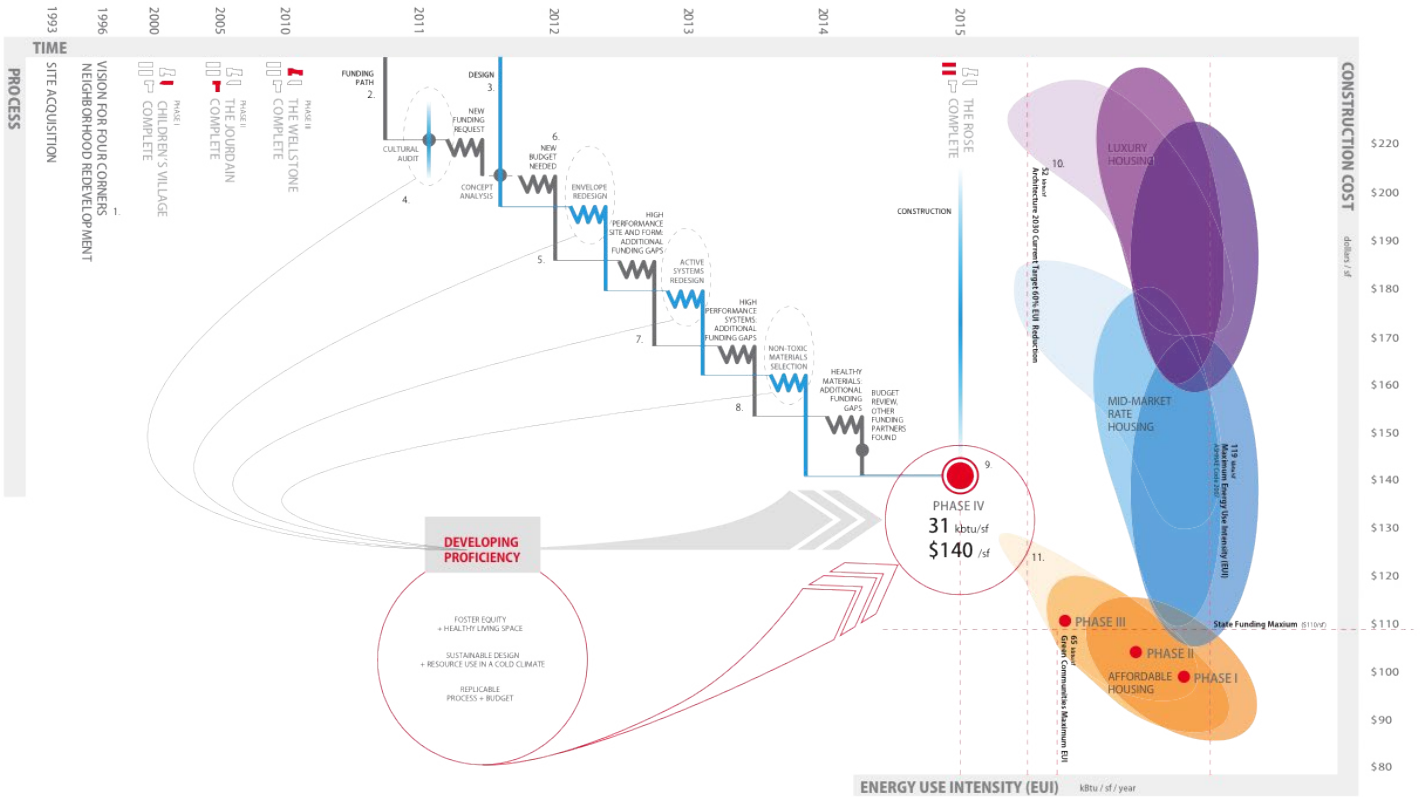
1. Select Location: San Jose, CA
2. Calculate potential size of the solar array for a 25,000 sf roof
(25,000sf ÷ 269sf X 4kW) = 371.75 kWh
4. Assume 16% efficiency
5. Assume fixed tilt of 20 degrees
6. Select Commercial Installation
7. PV Watts Result = 569,608 kwh/yr
8. Convert Units from kwh/yr to kbtu/sf/yr
(569,608kwh/yr ÷ 100,000 sf X 3.41 kbtu) = 17.8 kbtu/sf/yr
9. Reduce EUI target to meet Net Positive Energy requirement for 105% of consumption (17.8kbtu/sf/yr 105 X 100)
10. Project EUI target = 16.9 kbtu/sf/yr

APPENDIX F

The Rose Energy Diagram



REPLICABLE PROGRESS



1. The ROSE completes the fourth corner in a community development that is already revitalizing the South Main/Portland neighborhood of Portland and Franklin Ave.

4. Part of the conceptual design of Phase IV included a cultural audit. A professional journalist interviewed area residents and created a video summarizing the desires and observations that were recorded.

7. In-Mercuria passive (or 100%PI) powered) system is not viable at urban density level, especially on a low budget. A sweet spot between active system and passive envelope was found using energy models.

10. The current Architecture 2030 Challenge Target Energy Use Reduction goal will be 60% below the regional average, or code (ASHRAE 2007). In 2015 the Target will change to 70%. The Rose meets both.

APPENDIX G

Water Statistics & Specifications

GETTING TO 20 G/C/D

San Juan Community Home Trust's new community in Friday Harbor

On average: 24.7 gallons/person/day, recorded for a year by 2020 Engineering.

Issaquah ZEP Water Conservation Report / September 2, 2008

Scenario 1: Baseline values (City of Issaquah) 84 gcd

Scenario 2: High Efficiency Fixtures (No Rainwater Use) 41 gcd (50.8% Reduction)

Scenario 3: High Efficiency Fixtures (with Rainwater Use) 29 gcd (65.4% Reduction)

Conclusion:

The following fixtures that were used by Foundation Communities on the Capitol Studios project, using standard usage estimates, have been modeled to reduce water consumption to around 20 g/c/d.

Specify Fixtures with the Lowest Flow Rates	
Based on Standard Specification from Foundation Communities	
Toilet	Dual Flush HET 0.5/0.95 gpf
Lavatory	0.5 gpm
Kitchen Sink	1.5 gpm
Showerhead	1 gpm
Clothes washer	18 gpl
Dishwasher	4 gpl
Irrigation	Purple piped for landscaping and agriculture or none needed
Sample Fixtures	
Toilet	Niagara's Stealth® UHET® Dual Flush Toilet-Elongated Full flush is 0.95 gpf and reduced flush is 0.5 gpf
Showerhead	Bricor B100 Max Flowrate of 1 gpm

APPENDIX H

Sample Affordable Housing Materials List

Living Building Challenge project teams striving to meet the Materials Petal have generously agreed to share their materials tracking tables. This list is a tool to assist teams in materials research and specification; it is a compilation of the materials lists of the Bullitt Center, Midwest Project, and Frick Park, and the materials consultation for the Rose.

Please note:

- While these lists have been developed by the Institute in partnership with Living Building Project teams, they are not sufficient for materials documentation.
- Each team must conduct their own research and collect their own documentation.
- Declare (declareproducts.com) is the only official database of compliant building materials that addresses the Basic Documentation requirements
- Some materials may be compliant only through an exception, which requires advocacy or other Additional Documentation

We encourage project teams to take advantage of this list to reach out to companies in a coordinated effort to join Declare to and drive forward the transparency movement. Sending manufacturers the Declare Product Declaration Form and asking them to supply an ingredients list using that reporting format will facilitate each team's research process and collectively build demand for product transparency.

See the Brain Trust on the Living Building Challenge Community Subscription webpage (<https://ilbi.org/action/community/brain-trust/lbc-project-materials-lists>) for additional project teams' materials list contributions.

Products/Manufacturers in the Declare Database are listed below in Orange.

DIVISION 03 CONCRETE

Carbon Cure

03 50 00

Consolideck LS- Cementitious
Decks and Underlayment (Prosooco)

Laticrete

Thysen Krupp

DIVISION 04 MASONRY

04 20 00

Sioux City Brick and Tile Co

Carbon Cure

Cold Spring Granite

Sirewall

DIVISION 05 METALS

05 10 00: Vector Custom
Fabrications/Nucor- Structural
Steel

Metal Sales Manufacturing

DIVISION 06 WOOD AND PLASTICS

To meet LBC requirements project team must specific No Added Formaldehyde (NAF) products for interior composite wood: This means Solid Wood, Particle Board with an MDI binder, or Columbia Forest Products Purbond binder. Urea Formaldehyde, Phenol Formaldehyde, or Melamine Urea Formaldehyde binders are not allowed.

06 10 00

Maine Wood Treaters-preservative treated wood (Frick)

06 12 00
Ashland Soyad Adhesive-
formaldehyde free wood glue
Franklin Multibond 4000SF-
formaldehyde free wood glue

06 22 00
Columbia Forest Products
PureBond- Plywood

Collins Company FreeForm

Temple Inland Ultra Stock Free
MDF

Temple Inland Ultra Stock MR Free-
moisture resistant MDF Sierra Pine
Medite FR-flame retardant MDF

Sierra Pine Medex- Moisture
Resistant MDF

06 41 00
Biosurf Solutions- soy/corn based
laminated adhesives

Laminex

Nordic Engineering

Accys Technologies

Neil Kelly Cabinets

Collins Companies

Columbia Forest Product Purbond

Plyboo

DIVISION 07 THERMAL AND MOISTURE PROTECTION

Formaldehyde free fiberglass
insulation products with bio-based
binders are readily available and
should not have any cost
differential. Foam Insulation is
allowed with a small amount of
HFRs in particular applications.

07 21 00
FoamGlass
Cell-Pak

Hunter Insulation

Johns Manville (JM) ENRGY 3.E
(roof only)

FoamGlass
Cell-Pak

Knauf Insulation

Owens Corning EcoTouch

Green Fiber Insulation

Roxul Mineral Wood (exterior only)

Thermafiber Mineral Wool (exterior
only)

Thermocork - Amorim Isolamentos

07 84 00
Hilti CP 637 Firestop Mortar

Hilti FS ONE Firestop Sealant

Hilti CP 604 Self Leveling Firestop
Sealant

Hilti CP 506 Smoke and Acoustic
Sealant

07 90 00
CR Laurence Silicone Sealant
MEI 22-15 mastic Adhesive

BASF Sonolastic Ultra

Franklin Titebond All Weather

Dow Corning sealant 795

Dow Corning sealant 995

Neogard M-1 Caulking Sealant for
traffic coatings

Metal Sales

Columbia Green (Green Roof)

DIVISION 08 DOORS AND WINDOWS

08 12 00

Assa Abloy Trio-E Metal Doors

A.G. Mauro- steel doors and frames

Ceco Door Metal Door Frames (an Assa Abloy Co.)

Ceco Door Regent Metal Doors

08 14 00

Assa Abloy Graham Doors

Trustile Doors (FSC Mixed)

08 44 00

Kawneer Aluminum Curtain Wall and Entrances

08 52 00

Loewen Windows- FSC Wood Frame Windows

08 71 00

Hager Co- Hinges

Rockwood Mfg- Door stops, Flush Bolts, Architectural Door Pulls

Dorma- Door closers, patch fittings

Schlage- locks, handles

LCN- concealed closers

ABH Mfg- concealed closers

Shucco

Kawneer

Cascadia

Sun Central

DIVISION 09 FINISHES

Sheetrock sheet good products often contain formaldehyde and vinyl compounds. The following are formaldehyde free.

09 22 16

Clark Deitrich- Pro Stud Drywall Framing (recycled content in metal exemption)

Marino Ware - Cold Formed Framing (recycled content in metal exemption)

Telley- Cold Formed Metal Framing (recycled content in metal exemption)

09 28 00

James Hardie Backer Board

09 29 00

National Gypsum- Gold Bond products

US Gypsum- Fiberrock products

CertainTeed- Type X

Lafarge- Type X

US Gypsum- Sheetrock joint tape

US Gypsum- Sheetrock paper faced metal bead trim

Dietrich- corner bead

CertainTeed ProRoc LITE Sand Setting Compound

CertainTeed Flexible corner bead

09 30 00

Custom Building Products Veraset Thinset Mortar

Custom Building Products Polyblend Grout

Crossville EcoCycle- Porcelain Tile

09 60 00

Shaw Industries Ecoworx

Tufted SD Nylon Carpet on Actionbac (Submitted to Declare)

Bolyu carpet tile

Mohawk carpet tile with ecoflex
NXT

Bentley Mills Cushion Back

US Gypsum Levelrock-
subfloor/finish gypcrete flooring

Diversey Aquaria Floor Coating

Flexco- wall base

Armstrong Flooring- biobased tile

Forbo Flooring- Marmoleum

Mediterra Cork Flooring

Milliken Carpets

Interface Superflor

09 81 16
K-13 Acoustic Spray Insulation
(NRDC)

K-13 Isoprime (NRDC)

Bonded Logic- Ultra Touch Denim
Insulation

Acoustical Surfaces Inc- Echo

Eliminator (NRDC- not installed)

Knauff ECOSE Insulation Board

Ceilings
9Wood

09 90 00
Imperial Paints
Rodda

09 77 23
Carnegie Fabrics

DIVISION 10 SPECIALTIES

10 26 00
Alpar Architectural Products
DeTerra (Declare)

Wall Protection
Alpar Architectural Products

Louvershade

DIVISION 12 FURNISHINGS

12 36 61
IceStone- recycled glass counter
tops

3 Form 100%- solid surface counter
tops (NRDC-not installed)
Shades

Ceasar Stone Countertop

Squawk Mountain Stone

Sportwork Northwest

DIVISION 13 SPECIAL CONSTRUCTION

Sirewall

DIVISION 15 MECHANICAL

DIVISION 21 FIRE SUPPRESSION

Non-PVC piping for plumbing
should be given preference.
Alternative such as PEX, HPDE, and
Polypropylene are readily available.

21 13 00
Tyco Sprinkler Heads (copper)

Fusiotherm Polypropylene
Aquatherm (greenspec)

Polystar Polypropylene Pipe
(greenspec)

DIVISION 22 PLUMBING

22 40 00
Elkay Lusterstone Sink

Elkay Rubber stopper

Hansgrohe fixtures

Zurn Fixtures

Kohler Fixtures
Sloan- fixtures and valves

Beneke- fixtures

Appolo Valve

Chicago Faucets- plumbing fixtures and fittings

10 80 00

Rosie's Cylce Toilet

Pheonix Toilet

TOTO Toilet

Kohler Toilet

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

23 30 00

Ductmate Greenseam HVAC Pipe

Elgen HVAC Metal Flanges and HETO

Nucor Sheetmetal

Design Polymerics DP 1010 Duct Sealant

Ruskin- dampers

Knauf Insulation Products

23 37 00

Titus- Diffusers and Grilles (NRDC)

UltimateAir RecoupAerator® 200DX Zhender

DIVISION 26 ELECTRICAL

It is recommended to use the MEP engineer as a resource for product information. Since product reps want to make a sale they can be useful starting point for research and advocacy.

26 00 00

Allied Tube Conduit

Emerson Electric- outlet/switch boxes, back plates, clamps, brackets

Legrand- Polyester outlet covers

26 50 00

3G Lighting-light fixtures

Focal Point- light fixtures (full Red List disclosure)

Lighting Services Inc- light fixtures

Optolum- light fixtures

Lithonia- fluoescent strip fixtures

Itek

Phillips Lights

Led Manufacturer Lights

Sunny Boy Lights

Sunpower Lights

Schneider Lights

Seimens Lights

Cooper Lighting

Sylvania Lights

DIVISION 26 WATER AND WASTEWATER EQUIPMENT

Aquacell

Pheonix

Rosie's Cycle



APPENDIX I

Sample Affordable Housing Materials Transparency Letter to Manufacturers

[Your Name]

[Your Organization Name]

[Project Name]

RE: Building Material Disclosure Initiatives

[Date]

Dear [Product Manufacturer],

[Your Organization Name] is dedicated to making environmentally informed decisions regarding the architectural building products used in our designs of affordable multi-family housing developments. We feel that all people, regardless of economic status, have a right to housing that is healthy, safe, affordable and environmentally sound. We hope you agree.

When selecting building products, it is key to have access to transparent data regarding chemical content and health considerations. Product specification and selection is a complex process, and we've found that cost, aesthetic and performance are no longer the only factors up for consideration. Investigation into the chemical content and life cycle are also now just as critical components to help make our decisions about material selection.

Rather than use products that contain substances harmful to humans and the environment, we will seek out alternatives. We believe that it is appropriate to apply the precautionary principle when selecting and specifying products and materials in light of the lasting impact such materials may have on the users of facilities we design. [Your Organization Name] develops over [insert number square feet] of homes a year, and the affordable housing industry overall created more than 2.5 million homes between 1986 and 2012 in the US. Transparency and toxic chemical avoidance are not only important to our organization, they are critical issues for our industry overall, and many developers are following our lead.

[Your Organization] and our consultant teams use Living Building Challenge's Declare program (declareproducts.com), to identify healthy materials that comply with the Living Building Challenge Red List. We encourage you to list your product in Declare and remove toxic Red List ingredients, so together we can deliver healthier buildings to owners and end users. Manufacturers that provide full, transparent disclosure of their product contents are the most helpful to our designers.

As we continue to integrate the information gained from these building industry initiatives into our daily practice, we are committed to creating environments that truly enhance the environment and the human experience.

We thank you in advance for taking these steps.

Sincerely,

[Your Name, Title]