INTERNATIONAL
LIVING FUTURE
INSTITUTE℠

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 to serve as focal points for inspiration and education in their local communities. They are comprised entirely of healthy, sustainable building materials, harvest all their energy and water on site, and weave equity and social justice into their design goals. As the world's most impactful green building certification program, the Living Building Challenge can enhance the positive contributions of affordable housing while mitigating the persistent inequalities often present in low-income communities. This update is intended to provide additional pathways and case studies for affordable housing projects to realize these benefits.

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 and renovation of sustainable affordable multifamily housing.

THE INTERNATIONAL LIVING FUTURE INSTITUTE

The mission of the International Living Future Institute (the Institute) is to lead and support the transformation. The Institute is an environmental NGO committed to catalyzing the transformation toward communities that are socially just, culturally rich, and ecologically restorative. The Institute is premised on the belief that providing a compelling vision for the future is a fundamental requirement for reconciling humanity's relationship with the natural world. The Institute operates the Living Building Challenge, the built environment's most ambitious performance standard. It is a hub for many other visionary programs that support the transformation toward a living future. For more information, please visit https://living-future.org.

THE JPB FOUNDATION AND STAKEHOLDERS

The Living Building Challenge Framework for Affordable Housing is funded by the JPB Foundation. The report and the ongoing success of future projects rely on the continued and essential contribution of the foundation as well as some of the nation's leading innovative affordable housing designers, developers, and nonprofit organizations dedicated to continually raising the bar for green affordable housing.

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Capital Studios, an Affordable Housing Pilot Program project. Image: Paul Bardagiy

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LIVING AFFORDABLE HOUSING - MISSION ALIGNED + HIGH IMPACT

Housing that provides for a dignified, healthy life without excessive cost burdens is fundamental to a just and equitable society. The Living Building Challenge helps affordable housing developers fulfill their mission - creating a house, a home, a community, and a better future for low-income individuals and families. The Living Building Challenge provides a framework for designing to fully reflect and fulfill these mission goals through all phases of building design, construction, and operation.

Health is an important priority for affordable housing residents + developers and within the Living Building Challenge.

- The health of affordable housing residents is disproportionately affected by environmental + social issues.

- Materials selection + designing for good indoor air quality are critical + often overlooked factors in healthy environments.

- Access to nature + urban agriculture are vital to physical + psychological wellness.

The healthy materials market is scaling rapidly.

-Many residential products are available at cost effective/cost neutral pricing.

-Manufacturers are increasingly investing in social equity by providing discounted or free products to affordable housing projects.

-The Declare Database is the go-to resource for project teams looking for healthy materials.

Living Buildings improve quality of life while reducing the cost of living for residents.

-Living Buildings have lower utility + transportation costs; provide access to local + healthy food.

-Living Buildings reduce healthcare costs + result in fewer sick days from school + work.

-Living Buildings encourage pride + engagement in place + community.

Sustainability + affordability are not mutually exclusive.

-LBC strategies can reduce development + long-term costs.

-Lowering embodied carbon + increasing energy efficiency often reduce scope + project cost.

-Photovoltaic panels pay back within 5-10 years, providng free energy for 30-50 years.

Net Positive Energy is being achieved on many affordable housing projects + is within reach for all.

-Achieving Net Positive Energy for very low-density + single-family affordable housing is easily achievable.

-Low- and mid-rise buildings can achieve Net Positive Energy using cost-efficient energy reduction strategies.

-Energy efficiency technologies + community scale renwables are making Net Positive Energy viable for high-rise affordable housing.

LBC 4.0 includes new pathways for affordable housing to streamline the process + create impact across a developer's portfolio.

-Water handprinting allows developers to improve water efficiency + reduce water costs across their portfolios.

-The blackwater exception for affordable housing is expanded to recognize the challenges faced by projects of varying densities.

-Materials vetting is streamlined to focus on the most impactful materials.

Affordable housing can serve as a model for all building types—showing that Living Buildings are possible on all budgets, in all climates, and in all communities.

-Affordable housing developers are leaders on equity in the built environment.

-Advancements in healthy materials + regenerative strategies in affordable housing allows for all housing to have more options.

-A people-first ethic results in meaningful outcomes + inspires change throughout the community + sector.

EXECUTIVE SUMMARY

Every person, regardless of economic status, has a right to housing that is healthy, safe, affordable, and environmentally sound. Truly sustainable, resilient housing will have a substantially positive effect on some of our most vulnerable populations. Broadly speaking, low-income residents pay more per square foot for energy costs than other households and are disproportionately affected by rising energy costs, as well as water costs and shut-offs.[1] Freedom from monthly water, heat, and electricity bills will improve the financial health of struggling families and help insulate them from unpredictable and often staggering cost increases. Even in cases where residents do not directly pay utility bills, net-positive energy and water strategies will improve the financial performance of a project long term, freeing up funds for affordable housing owners to reinvest in building additional units or in providing additional services for residents.

Furthermore, low-income families, who disproportionately suffer negative health effects from poor air quality and exposure to high levels of toxins,[2] benefit greatly from higher 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, economic uncertainty, and social struggles offers a platform for growing family health and stability, community development, and economic empowerment. The Living Building Challenge (LBC) provides the affordable housing community a compelling, mission-aligned vision and a clear, actionable path for achieving just such critically needed housing.

Courtyard of Silver Star Apartments built by A Community of Friends in Los Angeles, CA. A phase 2 Affordable Housing Pilot Project, Silver Star Apartments is seeking Energy Petal or Zero Energy certification. Image: Natalia Knezevic.

1 https://www.energyefficiencyforall.org/resources/lifting-the-high-energy-burden-in-americas-largest-cities-how-energy/
2 https://www.scientificamerican.com/article/people-poor-neighborhoods-breate-more-hazardous-particles/

ILFI's Affordable Housing Program by the Numbers

REGISTERED PROJECTS: **27**
UNITS: **758**
RESIDENTS: **THOUSANDS**
INCOME LEVELS: **30% AMI – 80% AMI**
STATES + PROVINCES: **13**
CERTIFIED AFFORDABLE HOUSING PROJECTS: **3**
PROJECTS PURSUING LIVING CERTIFICATION: **4**
PROJECTS PURSUING PETAL CERTIFICATION: **16**
PROJECTS PURSUING ZERO ENERGY CERTIFICATION: **4**

The Living Building Challenge Framework for Affordable Housing (updated August 2019) provides pathways and strategies for affordable housing projects to achieve the International Living Future Institute's (ILFI or the Institute) market-leading certifications, including Living Building Challenge, Core Green Building Certification, Zero Energy Certification, and Zero Carbon Certification. Taken alone and together, these certifications are considered the world's most rigorous performance-based certifications for sustainable design and construction of the built environment. The intent of this Framework is to inspire more affordable housing projects that are socially just, culturally rich, and ecologically restorative, as well as to offer the information, tools, and support to ensure that current and future affordable housing projects pursuing the Living Building Challenge succeed.

"I don't think it is a question of... should I build sustainable or should I build affordable. You can do both at the same time."

Krista Egger, Director of Initiatives at Enterprise Community Partners[3]

"Our affordable housing clients are perfectly aligned with the intent and the goals of International Living Future Institute. Whether it be reducing energy and water operating costs in order to enhance affordability for homeowners or ensuring that the interior environment is free of the toxins that are all too prevalent in typical building materials, the holistic approach of the LBC is an excellent framework for equitable project development. As a result, the visionary approach that the Living Building Challenge promotes is inspiring to like-minded affordable housing developers and occupants alike."

Kenner Kingston, President, Architectural Nexus, Inc.

While many feel there is a dichotomy between sustainable building and affordable housing, the goals of each are actually very well aligned and the opportunities to achieve both numerous. As Sunshine Mathon, CEO of Piedmont Housing Alliance in Charlottesville Virginia states, "On the mission side, anything we can do to help facilitate a more stable economic environment for residents that we serve also furthers the mission."[1] Achieving the Living Building Challenge on affordable housing projects does just that – improving health and happiness, increasing housing durability and longevity, reducing operating costs, increasing pride in place, as well as connecting families and communities with each other, nature, and culture. Low-income communities and residents need sustainable housing the most.

The Institute's Affordable Housing Pilot Program has seen remarkable progress over the past five years. Since the first edition of this Framework (published in 2014), the Affordable Housing Pilot Program has expanded to 27 projects located in eleven states, the District of Columbia, and Canada. These projects are demonstrating that the Living Building Challenge is possible in affordable housing and that pursuit of the program offers a myriad of benefits.

This update presents an expansion of lessons learned, gathered as a result of working with these industry-leading project teams and strategic partners throughout the affordable housing sector. Strategies and techniques are identified throughout to move beyond best practice to achieve each Imperative of the Living Building Challenge in an affordable housing context. In-depth case studies are provided at the end of each section to demonstrate how affordable housing project teams approached each Petal, with the intent of providing replicable strategies for the entire affordable housing sector.

3 https://www.buildinggreen.com/feature/affordable-housing-and-sustainable-design-goals-are-aligned

EXECUTIVE SUMMARY

"The project did not have that 'new building' smell. Contractors could not tell when a unit had been punched, because they could not smell anything. I was 9 months pregnant when the building was being completed and felt completely comfortable on site."

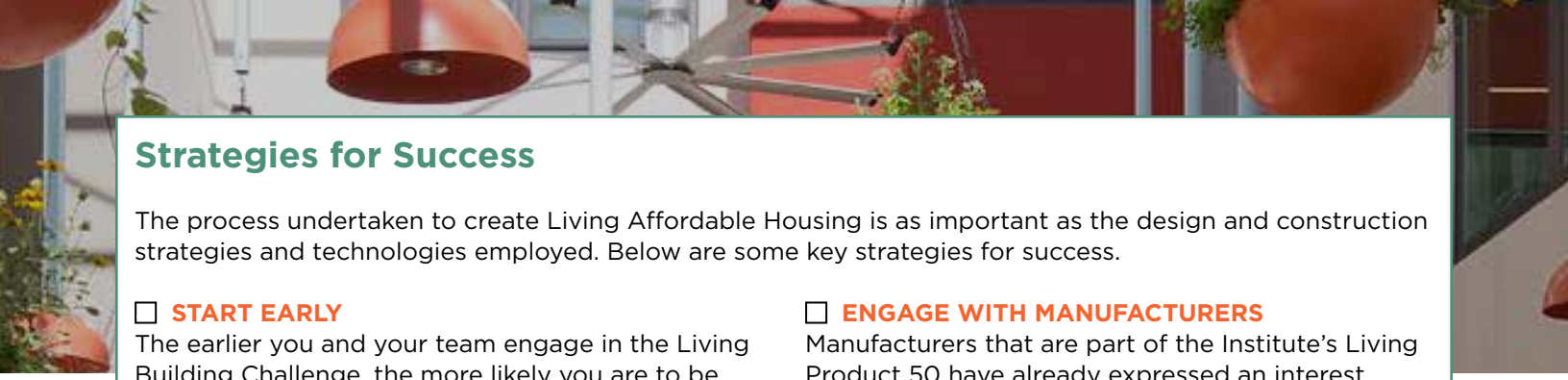
Leslie Roering, Senior Project Manager, Housing Development, Aeon

The Water, Materials, and Energy Petals set ambitious goals for affordable housing. While taking on the challenges presented by each of these Petals, pilot projects have achieved significant success toward Red List Free materials, net positive energy, and water conservation not thought possible even a few years ago. Net Positive Water and Energy strategies have been modeled using updated data. The modeling results demonstrate the feasibility for multifamily projects to meet these Petals in various climate zones and densities.

Nearly all affordable housing developers express strong interest and alignment with the other four Petals - Place, Health + Happiness, Equity, and Beauty. Some affordable housing projects that do not yet feel ready to take on the Water, Materials, or Energy Petal in their entirety have found that these four Petals provide a useful structure for improving the quality of life of residents and benefitting the environment, generally at minimal cost. This update expounds on the Imperatives for each of these Petals, offering strategies and case studies.

Josh and Porscha Doucette's house, the ninth home built by Community Rebuilds in Moab, UT. Community Rebuilds has one certified Zero Energy home (Rocky Road Straw Bale) and one volume pilot project (The Projects at Mill Creek). All homes built by Community Rebuilds aim to be net-zero energy. Image courtesy of Community Rebuilds.

We are working to create a Living Future. If that doesn't include everyone, regardless of income, then we have not met our goals.



Strategies for Success

The process undertaken to create Living Affordable Housing is as important as the design and construction strategies and technologies employed. Below are some key strategies for success.

☐ START EARLY

The earlier you and your team engage in the Living Building Challenge, the more likely you are to be successful. Early decisions about team selection, site selection, building siting, massing, and orientation can determine process efficiency and cost effectiveness.

☐ FOLLOW AN INTEGRATED DESIGN PROCESS

An integrated design process is critical to ensure that Living Building Challenge goals are realized during construction.

☐ EDUCATE YOURSELF AND THE TEAM

Knowing the what, why, and how of what you are trying to accomplish makes a difference. The Institute has a large and growing suite of online, in person, and customizable educational offerings to assist affordable housing project teams pursuing the Living Building Challenge. The Institute is committed to education and information sharing and to providing venues for others to share their stories.

☐ HIGHLIGHT YOUR SUSTAINABILITY GOALS IN YOUR FUNDING APPLICATIONS

Many QAPs offer additional points to projects that include sustainable design features. The Institute has partnered with several state housing finance agencies in order to integrate programs like LBC, Zero Energy, and Declare into their Qualified Allocation Plans (QAP). Project teams that pursue these programs receive additional points in their application for low income housing tax credits, increasing their chances of receiving critical funding.

☐ MAKE USE OF INCENTIVES

Many state and local governments, as well as utilities, have incentives available to encourage and fund sustainability features in new and existing buildings. For example, Zero Energy Certification (and other LBC certifications on a case-by-case basis) is now included in Fannie Mae's green lending program, which results in lower interest rates for certified projects.

☐ ENGAGE WITH MANUFACTURERS

Manufacturers that are part of the Institute's Living Product 50 have already expressed an interest in and commitment to working with Affordable Housing Projects to provide free or discounted products. Companies pursuing Living Product Certification are using social equity handprints to benefit low-income communities and affordable housing.

☐ USE THE DECLARE DATABASE

Make use of the Declare Database and all the other tools and resources the Institute and its partners have created to help make the process easier.

☐ IMPLEMENT WATER HANDPRINTING

Handprinting allows affordable housing project teams the opportunity to reduce water use elsewhere, potentially within other projects in their portfolio, thus reducing long-term utility costs across their portfolio. Many water efficiency upgrades, such as low-flow showerheads and aerators, have low up-front costs and can provide substantial savings in both energy and water. Incentive programs for water upgrades in affordable housing also exist in numerous jurisdictions that may help fund the limited cost to make these upgrades.

☐ ASK FOR HELP

The Institute provides project-specific consulting services to affordable housing teams. Thanks to generous foundation support, these services are provided at no cost to those affordable housing projects that are part of the Institute Affordable Housing Pilot Program. For others, they are available at modest fees. The Institute's technical services are designed to build capacity, instill confidence, and help ensure a project team remains on the path to success during the design and construction process.

☐ CONNECT WITH OTHER AFFORDABLE HOUSING DEVELOPERS

Why not learn from the experience and expertise of others? There are other forward-thinking, innovative affordable housing developers like you. Connecting with them to share stories and resources, seek and offer advice, and support each other may be the secret to success. The Institute's Affordable Housing Pilot Program is a great place to start.

KEY FINDINGS

PLACE

- The Place Imperative relates to aspects that are typically already prioritized in new affordable housing developments and, if not already explicitly in project plans, can be implemented at little or no cost to enhance the effectiveness of the building and the organizational mission.
- Designing with the environment and community context in mind increases residents' connections to place, history, and culture, helping to transform housing into actual homes.
- Focusing on the human scale and adding areas for gathering increases the sense of community and make residents feel safe and connected.
- Designing for alternative means of transportation offers important economic, health, and well-being benefits to affordable housing residents.
- Project teams have consistently found that urban agriculture, by allowing access to healthy food and areas to grow their own food, is highly valued by residents.

"When you have a bad day, you just come out here and feel the dirt. I bring my grandkids and let them see I just love it: humans and nature combining together."

Garden Leader at The Rose, Aeon[4]

The Rose. Image courtesy of Aeon

WATER

- Water quality and water affordability are leading environmental, health, and social justice issues.
- Water is a significant operating expense—in many cases, the highest operating cost—in affordable housing projects.
- High-efficiency fixtures are nearly sufficient to meet the water reduction goals set in Imperative 5 - Responsible Water Use. A small amount of handprinting (approximately 3.5 gallons per day), using foam or vacuum flush toilets, or using non-potable water for laundry or toilet flushing will allow affordable housing projects to fully meet the Imperative requirements, model best-in-class design, and significantly reduce operating costs.
- Meeting 100% of a project's water needs solely through on-site sources is challenging in high density affordable housing projects.
- Handprinting strategies can be used to achieve a net positive impact within the watershed and create positive economic, social, and environmental impacts across the affordable housing developer's portfolio. Installing lower-flow fixtures (such as low-flow showerheads or aerators) within their existing projects can be a low cost way to meet Imperative requirements and result in lower operating costs portfolio wide.
- Some regulatory and financial barriers remain to achieving the Water Petal, though there are numerous resources, case studies, and alternative compliance pathways available to mitigate these challenges.
- Several California projects are providing important precedents for permitting and installing greywater reuse systems in multifamily affordable housing projects.

4 https://www.aeon.org/wp-content/uploads/2019/06/The-Rose-Study.pdf?utm_source=Aeon+Email+List&utm_campaign=8f94a49cb0-EMAIL_CAMPAIGN_2019_01_15_10_32_COPY_04&utm_medium=email&utm_term=0_c4bdd692d6-8f94a49cb0-296170641

ENERGY

- Climate change is the leading environmental, health, and social justice issue of our time. Net Positive Carbon buildings are one of the key solutions, offering clean energy, affordability/access, and resiliency.
- Lack of energy affordability affects human health and well-being, as well as economic health.
- Momentum is building quickly for zero-energy and net-positive energy affordable housing projects.
- Building density, rather than climate zone, has the largest impact on the level of energy reduction needed to achieve Net Positive Energy.
- Achieving Net Positive Energy (supplying at least 105% of the project's energy needs through on-site renewable energy) is possible in most regions. Using best practices for envelope sealing and energy efficient systems, makes on-site achievement of net positive energy more feasible. Higher density projects may require the utilization of scale jumping or the Offsite Renewable Exception.
- Consideration of the embodied carbon in materials is a critical climate action. Use of wood, other natural materials, salvaged materials, and materials made with recycled content are ways for affordable housing projects to reduce embodied carbon and, in many cases, avoid toxic chemicals.
- There are a growing number of financial incentives available to fund net-positive energy in affordable housing, such as: Fannie Mae's green lending program, the federal solar tax credit (Investment Tax Credit), incentives in the Qualified Allocation Process in various states, PACE financing programs, or incentives available through utilities.
- Net metering restrictions and low costs for fossil fuel remain as barriers in some regions, but there continues to be regulatory and financial advocacy and improvements.

"A home that conserves water and energy can save lives and improve the planet. We know people die when they cannot heat or cool their homes adequately. Disproportionately, this affects people with low incomes and in particular low-income African-Americans. High utility bills from underperforming housing conditions can put households at risk for eviction."

Dana Bourland, Vice President of the Environment Program, JPB Foundation

HEALTH + HAPPINESS

- Many affordable housing developers assert, and the Institute agrees, that "housing is healthcare," with the built environment playing a significant role in personal and community health outcomes.
- Health is a top priority for both affordable housing residents and owners.
- Use of the Declare database makes identifying low-emitting interior materials easier.
- Design and construction practices, as well as building operations protocols, have significant impacts on the health and quality of the built environment.
- At limited to no additional cost, achieving the three Health + Happiness Imperatives can significantly improve indoor air quality, occupant health, and overall well-being for our most vulnerable populations.

"Putting a roof over someone's head doesn't mean you have solved homelessness for them. To really allow someone to heal, they need to feel like they belong, that they are part of something greater. By living in a BLOCK Home - the most sustainable home on the block - the resident will not only be proud of where they live, but also hold and share beautiful knowledge on how to take care of our planet."

Jenn Lafreniere, Co-founder, Block Architects

MATERIALS

- Low-income populations suffer disproportionately from the negative health impacts associated with building materials due to increased exposure to toxic materials in their homes, neighborhoods, and jobs.

- With the dramatic expansion of the Declare database and growth of demand for Red List Free products, there are now many more options available for affordable housing projects. Several product categories have no cost premium and minimal vetting requirements. Many other product categories have only minor cost premiums.

- Hard costs remain problematic for a few specific product categories; however, some affordable housing projects are achieving a Red List Free building without overall cost premiums to the project.

- Existing tools and resources, such as Red2Green and the Certified Project Materials Database, have reduced the time and cost for materials vetting. The Institute is developing more tools to further streamline the process.

- Several affordable housing pilot projects recently have made great strides toward achieving the Materials Petal. The materials lists from these projects will provide an important resource for future project teams.

- Partnerships between the Institute and organizations such as Enterprise Community Partners to scale healthy materials across the industry will accelerate market transformation. The partnership between the Institute and Housing Partnership Network will continue to bring down the price and effort associated with meeting the Materials Petal.

- Partnerships between project teams and manufacturers (which can be facilitated by the Institute) are showing great promise for reducing materials costs and increasing net benefits.

EQUITY

- Equity is an area where affordable housing developers can lead the way forward for other project types pursuing the Living Building Challenge.

- There are several important precedents of affordable housing developments choosing to intentionally create frameworks for economic inclusion of underserved groups in the design and construction process and for ensuring that the project, once completed, serves the entire community.

- Ensuring that the project provides an economic and social benefit to the greater community is integral to the mission of affordable housing and to the Living Building Challenge.

BEAUTY

- Biophilic design is a significant area of interest for many affordable housing developers as it can help create a unique housing experience that feels both beautiful and contextual.

- The power of healing through biophilic design and natural elements has begun to be documented and provides an interesting area of future exploration that could be greatly beneficial to affordable housing residents.

- When incorporated early in the design process, biophilic design can be implemented at minimal cost.

- Most project teams are eager to tell their story and share the successes and lessons learned from projects. The Inspiration and Education Imperative formalizes a means for each project to do so in a manner that inspires other projects to pursue the Living Building Challenge.

"The Red List has been one of the LBC's most transformative initiatives – a story of early-adopter magnanimity and a committed industry working together as an organism – and the Institute's efforts over the past several years to target products common in affordable housing has been no exception. After over a decade of market transformation and LBC teams sharing their research, overcoming the Red List is not as great an obstacle as it used to be."

Katie Ackerly and Chelsea Johnson, David Baker Architects

NEXT STEPS

The growth in the number of affordable housing projects pursuing the Living Building Challenge is strong. The successes and benefits achieved are significant. The momentum is growing and the potential for even broader impact is profound. The publication of this updated Framework marks a key milestone in synthesizing key strategies, critical lessons learned, and inspiring stories into a single document to catalyze further market transformation.

However, the Institute is not stopping here. As each new project demonstrates that Living Affordable Housing is possible, the Institute will continue to update resources and case studies to inspire, educate, and equip the affordable housing sector. The Institute, through work with its partners and pilot projects, has identified several key next steps.

HEALTHY MATERIALS IDENTIFICATION AND ADVOCACY

Since the release of the first LBC Framework for Affordable Housing in 2014, ILFI has seen a massive increase in the number of Declare labels and Living Product Challenge certifications. Since 2014, there has been a nearly eight-fold increase in the number of labels. The Institute now has close to 900 labels covering nearly every product category and thousands of individual SKUs. The Living Product Challenge has grown from zero in 2014 to over 70 products, many directly applicable to the affordable housing sector. Despite this phenomenal increase, more work needs to be done to ensure more Red List Free residential products are available, particularly those directly applicable to affordable housing. In order to increase the number of options available, the Institute is continuing to conduct direct outreach and advocacy specifically to manufacturers of residential-grade products.

Lakeline Learning Center in Austin, TX. First Zero Energy Certified Affordable Housing Pilot Project. Image: Casey Chapman Ross

RED2GREEN TOOL is an ever-growing healthy materials database with currently more than 10,000 products available from nearly 3,000 manufacturers. Project teams can access the database through the online software platform and organize files to eventually submit documents for certification. https://materiallybetter.com/

RESOURCE DEVELOPMENT

Continued development of key resources to make the process more efficient and effective is critical. Two such resources are the Master Materials List for Affordable Housing and the Red2Green tool. With several projects now pursuing the Materials Petal and others vetting a particular scope of materials for Red List and FSC compliance (such as interior materials), updating the Master Materials List and increasing the number of products available through Integrated Eco Strategy's Red2Green tool are critical. The Institute will continually update these resources to provide a further head start for future affordable housing project teams working to avoid Red List products in their specifications without the cost and time needed for individual research.

MARKET ALIGNMENT

The Institute plans to continue to work with key partners such as the United States Green Building Council (USGBC) and Enterprise Community Partners to upgrade and align their materials and other requirements with the Living Building Challenge. Doing so streamlines the process for project teams and ensures that everyone is working efficiently toward the goal of healthy and sustainable housing for all.

FINANCING INCENTIVES AND RESEARCH

As determined in the first edition of this report (published in 2014), the financing mechanisms within affordable housing impede innovative sustainable design by requiring adherence to stringent timelines and cost caps that generally do not account for long-term cost savings. Targeted ILFI advocacy has already resulted in three states adding the LBC to their Qualified Allocation Plans (QAPs). ILFI has primed five more states to follow. Additionally, ILFI's Zero Energy Certification was approved for Fannie Mae's list of green building certifications. Outside of the Institute's efforts, many municipalities and utilities across the country now provide significant incentives for energy/water efficiency and renewable energy. This represents significant progress in a relatively short period of time. However, greater availability of incentives for healthy

Lopez Community Land Trust - Common Ground on Lopez Island, WA. Affordable Housing single family neighborhood Net Zero Energy certified. Design by Mithun. Image: Juan Hernandez.

materials and other important elements of the Living Building Challenge are needed. More research is necessary on the financial and social benefits of healthy materials, interior air quality, urban agriculture, and biophilic design for affordable housing to convince decision-makers at the local, state, and federal levels that regenerative design must be incentivized and implemented broadly in all affordable housing. ILFI seeks to expand research in this area, quantify these benefits, and make a clear and convincing case to state housing finance agencies that LBC-aligned, cost-effective healthy building materials requirements, as well as other Imperatives, must become incentivized through the allocation of affordable housing funds.

TOP: Lopez Community Land Trust - Common Ground on Lopez Island, WA. Affordable Housing single family neighborhood Net Zero Energy certified. Design by Mithun. Image: Juan Hernandez

BOTTOM: Nancy and Eric's Home, the third home built by Community Rebuilds, in Moab UT. Image courtesy of Community Rebuilds.

PRICE PARITY AND MATERIALS DISCOUNTS

To facilitate more competitive pricing by leveraging collective buying power, the Institute is partnering with Housing Partnership Network with the common goal of making healthy products accessibly priced for affordable housing.

The Institute will also continue reaching out to companies that are participating in the Living Product 50 or Declare to provide donations and/or discounted price products to reduce the cost of healthy materials. The savings from these donations not only helps achieve healthy materials, but can also fund sustainable design features, such as renewable energy systems or biophilic design. Clear interest from the affordable housing sector in appropriately priced, healthier materials also signals to manufacturers that development of these products in their standard offerings for affordable housing would be beneficial to their business. As the Living Product 50 and the number of manufacturers pursuing Living Product Challenge increases, the availability of high quality, truly sustainable materials at a reasonable price point will help to reduce the cost and effort necessary to achieve Living Building and Materials Petal Certifications.

PROJECT TEAM SUPPORT

The Affordable Housing Pilot Program now includes 27 projects within three phases: three in Phase 1, ten in Phase 2, and fourteen in Phase 3 (including the BLOCK Project and Apartments at Mill Creek, which are registered as Volume projects and will result in multiple certified buildings). Our experience demonstrates that direct technical support and the creation of peer-to-peer learning networks such as our cohort of affordable housing pilots will continue to be necessary to overcome persistent barriers. The Institute is continuing to work with all of these projects that are actively in design and construction phases to incorporate healthy materials and other Living Building Challenge strategies. The completion of these groundbreaking projects provides a wealth of precedents (and coinciding resources) that will provide a replicable blueprint for transformation of the industry.

EDUCATION

To further scale the impact of this report and the work overall, a continued and robust education and outreach program drawing from the case studies and lessons learned from the innovative pilot projects will be necessary to inspire other projects and to educate key players across the sector.

FROM POSSIBLE TO SCALABLE

Although the pilot program has shown that the Living Building Challenge is possible for affordable housing in a variety of climate zones and building types, the solution must be scaled up. The release of Living Building Challenge 4.0 and the development of a volume certification pathway, designed to lower the cost and effort of certification across a whole portfolio, offer significant potential for the affordable housing sector to increase adoption of the Living Building Challenge. In May 2019, two members of the current affordable housing cohort, Community Rebuilds and the Block Project, committed to pursuing LBC at volume across their existing and new project portfolios. This kind of forward-thinking commitment to health and sustainability is what is needed to create homes for everyone that are socially just, culturally rich, and ecologically sustainable.

Hunters View Phase III in San Francisco, CA, part of the larger Hunters View redevelopment and a Phase 3 Affordable Housing Pilot Project. Rendering courtesy of David Baker Architects

Alongside the successful development of pilot projects, the Institute has made significant strides in market education, resource creation, policy advocacy, and manufacturer engagement to facilitate the integration of healthy materials and catalyze market uptake of the Living Building Challenge. While significant progress has been made, there is more work to be done to achieve our ambitious vision of Living Affordable Housing for all, ensuring that everyone, regardless of economic status or location, has the opportunity to have a truly healthy and sustainable home. We intend to build off past successes, the momentum of the movement, and the impact of this report to continue to scale this critical initiative. In pursuit of that goal, we actively seek forward-thinking developers, designers, manufactures, and policymakers, along with inspired foundation support, to turn this vision into reality.

Living Affordable Housing for Everyone in Every Community.

SECTION 1

Background Information

THE LIVING BUILDING CHALLENGE

The Living Building Challenge (LBC or 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, landscape, or infrastructure project of any scale and at any location to advance their sustainability goals.

As of July 2019, 425 projects worldwide have registered to pursue the Challenge and are in various stages of the certification pipeline. In addition to these 425 projects, another 161 have registered for the Zero Energy certification program. Of these 586 projects, 33% are residential, including 53 multi-family housing projects and 34 affordable housing projects. Of these 34, 27 are part of the Institute's Affordable Housing Pilot Program.

FIGURE 1. Summary matrix for the Living Building Chalenge.

PETAL	IMPERATIVE	TYPOLOGY: New Building	Existing Building	Interior	Landscape + Infrastructure
PLACE	1 Ecology of Place	■	▨		■
	2 Urban Agriculture	■	■		
	3 Habitat Exchange	■	■	■	■
	4 Human Scaled Living	■	▨	▨	
WATER	5 Responsible Water Use	■	■	■	■
	6 Net Positive Water	■	■		■
ENERGY	7 Energy + Carbon Reduction	■	■	■	■
	8 Net Positive Energy	■	■	■	■
HEALTH + HAPPINESS	9 Healthy Interior Environment	■	■	■	
	10 Healthy Interior Performance	■	■	■	
	11 Access to Nature	■	■	■	
MATERIALS	12 Responsible Materials	■	■	■	■
	13 Red List	■	■	■	■
	14 Responsible Sourcing	■	■	■	■
	15 Living Economy Sourcing	■	■	■	■
	16 Net Positive Waste	■	■	■	■
EQUITY	17 Universal Access	■	▨	▨	▨
	18 Inclusion	■	■	■	■
BEAUTY	19 Beauty + Biophilia	■	■	■	■
	20 Education + Inspiration	■	■	■	■

LIVING BUILDING CHALLENGE™

Figure 1.
Living Building Challenge 4.0
Summary Matrix

CORE IMPERATIVE
SCALE JUMPING ALLOWED
HANDPRINTING IMPERATIVE
IMPERATIVE REQUIRED FOR TYPOLOGY
REQUIREMENT DEPENDENT ON SCOPE
NOT REQUIRED FOR TYPOLOGY

LBC 4.0

The Living Building Challenge 4.0 was released in May 2019. Two overarching goals informed this revised version of the Living Building Challenge:

1. Ensure the level of effort project teams apply to achieving LBC Imperatives better aligns with the impacts of these efforts, at both project and market scales; and
2. Fill the gap between the highest levels of mainstream green building certifications, and the entry point to the Living Building Challenge.

The resulting standard is streamlined, eliminating time-consuming requirements that were not directly influencing projects or markets. LBC 4.0 also raises the bar by requiring project teams to achieve baseline green building milestones across all Petals, even if the project is primarily focused on a more limited scope of priorities. In addition, a number of new, performance-based compliance paths have been added to increase flexibility for teams. These changes promise to eliminate requirements seen as barriers to certification in previous versions, while maintaining the high standards and inspirational vision that the ILFI community expects from the Living Building Challenge.

The Living Building Challenge now has ten Core Imperatives that address the fundamental tenets of each Petal. All Core Imperatives are required for Petal Certification, and together they constitute the requirements of the Institute's new Core Green Building Certification program. Notable updates in LBC 4.0 by Imperative include:

I-01 Ecology of Place includes a performance-based approach to the project location and local ecology and community.

I-02 Urban Agriculture introduces a secondary path to improve the accessibility to fresh food in conjunction with on-site food production. Required percentages of site area have been simplified and are now based on Transect rather than Floor Area Ratio (FAR). Food storage requirements are modified.

The Water Petal has been divided into two Imperatives, Core and Living, and requires water use reduction against a baseline.

The Energy Petal has been separated in two Imperatives, Core and Living, and incorporates a minimum reduction in EUI and embodied carbon.

I-09 Healthy Interior Environment is now a Core Imperative that outlines baseline requirements to achieve exceptional indoor air quality.

I-10 Healthy Interior Performance includes some of the previous requirements of LBC 3.1 Civilized Environment and Healthy Interior Environment plus some expanded options for fresh air and controls.

I-11 Access to Nature is a new Imperative based on one of the previous requirements of the LBC 3.1 Biophilic Environment Imperative.

I-12 Responsible Materials is a new Core Imperative setting a materials baseline for all projects.

I-13 Red List has been updated based on classes of chemicals, as a means to clarify the process for updating the Red List Chemical Abstract Services Registry Number list and to avoid regrettable substitutions. The threshold for compliance has been set at 90%.

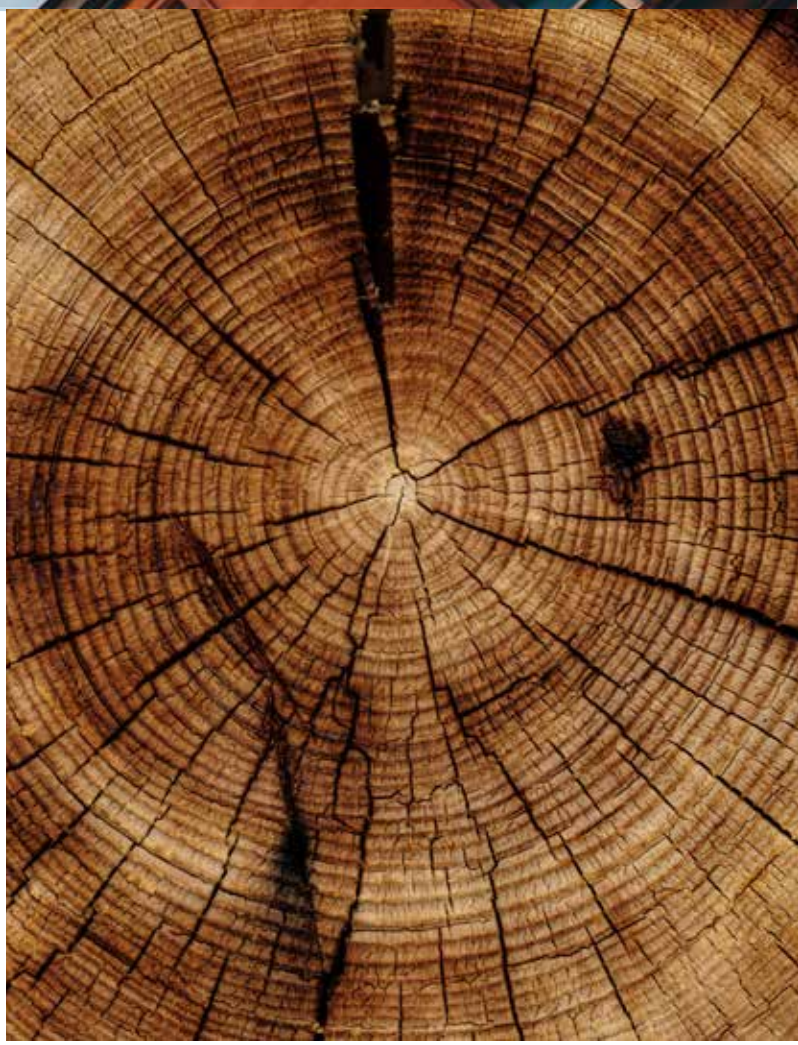
I-14 Responsible Sourcing added an FSC project certification pathway, and the calculation to determine the number of required Declare labels has been updated.

I-18 Inclusion is a new Imperative addressing diversity in hiring and access to training. The Just label requirement has been updated and incorporated into this Imperative.

I-19 Biophilic Design includes most of the requirements of the LBC 3.1 Biophilic Environment Imperative integrated with the requirements from the LBC 3.1 Beauty + Spirit Imperative.

I-20 Education + Inspiration now requires one Living Future Accredited (LFA) professional on each project team.

CORE
GREEN BUILDING CERTIFICATION



CORE GREEN BUILDING CERTIFICATION

The Core Green Building Certification℠ (Core) is a simple framework that outlines the ten best practice requirements that a building must achieve to be considered truly sustainable. Core considers the building's connection to nature, its ability to support equity in the design, build, and operation phases, and its ability to command our affection equal to the typical water, energy, and materials concerns. Core seeks to rapidly diminish the gap between the highest levels of established green building certification programs and the aspirations of the Living Building Challenge.

Core satisfies our left-brain craving for order and thresholds, and our right-brain intuition that the focus needs to be on our relationship with and understanding of the whole of life. Regardless of the size or location of the project, Core simplifies the complexity contained within our current understanding of how we define a "green" building.

Joining Zero Carbon Certification, Zero Energy Certification, Living Building Challenge Petal Certification, and Living Certification, Core completes the family of building certification programs administered by the International Living Future Institute. Together, they create a suite of certifications designed to address the many types of highly aspirational projects. The Imperatives of the Core Green Building Certification fit seamlessly into the Living Building Challenge; Core is both a stand-alone program and an integral part of the Living Building Challenge.

Projects that achieve Core certification can claim to be role models in their communities for redefining the future of the built environment. Whether the project is Zero Energy, Zero Carbon, Core, Living Building Challenge Petal, or Living Certified, it has a home in the construct of ILFI building certifications.

The Core Green Building Certification contains ten straightforward Imperatives that must be met for any type of project, at any scale, in any location around the world. Core is not a checklist—the requirements are performance-based and position demonstrated best practices as an indicator of succes.

CERTIFICATION PATHS

There are five pathways to certification under the Institute's building scale programs, recognizing that the achievement of even a portion of the program is a significant step forward for the built environment. The five pathways are Living, Petal, Core, Zero Energy,[5] and Zero Carbon Certification.[6]

A project achieves Living Certification, the highest level of sustainability and regenerative design, by attaining all Imperatives assigned to its Typology. Petal Certification requires the achievement of all ten Core Imperatives in addition to all the Imperatives in either the Water, Energy or Materials Petal. Core Certification requires achievement of the ten Core Imperatives, up to two per Petal. Zero Energy Certification requires that 100% of the building's energy needs on a net annual basis are supplied by on-site renewable energy, with no combustion. Zero Carbon Certification requires that 100% of the operational energy use associated with the project be offset by new on- or off-site renewable energy.

It also requires a targeted energy efficiency level and a reduction in embodied carbon of the project's primary materials. In addition, 100% of the carbon emissions impacts associated with the construction and materials of the project must be disclosed and offset.

Regardless of the pathway pursued, certification is based on actual, rather than modeled or anticipated, performance. Therefore, projects must be operational and show that the targeted performance levels have been met for at least 12 consecutive months prior to certification.

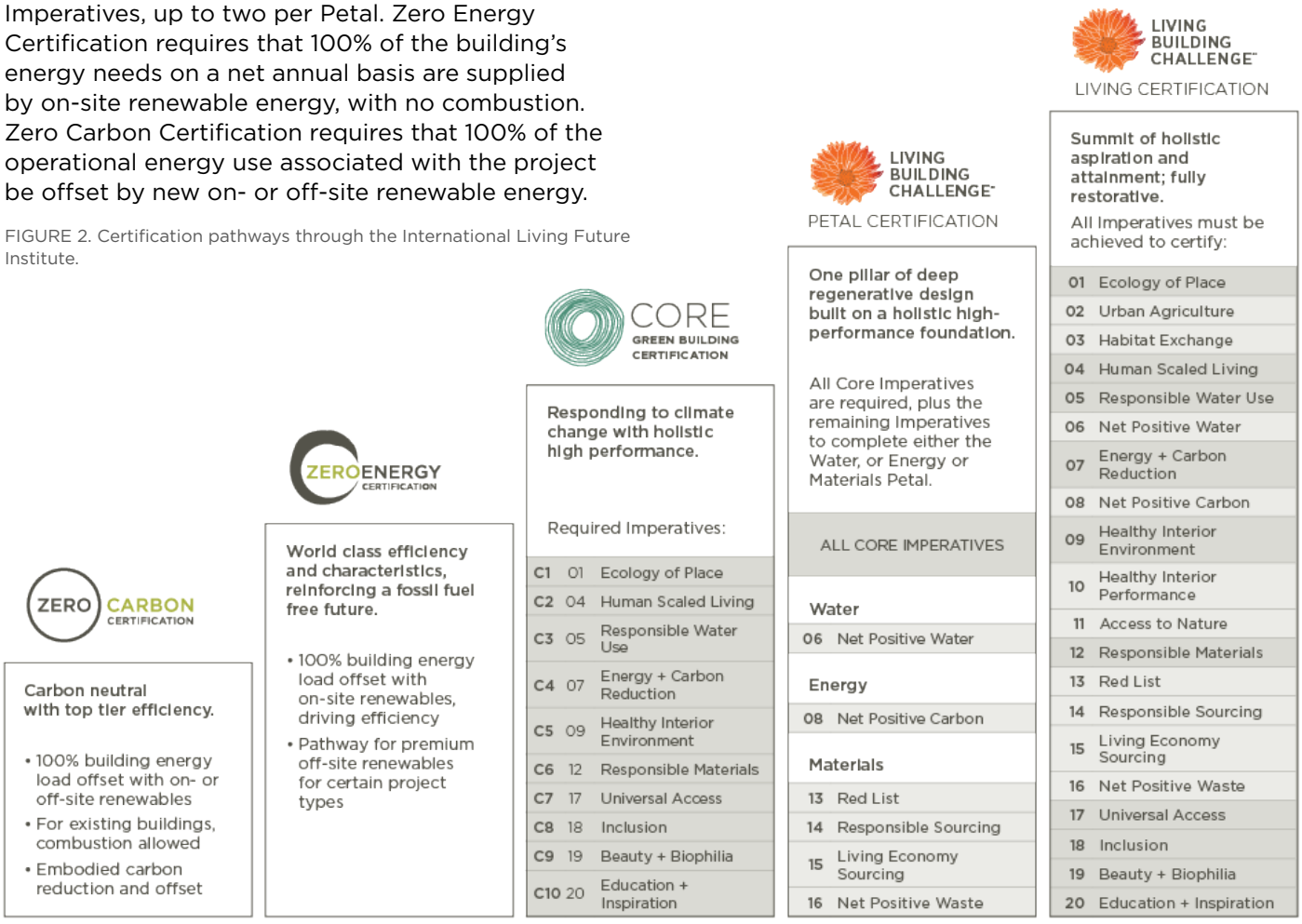


FIGURE 2. Certification pathways through the International Living Future Institute.

5 https://living-future.org/net-zero/

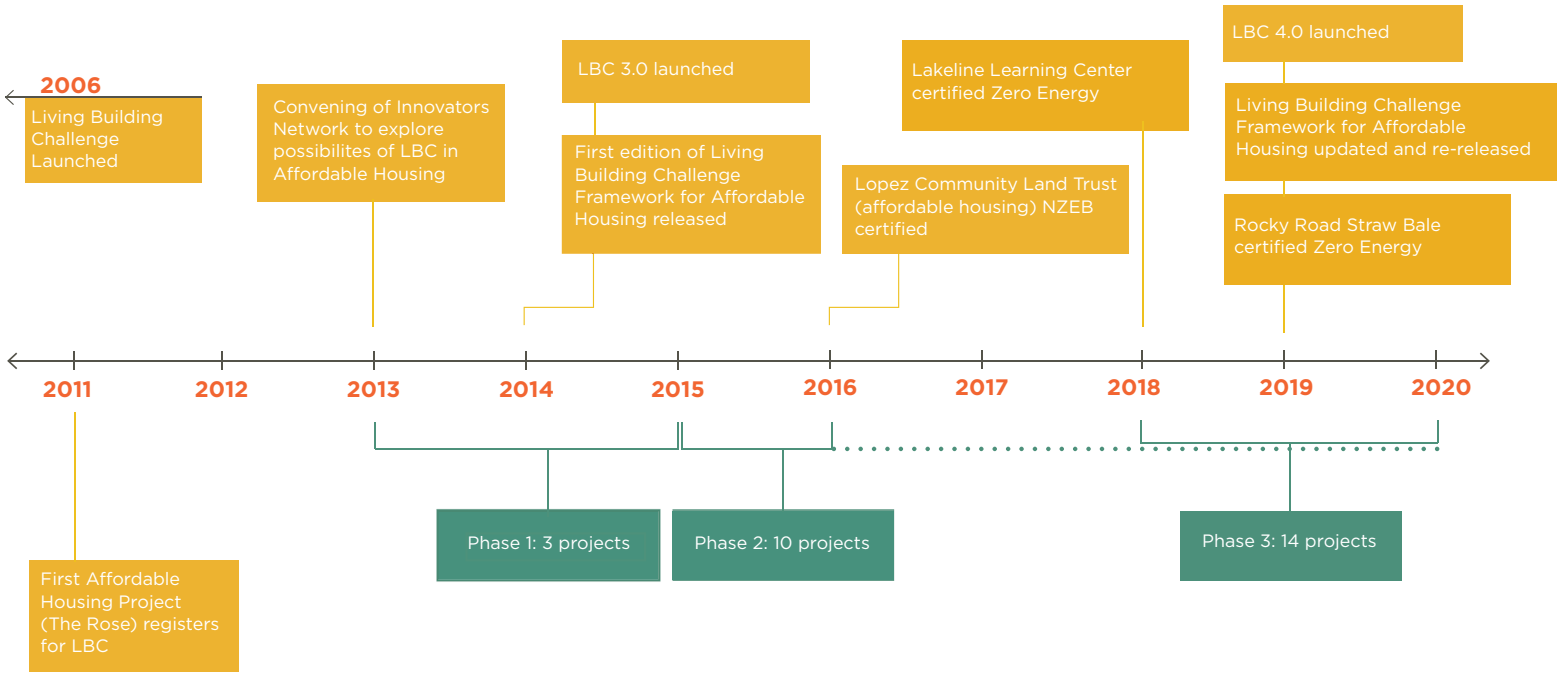
6 https://living-future.org/zero-carbon-certification/

AFFORDABLE HOUSING PILOT PROGRAM

The Institute's work in Affordable Housing began in earnest in 2013 with a convening of some of the leading affordable housing developers and designers in the nation who had pursued or investigated the use of the Living Building Challenge on their projects. This group became known as the Living Affordable Housing Innovators Network (Innovator Network). With the help of the network and Enterprise Community Partners, the Institute identified three 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. These three pilot projects were: the Rose in Minneapolis, MN; South Second Street Studios in San Jose, CA; and Capital Studios in Austin, TX. From December 2013 until December 2015, the Institute provided a variety of technical assistance to these projects including materials consulting and design development reviews. During this time period, the Institute and our partners within the Innovator Network also held a series of workshops that explored the feasibility of living affordable housing and developed a plan to provide technical assistance to affordable housing project teams. This work (now known as Phase 1) culminated in the publication of the first edition of the Living Building Challenge Framework for Affordable Housing in 2014.

From July 2015 until December 2016, the Institute led Phase 2 of the Affordable Housing Pilot Program. This work included selected and assisted several additional affordable housing projects seeking Living Building Challenge certification. There were initially eight projects within the second group of pilot projects, but one affordable housing developer, A Community of Friends, decided to pursue

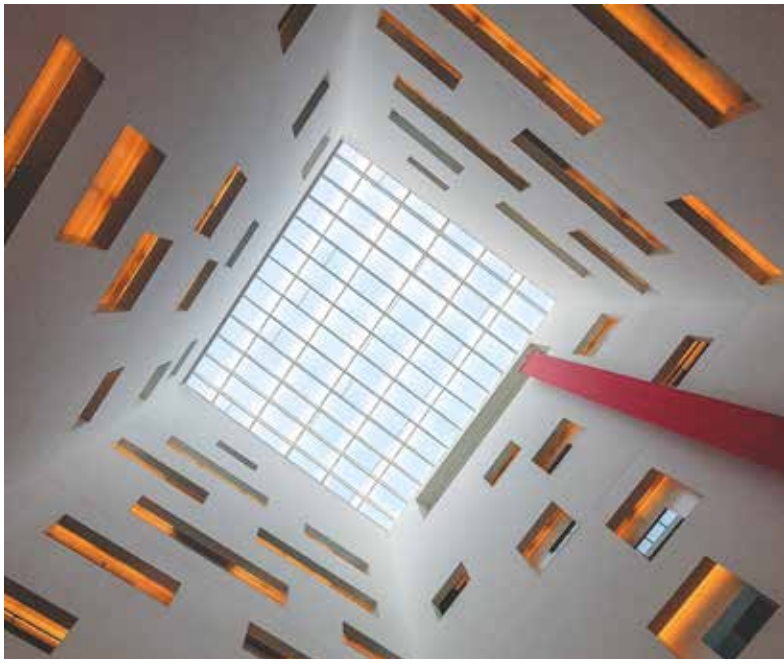
FIGURE 3: Evolution of the International Living Future Institute's Affordable Housing Pilot Program.



certification for three projects within their portfolio, and thus, this cohort grew to ten projects. Several new resources and tools were developed during this period: including a 5-part online course on living affordable housing, an additional on-line course on Tenant Engagement, and a Healthy Materials List for Affordable Housing. Technical assistance with these project teams included design charrettes, feasibility studies, design review guidance, and materials consulting. The first Affordable Housing Pilot Project to become certified, Lakeline Learning Center, achieved Zero Energy certification in October 2018. Most of the projects within this second group remain on-going either in performance periods, design and construction, or financing. ILFI continues to support these project teams as needed, even though the official program period has ended, with the goal that each one can achieve some level of certification and that all of them will continue to provide valuable lessons for others in the industry to follow.

In 2018, the Institute began Phase 3 of the Affordable Housing Pilot Program. In July of 2018, the Institute issued a call for an additional ten affordable housing projects to participate in the program. Out of more than two dozen applications, the Institute selected 12 projects to participate in the third cohort of Living Building Challenge affordable housing projects. ILFI will continue to officially engage with these project teams through Summer 2020, although the Institute plans to continue to support these projects beyond this point if/as needed. Similar to the previous rounds of project teams, ILFI has assisted these projects by providing feasibility reports, design review guidance, charrette facilitation, general support regarding their sustainability efforts, and materials research. The Red2Green Tool was offered as a new research and database platform for project teams seriously pursuing the Materials Petal. Working with this group of project teams, ILFI has produced four additional affordable housing webinars – two on the Materials Petal, one on the Energy Petal, and one on green financing options. An updated Materials List for Affordable Housing projects, as well as other resources, is also being produced from the research of these and previous project teams. The second Affordable Housing Pilot Project to become certified, Rocky Road Straw Bale, achieved Zero Energy certification in May 2019.

This Phase 3 cohort includes several unique building typologies and locations that were not represented by previous phases. A few project teams also include members from past pilot projects, which has allowed for veteran team members to offer advice and experiences to those with less Living Building Challenge experience, as well as hear fresh perspectives and ideas. This has helped to flatten the LBC learning curve for new project teams and reduce the costs and time associated with education around the implementation of LBC requirements.



This report seeks to serve the same purpose – of flattening the learning curve to bring the Living Building Challenge within reach - for the entire affordable housing industry. The case studies and lessons learned throughout this document will allow future project teams to bridge any knowledge gap more quickly by learning from the pioneering group of 27 project teams now striving for the Living Building Challenge. A summary of the new resources available since the last publication of this document is provided at the end of this chapter. Below is a comprehensive list of each of the Affordable Housing Pilot Projects from all three phases of ILFI's Affordable Housing Pilot Program.

PILOT PROJECTS PHASE 1: 2013-2015

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 was 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.

Though the original design of the Rose project targeted Living Certification, the project team 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.

The Rose

LOCATION: Minneapolis, MN

DEVELOPER: Aeon, in partnership with Hope Community

PROJECT SIZE: 150,000 sf

TOTAL UNITS: 90

COST/SF: $151/SF

CONSTRUCTION COMPLETION DATE: SEPTEMBER 2015

CERTIFICATION PATH: N/A

The Rose. Image courtesy of Aeon

THE ROSE – 5 YEAR UPDATE

When developer Aeon registered the Rose under the Living Building Challenge (v2.1) in 2011, seeking to shift their thinking from "good" to "better" or "best," it was the first of its kind to do so. No other affordable housing project in the world had yet taken on the challenge of testing in a practical way how a multifamily affordable housing project could be constructed as a Living Building. This first step into the unknown paved the way for the nearly 30 affordable housing projects that have since registered and are on their way to certification. The Rose has now been occupied for more than four years. The detailed performance and occupancy analytics tracked by the project team can help inform decision-making around energy, water, and materials for subsequent projects.

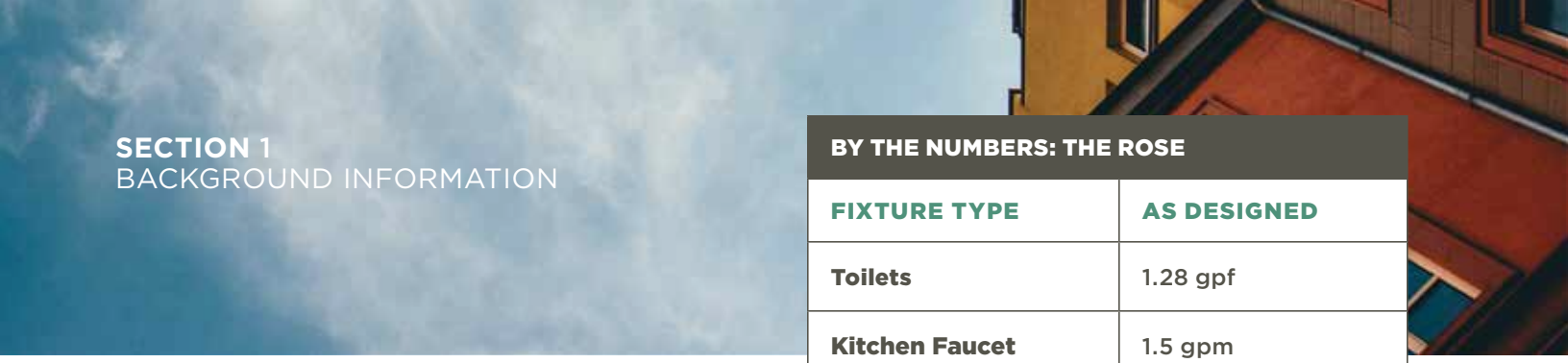
From the outset, the project team prioritized ensuring that the interiors of each unit would be Red List–Free in order to optimize the health benefits of the spaces where residents would spend the majority of their time. The project received grant funding for Red List–Free materials in these spaces that enabled them to upgrade items such as shelving, drywall, resilient flooring, paint, window treatments, countertops, and bathroom flooring. The impact of these upgrades was not only a significantly healthier living environment for residents, but also a much safer work space for the construction and development crew. Because the building did not have a "new building smell," contractors had a difficult time tracking which units had already been punched. Without the smell of VOCs and other toxins off-gassing, Aeon's project manager, who happened to be nine months pregnant when construction was nearing completion, felt completely comfortable walking around the unfinished project. While the design team acknowledges that getting full disclosure of ingredients from manufacturers was a challenge, it became easier over the course of the project's timeline.

Although water savings is typically Aeon's top priority with all buildings due to the amount spent on water bills throughout their portfolio, materials ended up being the most impactful aspect for all involved with the Rose. As a result,

Garden at the Rose. Image courtesy of Aeon

The Rose: Urban Agriculture

- 404 POUNDS OF FRESH PRODUCE HARVESTED
- 50 VARIETIES OF CROPS
- 7,500 SF GROWING SPACE
- 16 COMMUNITY COOKING NIGHTS
- COMMUNITY LED SKILL SHARES ON FACIAL TONERS, BREAD MAKING, CANNING TOMATOES, AND CHOKEBERRY JAM MAKING



BY THE NUMBERS: THE ROSE	
FIXTURE TYPE	**AS DESIGNED**
Toilets	1.28 gpf
Kitchen Faucet	1.5 gpm
Lavatory Faucet	0.5 gpm
Shower	2 gpm
Bath	-
Laundry	27 g/use
Dishwasher	7 g/use
TOTAL	**36.6 gcd**

Aeon now implements a thoughtful approach to materials within their specifications, looking for opportunities to integrate Red List–compliant products wherever possible throughout their portfolio. The integrated design process utilized on this project that involved all interested parties early on in the process has also become standard practice for the developer.

While the Red List–compliant materials have performed as expected with no additional maintenance costs, some of the energy-saving measures implemented on the project have proven more challenging. The operational EUI of the project, as measured from February 2017 to February 2018, was 58, compared to a modeled EUI of 31.8. Due to the challenging climate of the region (very cold, long winters and hot, humid summers), this is still nearly half the code-mandated EUI of 111. While the variable refrigerant flow (VRF) HVAC system has proven durable, even continuing to operate in temperatures 25 degrees below zero this past winter, it has also presented maintenance challenges. The system is too complex for the building's own maintenance staff to handle internally, so any issues that have arisen have required external professionals with expertise in the system type, which has been difficult to find within their market. The higher energy consumption of the building as compared to the model is attributed to a combination of higher ventilation and heating demands within the parking garage, suboptimal use of the roof-mounted solar thermal system, and tenant behavioral factors. In particular, natural gas is used for parking garage ventilation and within the hot water systems and has exceeded the predicted use by 20 kBtu. The solar thermal system is only heating hot water during off-peak hours, and the project does not contain enough additional storage to accommodate a greater use of this system. Tenant behavioral factors underline the need to understand the specific preferences of anticipated residents. In this case, in addition to plug load factors differing somewhat from the energy model, the project houses a large percentage of Somali residents who have generally preferred to keep their units warmer than anticipated. The project team also discovered that, while large windows offer a stunning view of the Minneapolis skyline, the south-facing units cannot be effectively cooled in the summer, requiring residents to open the windows, which thus further reduces the efficiency of the mechanical systems.

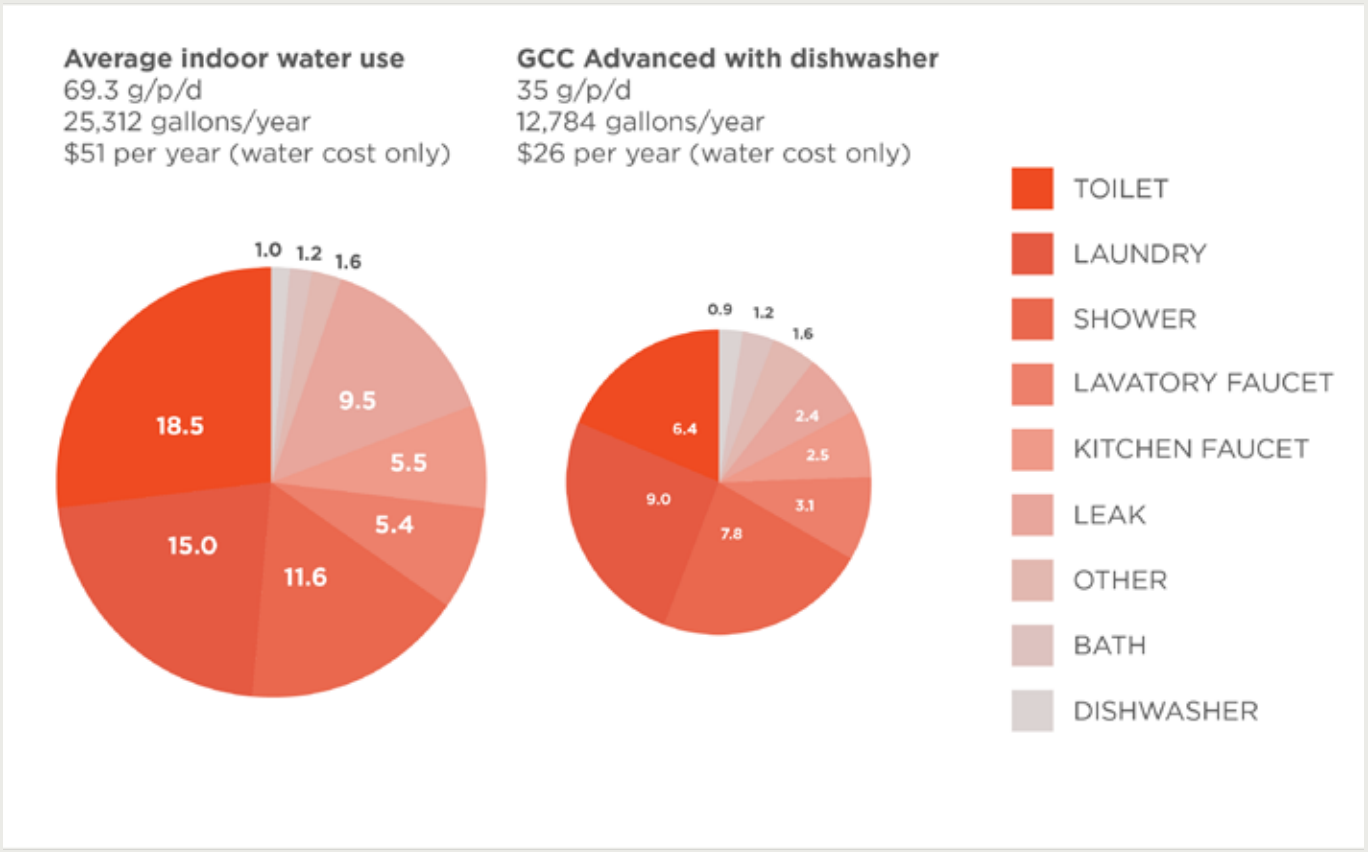
Regarding water use, the project is closer to the modeled target (35 gallons per person per day), with an average water use of 40.1 gallons per day per person—nearly half the typical daily water use for multifamily projects in the region. The performance data has indicated that more residents are home during the day than anticipated and that water use for irrigation of urban agriculture and landscaping has been higher than expected. However, the project, likely due to its very-low-flow fixtures, is actually hitting the modeled water use in all areas except irrigation, which is partially provided by collected rainwater.

The project team for the Rose took very significant steps toward net positive energy, net positive water, healthy materials, and the vision of Living Affordable Housing. The data-driven process coordinated between Aeon and the Center for Sustainable Building Research has

allowed for a precise output and interpretation of the building's performance relative to a baseline. Aeon intends to keep working with building operations staff and residents to reduce the water and energy consumption to the design standard.

The Affordable Housing Pilot Program was intended to forge a pathway within the industry of how to design for optimal human health and environmental impacts in the challenging context of a limited budget, a dense urban setting and, in this case, an extreme climate. Even while the project continues to adjust its water and energy consumption to meet its targets, the high aspirational goals of this project allowed it to surpass the sustainability and health standards of the developer's other buildings. The Rose, as ILFI's very first pilot project, showed that it is possible to nearly halve the energy and water consumption of a conventionally constructed building and provide a nearly Red List–Free interior living space. The lessons in the design and operations of this building will continue to provide valuable lessons for subsequent projects within the Affordable Housing Pilot Program and throughout the industry.

FIGURE 4: Estimated water use by end use. Comparison between standard fixtures (left) and the Rose (right).



PILOT PROJECT 2:
SOUTH SECOND STREET STUDIOS

South Second Street Studios is a four-story, 91,000 SF, mixed-use building that incorporates 79 efficiency units, 23 units for the developmentally disabled, 25 units for the chronically ill, 6 one-bedroom units, 1 two-bedroom unit, and 11,000 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 used modular construction to reduce waste, improve efficiency, and shorten the construction timeframe. 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 any anticipated cost increases. While this project never intended to pursue Living Building Challenge certification, the analysis was instrumental in reframing FCH's approach to sustainability on all their projects. One result is that First Community Housing is now pursuing the Living Building Challenge on a subsequent project, Orchard Gardens, featured below in Phase 2.

South Second Street Studios

LOCATION: San Jose, CA

DEVELOPER: First Community Housing

PROJECT SIZE: 11,000 SF Retail / 90,000 SF Housing

TOTAL UNITS: 134

COST/SF: $353/SF

CONSTRUCTION COMPLETION DATE: July 2017

CERTIFICATION PATH: N/A

South Second Street Studios. Rendering courtesy of First Community Housing

PILOT PROJECT 3:
CAPITAL STUDIOS

Capital Studios, a Single Room Occupancy (SRO) project, was the first affordable housing project to be built in downtown Austin in 45 years. The project had 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 had 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 charrette to explore a series of Living Building Challenge Petal–specific goals that they plan 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 Zero Energy Certification. The second is Lakeline Learning Center, which became the first certified pilot project in October 2018. Foundation Communities is using both of these projects as a testing ground for new financing and construction techniques that they and others will use to inform future multifamily affordable housing projects. The Institute has and will continue to provide technical assistance on both projects as appropriate.

Capital Studios

LOCATION: Austin, TX
DEVELOPER: Foundation Communities
PROJECT SIZE: 78,045 SF
TOTAL UNITS: 135
COST/SF: $205/SF
CONSTRUCTION COMPLETION DATE: November 2014
CERTIFICATION PATH: N/A

Capital Studios. Image: Paul Bardagiy

PILOT PROJECTS PHASE 2: 2015–PRESENT

PILOT PROJECT 4:
HOPEWORKS STATION PHASE II

Hopeworks Station, Phase II broke ground in April 2018 in Everett, Washington, and construction will be completed by fall 2019. The building will include three stories of housing above one floor of commercial space. The commercial space will be occupied by eight different social enterprises, including a culinary training program with a commercial kitchen, that will provide internship and training programs for the residents and others in the community. Located just two blocks from the Everett Transit Center, the building is the catalyst for a new transit-oriented development and is helping to set the standard for sustainability in the region. The project's architects and engineers came up with an iterative process for analyzing the anticipated energy savings associated with each energy reduction strategy until a sufficient combination of strategies resulted in the targeted EUI of approximately 18, less than half the expected EUI for a building in the greater Seattle region. This drastic energy use reduction should allow for the photovoltaic panels on the roof of the building and adjacent parking areas to generate at least 105% of the energy demands of the residential portion of the building. To read a case study of the specific energy reduction and production strategies, see the Energy Petal section of this document.

Hopeworks Station Phase II

LOCATION: Everett, WA

DEVELOPER: Housing Hope, Hopeworks Social Enterprises

PROJECT SIZE: 67,000 SF

TOTAL UNITS: 65

COST/SF: $323/SF

CONSTRUCTION START DATE: April 2018

ANTICIPATED CONSTRUCTION COMPLETION DATE: September 2019

CERTIFICATION PATH: Energy Petal

Hopeworks Station Phase II. Rendering courtesy of GGLO Design

PILOT PROJECT 5:
ORCHARD GARDENS

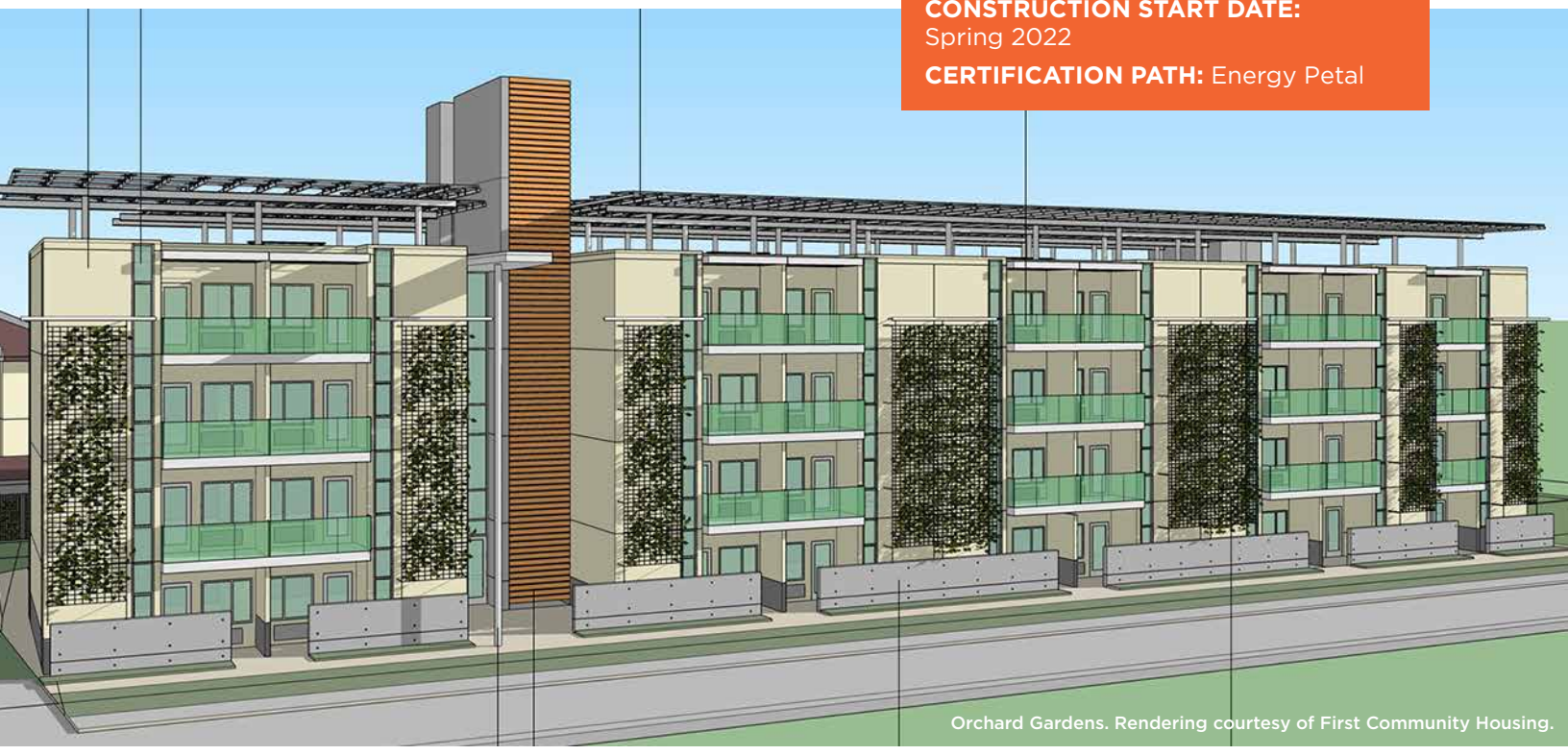
Orchard Gardens will involve the renovation of one existing residential building and the demolition and new construction of another building. New amenities will include offices, a community room, laundry facilities, a computer lab, outdoor patios, a shared-use plaza, a bicycle repair station, and a bicycle-share program. The goal of the project is to provide a healthy and regenerative environment for developmentally disabled individuals. The project is designed to be net positive energy, and also seeks to restore ecological water flows and native landscape to the site. Healthy materials and energy performance are the primary priorities, so the project team has planned to pursue the Energy Petal and a Red List Free interior of the building. The project is currently on hold due to delays in funding (unrelated to its Living Building Challenge or sustainability goals), but is expected to be underwritten in the next round of available funding and to start construction within the next three years.

"We are able to pursue the responsibility of providing housing in value-driven ways. We considered sustainability not just as physical design, but sustainability as a lifestyle."

Marty Keller, Director of Sustainability and Construction, First Community Housing

Orchard Gardens

LOCATION: Sunnyvale, CA
DEVELOPER: First Community Housing
PROJECT SIZE: 20,865 SF
TOTAL UNITS: 86
COST/SF: $410/SF
CONSTRUCTION START DATE: Spring 2022
CERTIFICATION PATH: Energy Petal



Orchard Gardens. Rendering courtesy of First Community Housing.

Lawson House YMCA Renovation

LOCATION: Chicago, IL
DEVELOPER: Holsten Development
PROJECT SIZE: 253,000 SF
TOTAL UNITS: 400
COST/SF: $296/SF
CONSTRUCTION START DATE: Early 2020
CERTIFICATION PATH: Materials Petal

PILOT PROJECT 6:
LAWSON HOUSE YMCA RENOVATION

Lawson House YMCA is an existing, 23-story 1930s art deco structure located just a few blocks from the Magnificent Mile in Chicago. The goal of the project is to preserve affordable units in a centrally located neighborhood that now has limited affordable housing options. The building will renovate what were previously 90–100-square-foot sleeping rooms with shared showering and restrooms on each floor to 250-square-foot micro-units with private bathrooms and kitchens. During construction, all residents will receive temporary housing, and they are guaranteed a spot in the renovated project once completed.

Lawson House YMCA Renovation. Image courtesy of Holsten Development and Farr Associates.

The project's integrated design process included a workshop with existing residents who articulated their priorities for the project, which ultimately helped shape the healthy environment and equity goals of the project. To read more about the community engagement process on this project, see the Process + Financing section of this document. The project will seek Materials Petal Certification. The project team also explored the Energy and Water Petals, but the limited roof and site area due to the urban core context, as well as a lack of options for storing water on site, resulted in a decision not to pursue these Petals. However, the project is targeting an aggressive EUI and plans to install best-in-class, low-flow plumbing fixtures. The project received funding through the Illinois Housing and Development Authority in 2019 and will begin construction in early 2020.

"In many ways Lawson House represents the future of affordable housing in established cities. In terms of carbon impact, there is no more sustainable building than an existing building. For cities where jobs, education, and other opportunities are concentrated in the urban core, having affordable housing that is integrated in neighborhoods that are already walkable and transit-served is essential. If we are able to save unique buildings that connect us to our past while providing a template for a high-performance, equitable, and carbon-free future, all the better."

Matthew McGrane, Farr Associates

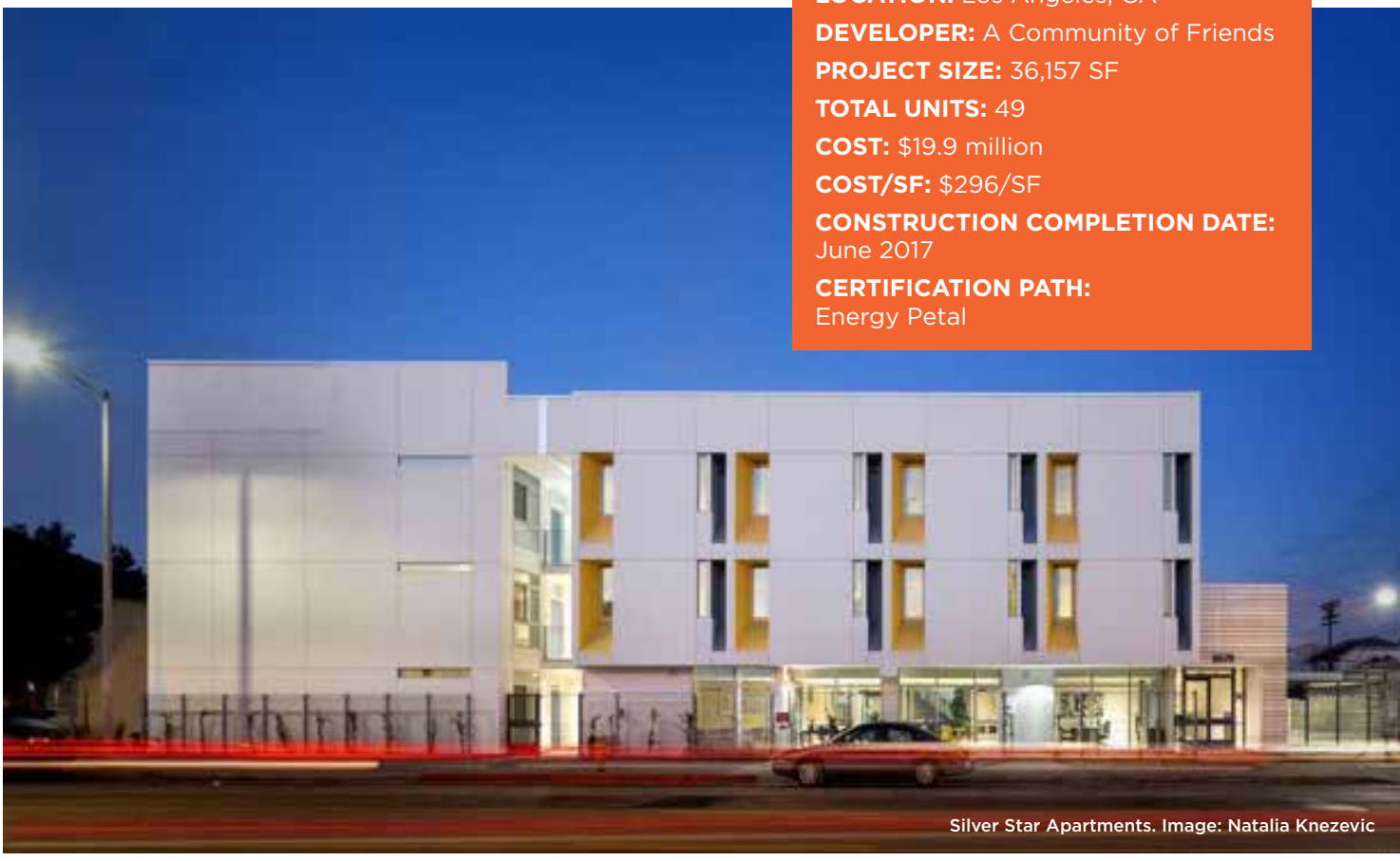
PILOT PROJECT 7:
SILVER STAR APARTMENTS

Silver Star Apartments houses veterans that are homeless and have disabilities. The project will eventually include the first permitted system for indoor greywater reuse within the city of Los Angeles. This system will save an estimated half-million gallons of water per year and reduce potable water use by 25% by reusing water for irrigation and toilet flushing. The three-story structure supports a 114 kW rooftop photovoltaic system, enabling the building to also become the first net zero affordable housing community in Los Angeles. The project is targeting Energy Petal Certification and is now investigating a 60 kWh battery storage option, which will likely far exceed the battery requirements of the Living Building Challenge.

Due to the prevalence of photovoltaics in the state of California, they are trying to minimize the amount of solar energy that must be stored by the utility or exported elsewhere. Therefore, utilities in the state have begun paying very little money for energy sold back to the grid during daytime hours. Energy sold back to the grid between 4 and 9 PM will be bought by the utility for 200-500% as much. These pricing signals change the economics of battery storage for individual projects such as this one and make larger battery storage options more financially attractive. This increased demand will likely have an influence on the battery market as well, potentially resulting in many more battery options appropriate for multi-family buildings.

Silver Star Apartments

LOCATION: Los Angeles, CA
DEVELOPER: A Community of Friends
PROJECT SIZE: 36,157 SF
TOTAL UNITS: 49
COST: $19.9 million
COST/SF: $296/SF
CONSTRUCTION COMPLETION DATE: June 2017
CERTIFICATION PATH: Energy Petal



Silver Star Apartments. Image: Natalia Knezevic

PILOT PROJECT 8:
LIBERTY LANE APARTMENTS

Liberty Lane Apartments is located in the City of Redlands, California, and is intended to serve low-income and homeless veterans. At least 75% of the units will be reserved for veterans with special needs and/or mental illnesses. The complex will include five two-story residential buildings, as well as a 4,700-square-foot community center that will provide supportive services to residents. The site will also include a community garden. The low-rise site design will allow for the buildings to utilize the roof space for photovoltaic panels and achieve the Energy Petal. This project is on hold pending a zoning matter in the local jurisdiction.

Liberty Lane Apartments. Rendering courtesy of A Community of Friends

Liberty Lane Apartments

LOCATION: Redlands, CA
DEVELOPER: A Community of Friends
PROJECT SIZE: 82,091 SF
TOTAL UNITS: 80
COST/SF: TBD
CONSTRUCTION START DATE: TBD
CERTIFICATION PATH: Energy Petal

PILOT PROJECT 9:
CEDAR SPRINGS

Cedar Springs includes four residential buildings and a stand-alone retail building on the 17-acre campus of David & Margaret Youth and Family Services. The site includes an edible garden, a children's play area, a dining terrace, and a community room. The residential buildings provide housing for very low-income residents (30-50% of the area median income [AMI]), youths transitioning out of the foster care system, and tenants with a mental health diagnosis. The project includes a greywater system that reuses 900,000 gallons of water per year for irrigation and sewage conveyance, in addition to photovoltaic panels on the roof area that are currently generating more power than the project uses. To read more about the greywater system and other water-saving strategies employed at Cedar Springs, see the Water Petal section of this document. The project is targeting Zero Energy Certification.

Cedar Springs. Image courtesy of Biohabitats

Cedar Springs

LOCATION: Los Angeles, CA
DEVELOPER: A Community of Friends
PROJECT SIZE:
TOTAL UNITS: 49
COST: $19.9 million
COST/SF: $209/SF
CONSTRUCTION COMPLETION DATE: June 2017
CERTIFICATION PATH: Zero Energy

PILOT PROJECT 10:
DEANWOOD NEIGHBORHOOD DEVELOPMENT

Deanwood Neighborhood Development will be developed as 10 to 15 single-family and rowhouse-style homes in the Deanwood area of Washington, D.C., approximately one half-mile from the Capitol Heights Metro Station. As this neighborhood is a food desert, the project will include on-site urban agriculture intended to simultaneously build community and provide healthy food options for residents. The project intends to capture and reuse rainwater on site and will contribute to restoring water quality to the Anacostia River. The units will be a model for low-income homeownership for a mix of income levels; however, all units will be affordable to households making 80% or less of the area median income (AMI). The project was initially planned to be built by the D.C. Department of Housing and Community Development, but plans changed within the agency and it will now be built by an external developer. The process for solicitation is underway and the overall vision for the project going forward is unclear at this point.

Deanwood Neighborhood Development

LOCATION: Washington, D.C.

DEVELOPER: D.C. Department of Housing and Community Development

PROJECT SIZE: TBD

TOTAL UNITS: 10-15

COST/SF: TBD

CONSTRUCTION START DATE: TBD

CERTIFICATION PATH: Living

Deanwood Neighborhood Development. Rendering courtesy of DC Dept. of Housing and Community Development (DHCD) + Dist. Dept. of Environ. (DDOE)

PILOT PROJECT 11:
MULDOON GARDEN

Muldoon Garden, which replaced a vacant blighted restaurant, was completed in December 2017 and includes 23 units. The project will provide permanent housing and is adjacent to a 50-unit temporary supportive housing structure intended for those exiting homelessness. In addition to housing, the project includes a daycare, offices, a common room, an exterior fitness space, and on-site apple trees and berry bushes. The project built upon traditional indigenous Alaskan practices for energy efficiency, such as thermal mass and passive solar heat gain. Although the orientation of the building could not be optimized due to funding restrictions that required the building to remain on its original footprint, the project still achieved an impressive EUI of 33 compared to a typical EUI in Anchorage ranging from 120-160. Due to the amount of time Alaskans spend indoors, the project prioritized healthy materials and a comfortable interior color palette that replicates the surrounding natural environment. Local woods and organic materials are used through the project to create a feeling of home, rather than an institution. The project is on track to become the first Materials Petal Certified project within the Affordable Housing Pilot Program. To read more about the materials used on Muldoon Garden, see the Materials Petal section in this document.

Muldoon Garden

LOCATION: Anchorage, AK

DEVELOPER: Rural Alaska Community Action Program (RurAL CAP)

PROJECT SIZE: 21,600 SF

TOTAL UNITS: 23

COST/SF: $238/SF

CONSTRUCTION COMPLETION DATE: December 2017

CERTIFICATION PATH: Materials Petal

Muldoon Garden. Image courtesy of Rural Alaska Community Action Program, Inc. (RurAL CAP)

PILOT PROJECT 12:
COLISEUM PLACE

Adjacent to a BART station and the Oakland Coliseum, Coliseum Place will serve as a transition from the single-family housing areas to the east and larger structures to the west. The project will provide 59 units, as well as a community room, common laundry, a fitness center, resident services, and property management offices. The design of the building is simple and efficient to control costs, which means less square footage to build, less exterior wall area, and simplified detailing of the thermal envelope. The overall sustainability approach is to utilize Passive House design methods coupled with simple, low-energy, and easy-to-maintain systems, as well as robust occupant education and feedback, as a pathway toward Energy Petal Certification. The project also plans to install Red List–Free materials on the interior of the residential units.

Coliseum Place

LOCATION: Oakland, CA

DEVELOPER: Resources for Community Development

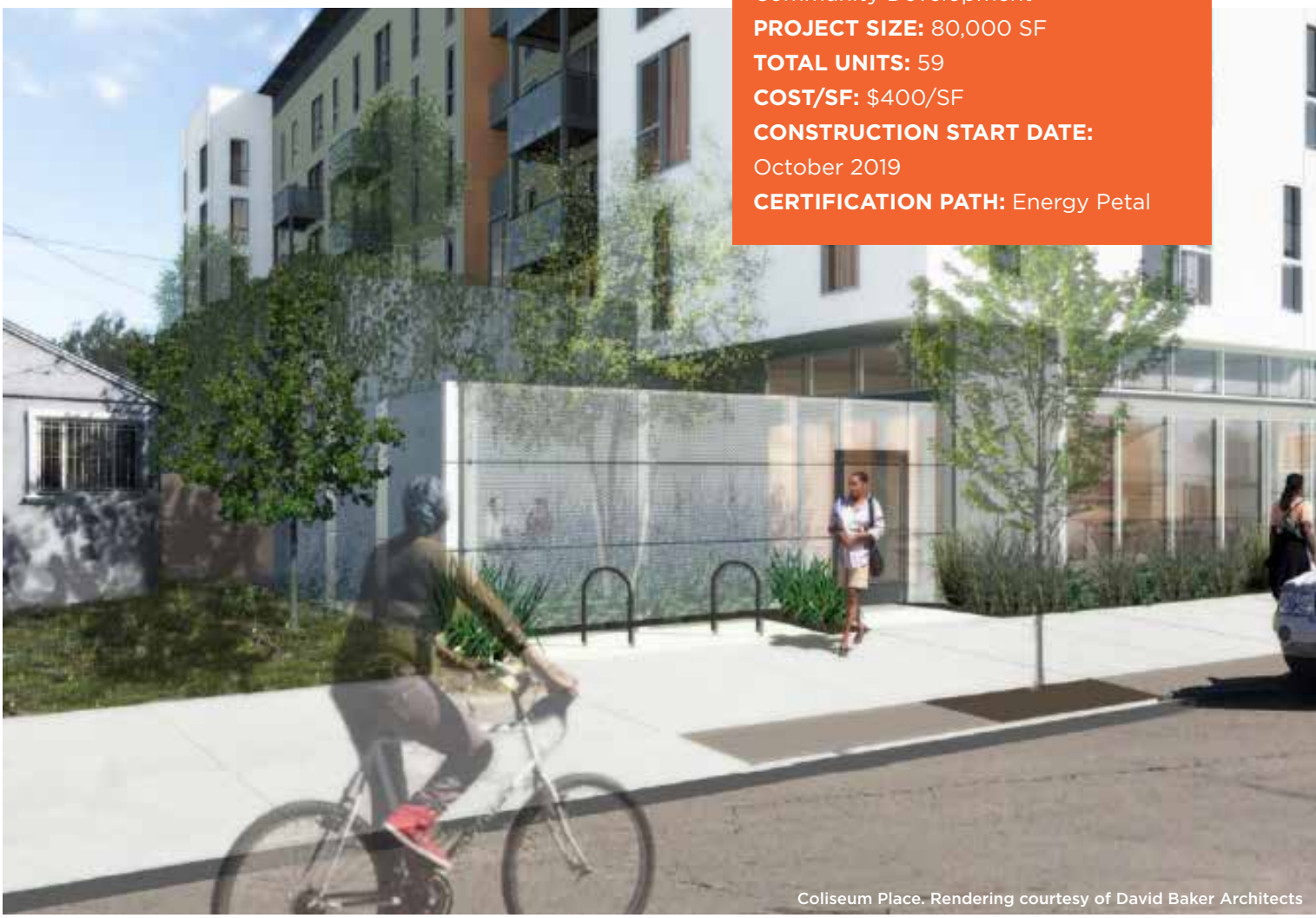
PROJECT SIZE: 80,000 SF

TOTAL UNITS: 59

COST/SF: $400/SF

CONSTRUCTION START DATE: October 2019

CERTIFICATION PATH: Energy Petal



Coliseum Place. Rendering courtesy of David Baker Architects

PILOT PROJECT 13:
LAKELINE LEARNING CENTER

Lakeline Learning Center is a 6,000-square-foot community learning center, located adjacent to the Lakeline Station Apartments. The roof-mounted photovoltaic panels produce 2,100 kWh/year, exceeding the building's energy use by more than 10%. The building is the first certified net zero commercial building in Austin. The landscaping of the site includes native low-water plantings and edible plants, such as blackberries, loquats, sunflowers, and herbs. Once established, all plants will be irrigated through captured rainwater alone. Healthy materials were also prioritized and only Red List Free materials were used on the interior of the building, with the exception of the windows. Lakeline Learning Center achieved Net Zero Building Certification in November 2018 and is the first certified project among the Affordable Housing Pilot Projects.

Lakeline Learning Center

LOCATION: Austin, TX
DEVELOPER: Foundation Communities
PROJECT SIZE: 6,000 SF
TOTAL UNITS: N/A
COST/SF: $295/SF
CONSTRUCTION COMPLETION DATE: May 2017
CERTIFICATION PATH: Zero Energy Certified
CERTIFICATION DATE: November 2018

Lakeline Learning Center. Image: Casey Chapman Ross

PILOT PROJECTS PHASE 3: 2018–PRESENT

Phase 3 Cohort includes one other project that remains confidential at this time.

PILOT PROJECT 14:
BROADWAY LOFTS

Broadway Lofts is a new affordable housing building in Gary, Indiana, at the corner of Seventh and Broadway. The City of Gary has experienced disinvestment and population loss since the 1960s, resulting in a significant rise in poverty levels and land vacancy. Broadway Lofts seeks to reverse this trend by providing high-quality affordable housing near downtown in close proximity to jobs and transit. As a participant in the Indiana Housing and Community Development Authority's Moving Forward program, the goal of the project is to achieve net-zero energy through a combination of energy-demand reduction, envelope efficiency, and on-site renewables. The project is proposing 213kW of photovoltaic panels on a combination of the building roof and an adjacent ground-mounted array. The existing residents of the neighborhood noted in early community engagement efforts that they feel the outside air is too unhealthy to breathe and they always avoid opening the windows. Therefore, the project team is seeking to make the interior spaces a healthy safe haven through the inclusion of materials that will not degrade the indoor air quality of the units. The project team is pursuing Energy or Materials certification, utilizing the Living Building Challenge as a framework to guide design. In addition to the residential units, the program includes commercial space, community space, outdoor play space, and a potential greenhouse for urban farming.

Broadway Lofts

LOCATION: Gary, IN

DEVELOPER: Miller Valentine Affordable Housing Partners

PROJECT SIZE: 39,000 SF

TOTAL UNITS: 38

COST/SF: $212

CONSTRUCTION START DATE: Winter 2019

CERTIFICATION PATH:
Energy and/or Materials Petal

Broadway Lofts. Rendering courtesy of Farr Associates

Gila River Indian Community Sustainable Housing

LOCATION: Sacaton, Gila River Indian Reservation

DEVELOPER: Gila River Indian Community and Arizona State University

PROJECT SIZE: 1,800 – 2,300 SF

TOTAL UNITS: 1 (prototype for future projects)

COST/SF: est. $100/SF

CONSTRUCTION START DATE: TBD

CERTIFICATION PATH: Living

PILOT PROJECT 15:
GILA RIVER INDIAN COMMUNITY SUSTAINABLE HOUSING

In 2016, the Gila River Indian Community (GRIC), through the governor's office, entered into discussions regarding sustainable housing with the Del E. Webb School of Construction at Arizona State University (ASU). The aim was to work collaboratively with students, faculty, and community members to explore ways to design and build sustainable homes in the community. The intent was to increase energy efficiency, integrate culturally responsive design, explore natural building techniques, and develop thinking around circular economies in sustainable home construction (including job creation and training). The tribal lands of the Gila River Indian Community, located in the hot and dry Sonoran Desert, have been inhabited by indigenous communities employing climate-sensitive architecture and design for thousands of years.

However, in recent years the community has suffered due to the employment of climate-inappropriate designs that were foisted upon the community by federal building programs, resulting in residents paying upward of $600 in cooling bills in summer months. This project, through its collaborative process, intends to rediscover the building methods and designs that work for the community both culturally and climatically. The collaboration has included a review of historical building documents, a preliminary housing design report, an adobe block-making demonstration at the GRIC Community Fair, a housing survey, a sustainable housing design charrette, the co-design and co-build of a traditional shade structure, and a mobile design lab in the community. The purpose of this process was to create a sustainable and contextual prototype to be used to build more multigenerational housing in the community.

Gila River Community Sustainable Housing. Student rendering courtesy of Wanda Dalla Costa, Arizona State University.

PILOT PROJECT 16:
SUN VALLEY ECO-DISTRICT PHASE I

Sun Valley EcoDistrict (SVED) Phase 1 is the first of a multiphase redevelopment of the Sun Valley neighborhood in Denver, Colorado. This historically low-density, low-income community along the banks of the Platte River is poised to create a new model of community transformation with equity, environmental justice, and public health as its driving forces. SVED Phase 1 is a seven-stories-above-grade, steel-frame building with steel-framed wall assemblies, amenity space, a rooftop garden, and one level of parking below grade. The building will deliver 138 dwelling units through a mixed-use and mixed-income approach. The basic design approach is an integrated design team and stakeholder facilitation focusing on regenerative economy, cultural amenities, food systems, and capacity building. SVED Phase 1 is committed to a sustainability approach incorporating district-level energy, on-site renewable energy, high-efficiency windows, high-efficiency interior and exterior lighting, low-flow plumbing fixtures, high-efficiency heating and cooling equipment, and high-efficiency water heaters. The project is targeting Net Positive Carbon and Living Building Challenge Energy Petal Certification.

Sun Valley Eco-District Phase I
LOCATION: Denver, CO
DEVELOPER: Sun Valley Eco-District Trust
PROJECT SIZE: 190,000 SF
TOTAL UNITS: 138
COST/SF: $184/SF
CONSTRUCTION START DATE: TBD
CERTIFICATION PATH: Energy Petal

Sun Valley Eco-District. Rendering courtesy of Sun Valley Eco-District Trust

PILOT PROJECT 17:
FIFTH AVENUE APARTMENTS

Fifth Avenue Apartments will include a mix of studios, one-, two-, and three-bedroom units to serve a wide variety of households. Smaller units will be reserved for homeless veterans and individuals on the State Referral Network; all other units will be reserved for households with incomes ranging from 30–60% AMI. The site features a landscaped pathway leading to outdoor seating and dining, recreation, and garden areas. The project team intends to use the building as a demonstration project in order to develop an advocacy tool for environmentally friendly design strategies in affordable housing in the state of Illinois.

Fifth Avenue Apartments
LOCATION: Maywood, IL
DEVELOPER: Interfaith Housing Development Corp.
PROJECT SIZE: 76,950 SF
TOTAL UNITS: 72
COST/SF: $183/SF
CONSTRUCTION START DATE: June 2019
CERTIFICATION PATH: Energy Petal

Fifth Avenue Apartments. Rendering courtesy of HARLEY ELLIS DEVEREAUX Design

PILOT PROJECT 18:
OTHELLO SQUARE HOMEOWNERSHIP BUILDING

The Othello Square Affordable Homeownership Building is a 68-unit limited equity co-op that will provide affordable ownership to low-income individuals and families with household income of 80% or less of AMI in an ethnically diverse area of southeast Seattle. Located in a city-designated urban village with access to public transit, the building is one component of a larger infill development of four integrated buildings designed to create efficient links between education, business development, and community health resources. The development seeks to ensure that all residents and neighbors have what they need to achieve and maintain health and well-being. The integration of sustainability goals with the equitable development goals of the project is a fundamental belief of the project team, thereby creating socially just housing that provides a resilient and regenerative home for all its inhabitants. The project is pursuing Materials Petal Certification. To read more about the materials strategy on the project, see the Materials Petal section in this document.

Othello Square Homeownership Building

LOCATION: Seattle, WA
DEVELOPER: Homesight
PROJECT SIZE: 70,805 SF
TOTAL UNITS: 68
COST/SF: TBD
CONSTRUCTION START DATE: Fall 2019
CERTIFICATION PATH: Materials Petal

Othello Square Homeownership Building. Rendering courtesy of Sundberg Kennedy Ly-Au Young Architects

PILOT PROJECT 19:
GREENWAY MEADOWS

Greenway Meadows will be a 39-unit affordable senior housing development in Santa Monica, California. This development, located in the Pico neighborhood, will be Community Corporation of Santa Monica's first senior housing project. The Pico neighborhood is a working-class area that is the most ethnically diverse neighborhood within the city. The building will employ green design features, such as solar panels, native, drought-tolerant landscaping, and water-saving plumbing fixtures.

Greenway Meadows
LOCATION: Santa Monica, CA
DEVELOPER: Community Corporation of Santa Monica
PROJECT SIZE: 21,527 SF
TOTAL UNITS: 39
COST/SF: $587/SF
CONSTRUCTION START DATE: April 2019
CERTIFICATION PATH: Energy Petal

Greenway Meadows. Rendering courtesy of Community Corporation of Santa Monica

PILOT PROJECT 20:
ALDER PLACE

Alder Place, located in East Chicago, Indiana, is a participant in the Indiana Housing and Community Development Authority's Moving Forward program. The building is intended to address an urgent need for quality affordable housing in the area, as well as to help alleviate serious environmental issues that have plagued the neighborhood. The goal of the project is to achieve Net Positive Carbon through a combination of energy-demand reduction, envelope efficiency, and on-site renewables. The project will include a multifamily "hub" building with a potential to also include ancillary single-family homes in nearby infill lots. The project will also incorporate health and community services to address the holistic needs of residents.

Alder Place
LOCATION: East Chicago, IN
DEVELOPER: Up Development, LLC
PROJECT SIZE: 40,000 SF
TOTAL UNITS: 40
COST/SF: TBD
CONSTRUCTION START DATE: Summer 2019
CERTIFICATION PATH: Energy Petal

Alder Place. Rendering courtesy of UP DEVELOPMENT, LLC and Cordogan Clark & Associates

PILOT PROJECT 21:
HUNTERS VIEW PHASE III

Hunters View Phase III Affordable Housing is the final piece of the master-planned redevelopment of the Bayview Hunters Point public housing neighborhood on the eastern edge of San Francisco. This affordable housing project encompasses three parcels, including a new public park and amenities that will serve the larger community. The 109 new affordable homes will contribute to the overall replacement and expansion of the previous, decrepit, barracks-style public housing built in 1956. As a discrete part of a comprehensive multiphase development, this project offers a unique opportunity to explore the intersection of place, social equity, health, and well-being. Project sustainability goals include on-site storm water management, including the integration of cisterns and bioswale treatment areas; exploration of innovative strategies for on-site wastewater treatment; and analysis of embodied energy and life-cycle carbon of the materials used. The project is planning for Energy Petal Certification and for at least all interior materials to be Red List compliant.

Hunters View Phase III

LOCATION: San Francisco, CA
DEVELOPER: The John Stewart Company
PROJECT SIZE: 171,000 SF
TOTAL UNITS: 109
COST/SF: $480/SF
CONSTRUCTION START DATE: August 2020
CERTIFICATION PATH:
Energy or Materials Petal

Hunters View Phase III. Rendering courtesy of David Baker Architects

The Block Project

LOCATION: Seattle, WA

DEVELOPER: Facing Homelessness

PROJECT SIZE: 125 SF

TOTAL UNITS:
1 DADU per each lot

COST/SF: TBD

CONSTRUCTION START DATE: varies

CERTIFICATION PATH: varies from Energy Petal to Living

PILOT PROJECT 22:
THE BLOCK PROJECT

BLOCK Architects builds homes for those living on the streets, and takes the bold stand that we will never end homelessness through housing alone. A new approach is needed, one that acknowledges that relationships are the building blocks for healing our communities, and we can no longer see those who are homeless as "other." The BLOCK Project integrates into existing neighborhoods by placing 125 square foot Detached Accessory Dwelling Units (DADU) in backyards. These BLOCK Homes are fully functioning units, including a kitchenette and bathroom with running water, heat, sleeping and sitting area, storage, and covered front porch. The project developers believe that taking care of our community means taking care of our planet, which is why it is their goal to build the homes to meet the Living Building Challenge. The project plans to certify 10-20 homes over the next several years. The initial projects are intended to achieve Energy Petal Certification, while subsequent projects are being designed to achieve Living Certification. Their vision is to make this model accessible nationwide and create a foundation of compassion and empathy for future generations.

The BLOCK Project. Rendering courtesy of BLOCK Architects + Facing Homelessness

The Projects at Mill Creek

LOCATION: Moab, Utah
DEVELOPER: Community Rebuilds
PROJECT SIZE: 6,438 SF
TOTAL UNITS: 4
COST/SF: TBD
CONSTRUCTION START DATE: Fall/Winter 2019
CERTIFICATION PATH: Living

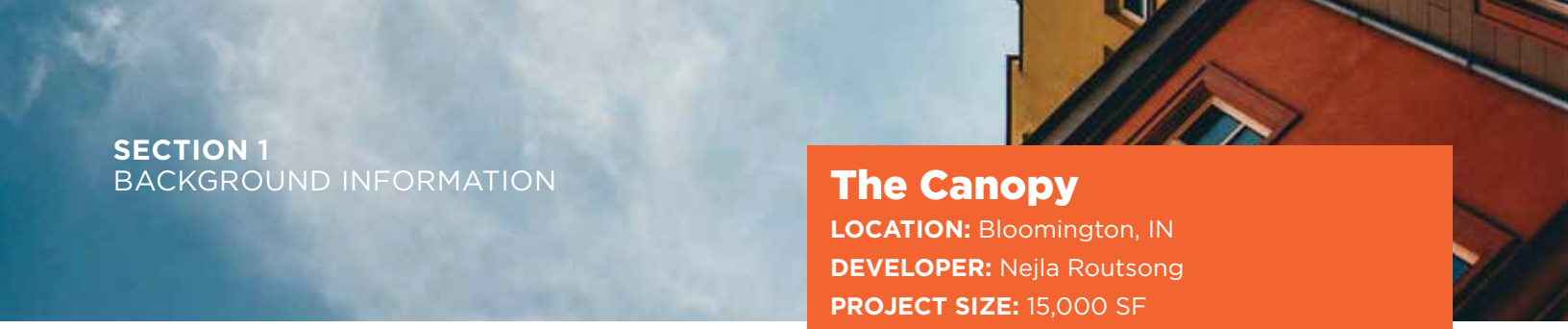
The Projects at Mill Creek. Rendering courtesy of Architectural Nexus, Inc.

PILOT PROJECT 23:
THE PROJECTS AT MILL CREEK

The Projects at Mill Creek are a cluster of four single-family homes in Moab, UT, seeking Living Certification. By partnering with designers at Architectural Nexus, Inc, Community Rebuilds is elevating its model to go beyond zero energy and become regenerative. Community Rebuilds has been building energy-efficient straw bale homes, many of which are zero energy, and educating students on best building practice since 2010. A previous project, Rocky Road Straw Bale, was recently certified Zero Energy. The Institute is working with Community Rebuilds to certify all of their past projects that have been performing at Zero Energy for at least a year. Undertaking the Living Building Challenge solidifies Community Rebuilds' commitment to build the best buildings possible and to prove that healthy and regenerative homes should be for everyone.

These homes will bring attention to water vulnerability and solutions in Moab's desert ecosystem and will change Community Rebuilds' material palette for many projects to come.

Community Rebuilds is a 501(c)3 nonprofit corporation whose mission is to build energy efficient housing, provide education on sustainability, and improve the housing conditions of the workforce through an affordable program. They construct affordable and energy efficient straw bale homes, working with and training a dedicated group of student intern volunteers on each home project. These students are emerging professionals with the desire to participate in an experiential program as they learn how to build low-carbon, modern, and natural buildings.



The Canopy

LOCATION: Bloomington, IN
DEVELOPER: Nejla Routsong
PROJECT SIZE: 15,000 SF
TOTAL UNITS: 57
COST/SF: TBD
CONSTRUCTION START DATE: TBD
CERTIFICATION: Energy Petal

University Square

LOCATION: Saint Louis County, MO
DEVELOPER: Urban Clarke Developers
PROJECT SIZE: 46,000 SF
TOTAL UNITS: 40
COST/SF: TBD
CONSTRUCTION START DATE: TBD
CERTIFICATION PATH: Energy Petal

Veridian at County Farm

LOCATION: Ann Arbor, MI
DEVELOPER: Avalon Housing
PROJECT SIZE:
TOTAL UNITS: N/A
COST/SF: TBD
CONSTRUCTION START DATE: June 2020
CERTIFICATION PATH: Energy Petal

PILOT PROJECT 24: THE CANOPY

The Canopy will be a mixed-income, ecologically restorative, rental co-housing community with 41 studio units. The Canopy aims to be Bloomington, Indiana's first Living Building Challenge Petal Certified project. Biophilic design will connect residents to their physical surroundings. The project will synergize with the adjacent city park and the nearby multiuse trail, which connects the neighborhood to the downtown, in the spirit of promoting a healthy community. A Net Positive Carbon building will help residents lighten their ecological footprints and will strengthen the status of Bloomington as a solar energy leader in the state. The developer seeks to raise the bar for private development by demonstrating that affordability, sustainability, and profitability are not mutually exclusive.

"As a rental housing developer and as a lecturer in social entrepreneurship and sustainable business at Indiana University, I am constantly asking myself, 'How can I make rental housing better?' Sustainable business practitioners look to improve existing industries to make them better for the natural environment, better for people's health and more economically just. So my plan for The Canopy speaks to all of these areas. The building will have Living Building Challenge petal certification as a net-positive energy building, at least 20% of the units will be designated as affordable housing, and the space is being designed in a way that will lead to a thriving community for the residents."

Nejla Routsong, Developer, The Canopy

PILOT PROJECT 25: UNIVERSITY SQUARE

University Square is a transit-oriented development located near the University of Missouri in Saint Louis County, Missouri. The project will include a mix of market-rate and affordable units. The project has a focus on connecting occupants to healthy, local food and lifestyle choices. As such, the project plans to incorporate an organic market, restaurant, and coffee shop in collaboration with a local farm and the university. The project will also include bicycle infrastructure in order to connect to the nearby Ted Jones Trail, which runs for two miles and connects the University of Missouri to the neighboring cities of Ferguson, Normandy, and Cool Valley.

PILOT PROJECT 26: VERIDIAN AT COUNTY FARM

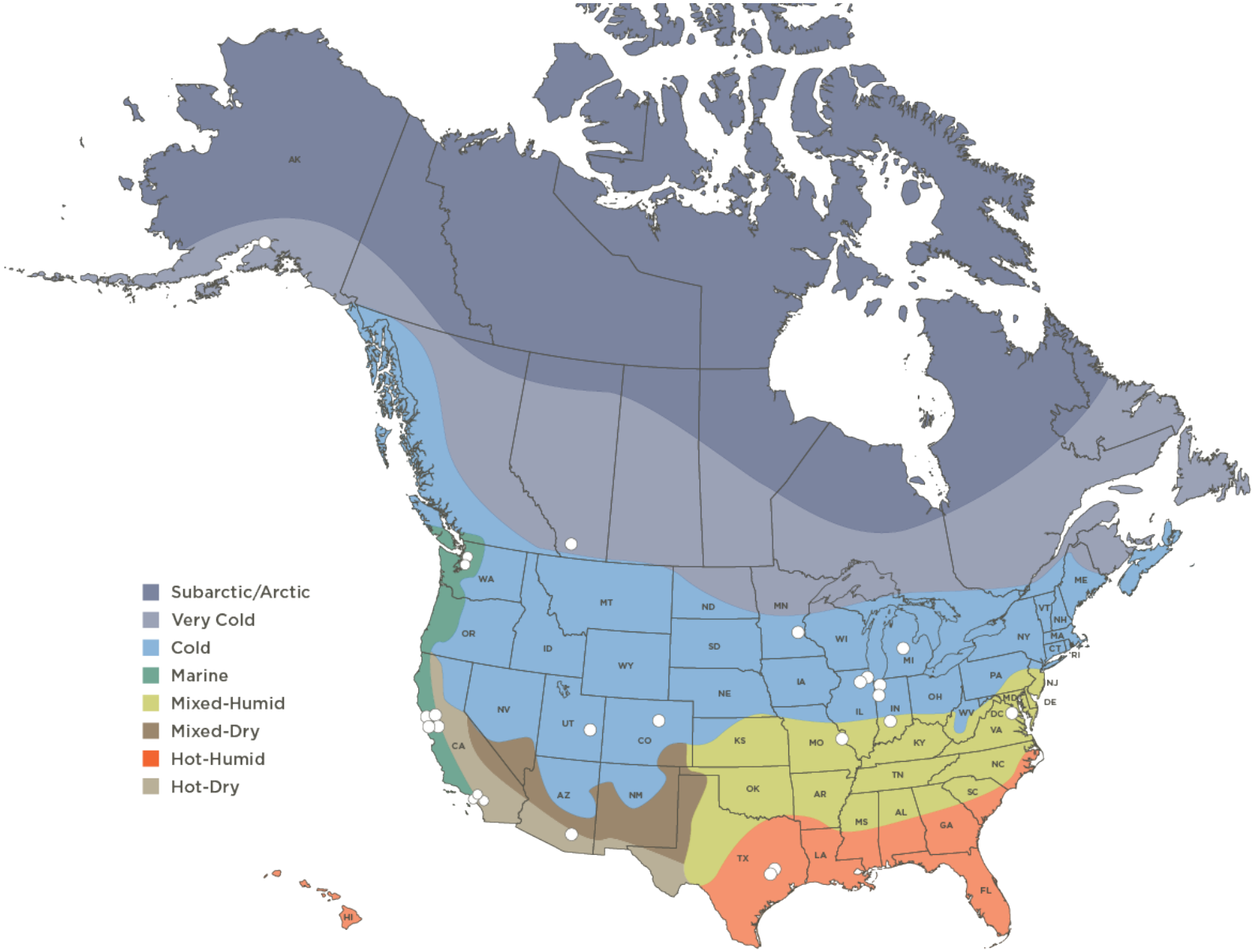
Veridian at County Farm will be located on a 13.5-acre parcel adjacent to the 141-acre Washtenaw County Farm Park. This development will be a 100% electric, mixed-income community, including 50 affordable units developed by Avalon Housing and 75 market-rate, for-sale units developed by Thrive Collaborative. Avalon will be developing a community building as part of this site. The community building will provide opportunities for residents of both developments to connect with each other, access support services to help them maintain housing stability (such as crisis response, case management, youth programs, and community building), and reduce the isolation and stigma that often accompany the previously homeless. The project team is planning to achieve Net Positive Carbon by designing a highly energy efficient building through thoughtful window and insulation selection, incorporation of heat pump systems, orientation of buildings, site and roof design, and on-site photovoltaic power systems.

Resources

Living Building Challenge 4.0 Standard
The LBC 4.0 Standard outlines all Petals, Imperatives, and pathways that project teams may use for LBC 4.0 Certification.
https://living-future.org/lbc/

Core Green Building Certification
The Core Green Building Certification provides the pathways for the 10 Imperatives needed to be achieved as best practices for any sustainable building.
https://living-future.org/core/

FIGURE 5: Climate zones and locations of Affordable Housing Pilot Program projects.



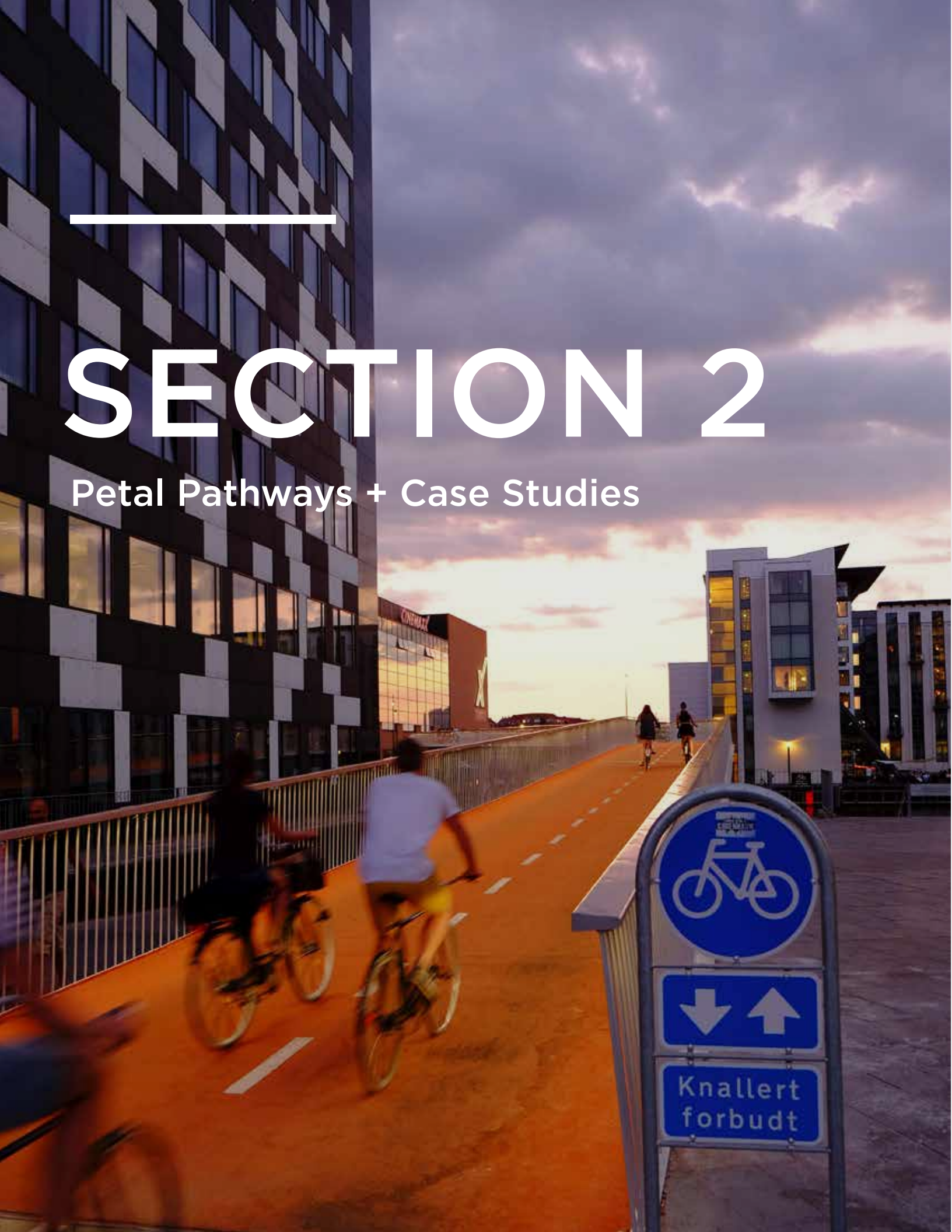
Resources cont.

Zero Carbon Certification
ILFI's Zero Carbon Certification program details and certification requirements are outlined on the website below.
https://living-future.org/zero-carbon-certification/

Zero Energy Certification
ILFI's Zero Energy Certification program details and certification requirements are outlined on the website below.
https://living-future.org/net-zero/

ILFI Affordable Housing Pilot Program
Access all resources, webinars, and learn more about each pilot project.
https://living-future.org/affordable-housing/#lbc-affordable-housing-projects

FIGURE 6: Climate typology of Affordable Housing Pilot Program projects.



SECTION 2

Petal Pathways + Case Studies

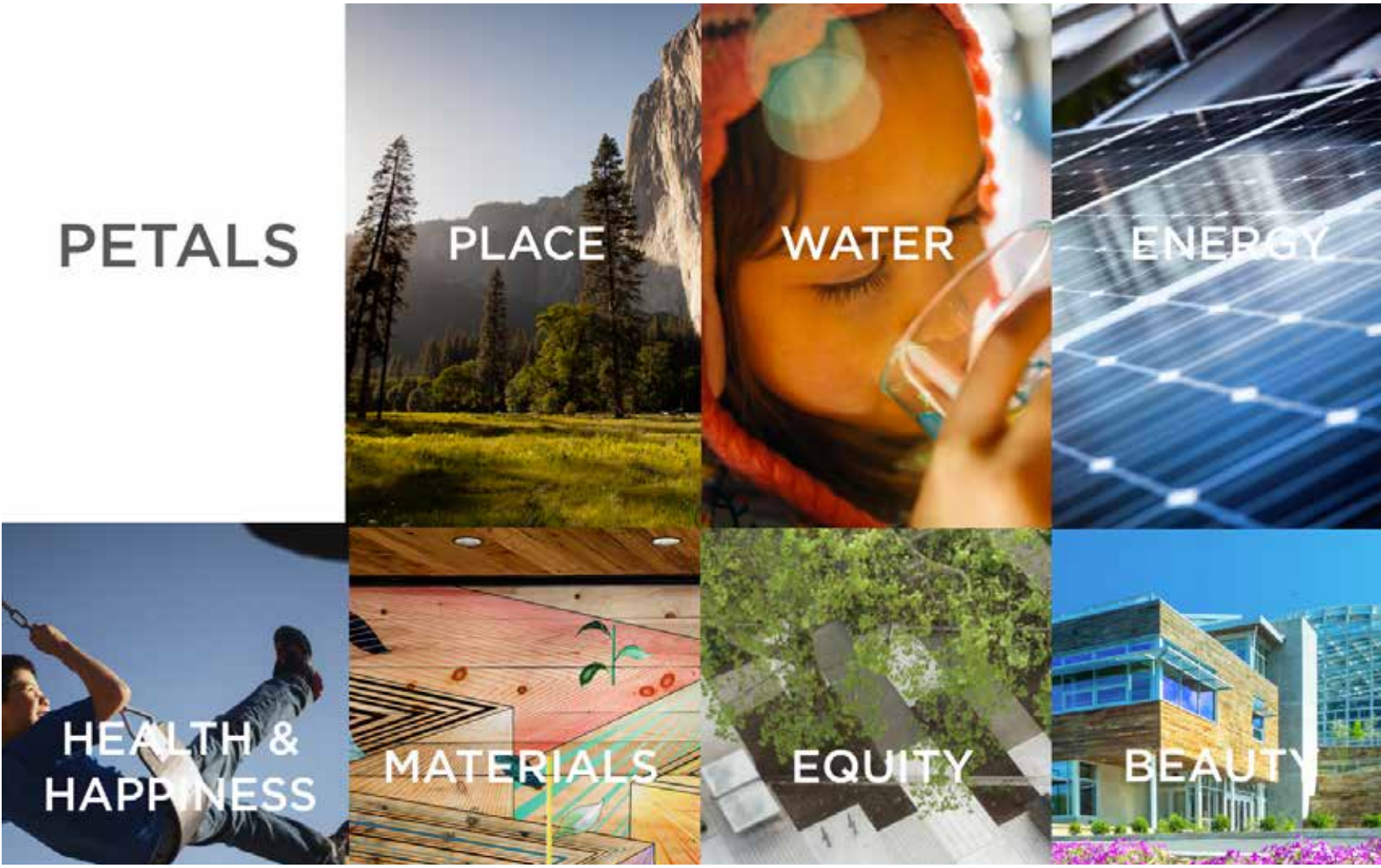
SECTION 2
PETAL PATHWAYS + CASE STUDIES

PATHWAYS TO CERTIFICATION

The strategies necessary to achieve each Petal are discussed in depth in this section. The most ambitious Petals in the Challenge (Energy, Water and Materials) pose significant challenges, but also offer an important opportunity to improve the quality, as well as the social and environmental impacts, 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 stated goals of most affordable housing projects and provide significant benefit to both tenants and the surrounding communities.

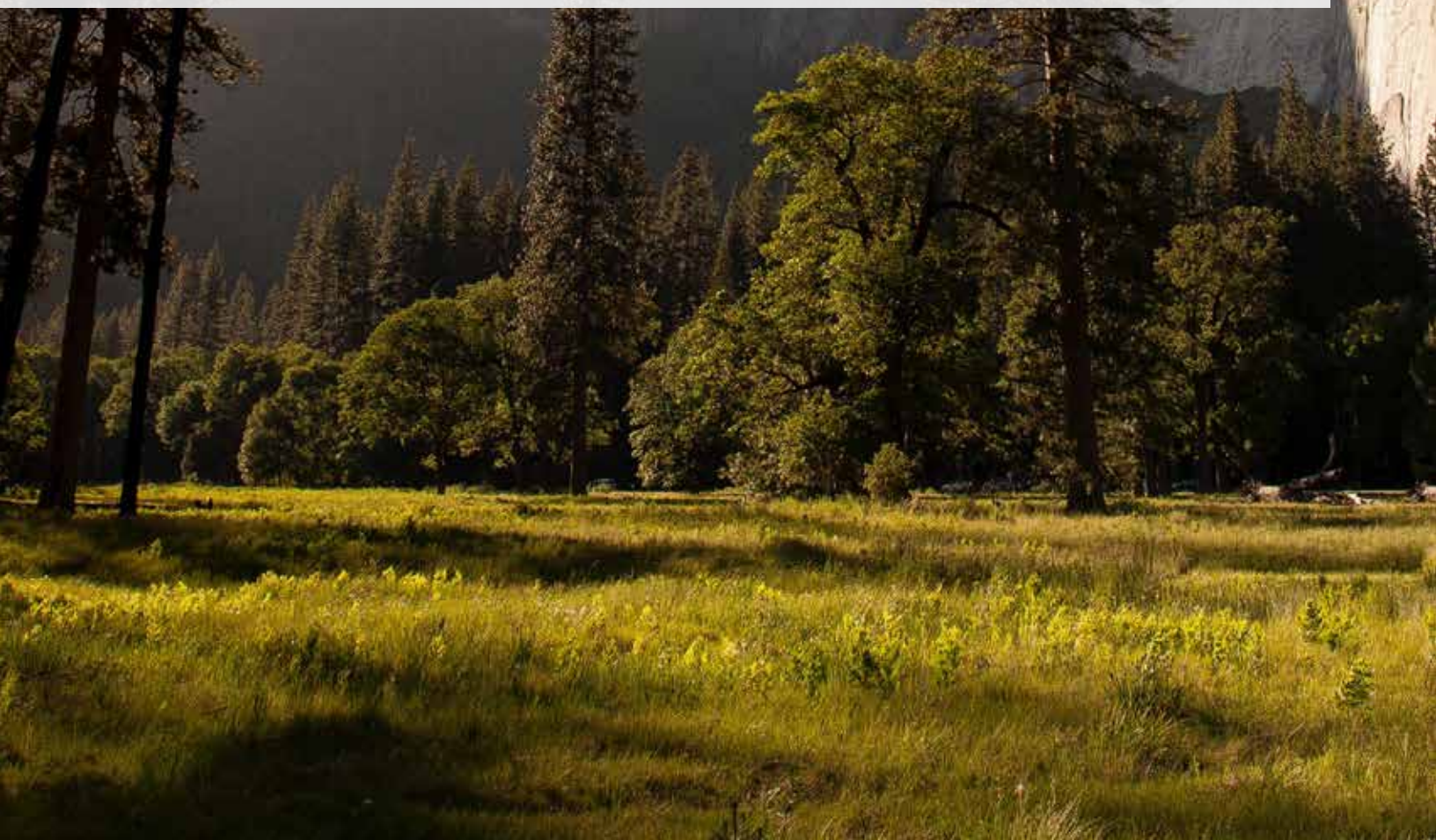
"The Living Building Challenge helped me as a developer and my design team push the boundaries of what we would normally try to achieve through our design. I'm glad we studied each of the petals, as we ended up incorporating elements from some of the petals we didn't pursue."

Alex Pereira, Project Analyst, UP Development



PLACE

Restoring a Healthy Relationship Between Nature, Place and Community



"We always do a site analysis, but somehow because of the Pilot program participation, it seemed that the analysis went a little deeper than normal and looked at existing natural resources more closely."

Susan King, Principal + Studio Leader: Housing + Education, Harvey Ellis Deveraux

PETAL INTRODUCTION

The intent of the Place Petal is to realign how people understand and relate to the natural environment that sustains us. The Imperatives, particularly I-01 Ecology of Place and I-03 Habitat Exchange, seek to protect those irreplaceable, still-wild habitats that remain. This is achieved primarily through avoiding construction on sensitive ecological habitats, as well as protecting pristine habitat equal to the amount of land developed. Other requirements ensure that the development of projects contributes positively to the natural and human community. Concurrently, other Place Petal requirements ensure that development of the project provides a humane, pedestrian-oriented environment that connects with the specific culture of the region, including connecting project occupants to locally grown food.

The Place Petal addresses two critical issues for low-income communities—access to healthy food and the cost/ease of transportation. According to the U.S. Department of Agriculture, over half of residents living in communities classified as food deserts are low-income.[7] Not only do residents of food deserts spend more time commuting to grocery stores, they often are forced to buy groceries from small corner shops where food is costlier and healthy food options are less abundant. Many of these same communities are classified as "food swamps," meaning that they not only lack access to fresh, healthy food options, but they are also inundated with a plethora of unhealthy fast-food restaurants. In the poorest socioeconomic areas, it has been reported that residents have 2.5 times more exposure to fast food than other communities.

Transportation is a key and often overlooked component in household budgets. It is commonly held that housing and transportation costs should account, together, for no more than 45% of total monthly income. Costly means of commuting, such as driving long distances in a single-occupancy vehicle, have a significant negative impact on overall household budgets. One report showed that the working poor spend 6.1% of their income on commuting, compared to only 3.8% for other households, and this burden increases to 8.4% for low-income residents who drive to work.[8] This is not just a financial issue, however, as access to efficient and affordable public transportation has also been linked to economic mobility.[9] The advent of bike-shares blossoming in neighborhoods throughout the nation offers a means of cheap and pleasant transportation for affordable housing residents, particularly those located in dense, urban neighborhoods. However, as of yet, the majority of these bike-share programs have been prioritized in higher-income areas and often require credit card or smart phone applications, locking out residents that lack one or both of these things.

Locating the project in a transit-served neighborhood and prioritizing low-access bike-share options and infrastructure (see best practices described in I-04 Human-Scaled Living) can help alleviate the economic and social burdens associated with long commutes.

The requirements of Imperatives under the Place Petal align particularly well with affordable housing project goals with few associated barriers. Often affordable housing projects are located in previously developed and primarily urban areas that do not threaten sensitive ecological areas. The two Core Imperatives (required for all CORE, LBC Petal, or LBC Living Certified projects), I-01 Ecology of Place and I-04 Human-Scaled Living, include elements that are typically already prioritized in affordable housing developments and, if not already explicitly in project plans, can be implemented at little or no cost to enhance the effectiveness of the building and the organizational mission.

7 https://www.dosomething.org/us/facts/11-facts-about-food-deserts
8 https://www.brookings.edu/research/commuting-to-opportunity-the-working-poor-and-commuting-in-the-united-states/
9 https://www.theatlantic.com/business/archive/2015/05/stranded-how-americas-failing-public-transportation-increases-inequality/393419/

PLACE

CORE IMPERATIVE 01

ECOLOGY OF PLACE

The intent of this Imperative is to protect wild and ecologically significant places and encourage ecological regeneration and enhanced function of the communities and places where projects are built.

- All projects must avoid building on pristine greenfield, wilderness, prime farmland or in a floodplain unless they meet an exception. Project must preserve thriving vibrant ecological environments and habitats.
- All project teams must document site and community conditions prior to the start of work, including but not limited to identification of the project's "reference habitat(s)."
- All projects must demonstrate that they contribute positively to the ecology of their place and restore or enhance the ecological performance of the site towards a healthy ecological baseline On-site landscape must be designed to mature and evolve, and emulate the functionality of the reference habitat, as appropriate to the project's Transect.
- All project teams must assess cultural and social equity factors and needs in the community and consider those identified needs to inform design and process decisions.
- No petrochemical fertilizers and pesticides can be used for the operation and maintenance of the on-site landscape, including urban agriculture.

Given the context of most affordable housing developments within previously established communities, as well as an inherent commitment to improve social equity, improving the ecological performance of the site and considering social equity factors are unlikely to be roadblocks to successfully achieving Imperative I-01. When a project is built on a previously developed site with no native habitat, project teams will need to investigate to understand what the native habitat of the site was and to understand current ecological conditions and concerns in the area. This information should be used to inform the project design, especially the landscape design, so that the measures the project team take contribute positively to the health of the ecosystem and work towards restoring some of the ecological function of that ecosystem. One project alone cannot do that alone, but the project should improve the conditions and contribute positively over time. For most small projects working in previously developed areas, experienced landscape architects and civil engineers should be able to perform the analysis and studies needed. In some cases, though, it may be necessary to work with a biologist or ecologist.

The requirement for project teams to assess cultural and social equity factors and needs in the community and consider those identified needs to inform design and process decisions intends to have a profound positive impact on communities as projects get built – regardless of whether the project is an affordable housing project or not. The intent is for all projects to reflect and address the culture history, traditions, and needs of the communities which they are a part of, and to directly benefit the community as a whole, not just the users of the project. For affordable housing projects, this goal is often a core part of the mission of the organizations and developer involved and the project itself.

"The Living Building Challenge was the first metric where I saw my [indigeneous] culture reflected."

Wanda Dalla Costa, Institute Professor, The Design School + Associate Professor, Del E Webb School of Construction, Arizona State University

Given this experience, affordable housing practitioners, likely have much to offer the larger design and construction industry as it learns to design for social equity and community health. Some of the case studies found later in this section provide inspiring examples of how this work is being done on a couple of affordable housing projects.

PLACE

IMPERATIVE 02

URBAN AGRICULTURE

SCALE JUMPING PERMITTED

The intent of this Imperative is to integrate opportunities for connecting the community to locally grown fresh food.

- All projects must dedicate a portion of their total project area to growing food, or they must dedicate a smaller portion of their total project area to growing food and must also directly provide weekly community access to healthy local food that address a community need, through farmers markets, CSA programs, or other local food producers.
- Scale jumping can be used as the means to expand the availability of healthy, local food (thorugh agriculture or other means) to a specific population or the community in general via an off-site location such as a food back, school, or other community resource.

Resilience Strategy

- All projects (except residential projects) must provide access to food for 75% of FTE occupants for a minimum of three days during an emergency.
- Residential projects must demonstrate the capacity to store at least a two-week supply of food.

LIVING TRANSECT	Percent of total project area for Agriculture	
	PATHWAY 1: Agriculture only	**PATHWAY 2:** Agriculture + food access
1	5%	2% + weekly access
2	20%	10% + weekly access
3	15%	7% + weekly access
4	10%	5% + weekly access
5	5%	2% + weekly access
6	2%	0% + weekly access

"I have something important to contribute. I can teach others. I appreciate food even more now that there are people who are interested in my food story."

Intern at the Rose, Aeon[10]

Urban agriculture is a growing and popular amenity within affordable housing projects. Community engagement activities often reveal that health issues, including a lack of access to healthy food options and the ability to grow their own food, rank as top priorities for residents. Developers will want to ensure that operations or program staff are aware of the planting, irrigation, and harvesting plan for the urban agriculture areas. Formal harvesting plans may not be necessary within multifamily projects, as past projects have found that residents will collect and harvest food as part of their daily routines. Using native, edible plantings is also recommended to decrease maintenance and irrigation needs. Though there are some additional up-front costs associated with urban agriculture, they are usually minimal. The primary issue can be finding enough room on site; however, project teams also may choose to fulfill the intent of this Imperative by combining urban agricultural areas with providing access to local farmers markets or CSAs.

PLACE

IMPERATIVE

03

HABITAT EXCHANGE

The intent of this Imperative is to protect land for other species as more and more land is taken for human use.

All projects must set aside land equal to the project area (or 0.4 hectares/1 acre, whichever is greater) away from the project site, in perpetuity, through an approved land trust organization or the Institute's Living Future Habitat Exchange Program.

Affordable housing projects do not typically have large site areas. There are two primary options available to affordable housing projects – donate to an accredited land trust or donate to the Living Future Habitat Exchange.

For the first option, accredited trusts can be found using the Land Trust Alliance's locator tool. For the purposes of LBC compliance, approved land trusts are either accredited trusts or, alternatively, non-accredited trusts responsible for the purchase and/or permanent easement, as well as ongoing stewardship and conservation, of land in contiguous tracts of at least 100 acres. Non-accredited trusts must adhere to the Land Trust Alliance Standards and Practices. The cost per acre depends upon the particular land trust selected; however, project teams report expenses of approximately $1,000 - $5,000 per acre.

For the second option, the Living Future Habitat Exchange aggregates monetary resources from all participating project teams and makes one annual high-impact purchase of a large, contiguous tract of intact ecosystem in partnership with an international organization. The single-acre offset will cost $2,000.

10 https://www.aeon.org/wp-content/uploads/2019/06/The-Rose-Study.pdf?utm_source=Aeon+Email+List&utm_campaign=8f94a49cb0-EMAIL_CAMPAIGN_2019_01_15_10_32_COPY_04&utm_medium=email&utm_term=0_c4bdd692d6-8f94a49cb0-296170641

PLACE

CORE IMPERATIVE

04

HUMAN-SCALED LIVING

SCALE JUMPING PERMITTED

The intent of this Imperative is to contribute toward the creation of walkable, pedestrian-oriented communities that reduce the use of fossil fuel vehicles.

All projects must maintain or increase the density of the site and support a human-powered lifestyle.

All projects (except single family residential) must also:

- Be built to a human scale that is appropriate for the neighborhood
- Provide places for occupants to gather and connect with the community
- Provide sufficient secure, weather-protected storage for human-powered vehicles and facilities, such as showers and lockers to encourage biking
- Provide at least two EV charging stations or one per thirty spaces, whichever is greater.
- Minimize impervious surface parking to no more than 20% (Transects 1-3), 15% (Transect 4), 5% (Transect 5), and 0% (Transect 6) of the Project Area and ensure that any surface parking area larger than 20m X 30M is separated with planted areas.

- Either reduce single-occupancy vehicle (SOV) trips and trips by fossil fuel-based vehicles by 30% over an established baseline relevant to the project's region and occupancy type,
  OR
- Implement at least four of the following best practices:
  - Consideration and enhancement of pedestrian routes, including weather protection on street frontages.
  - Advocacy in the community to facilitate the uptake of human-powered and public transportation.
  - A transit subsidy for all occupants of the building (if owner occupied) or requirement for tenant employers to provide a subsidy.
  - Carpool coordination assistance.
  - Access to either subsidized car sharing and/or hybrid or EV fleet vehicles.
  - Regular survey of occupants to determine current fossil-fuel based SOV trip.

Single-family homes (all Transects) must assess how occupants can reduce their transportation impact through car-sharing, use of public transportation, alternative fuel vehicles, or bicycles and implement at least two identified strategies.

Within this Imperative, project teams will recognize elements from LBC 3.1 I-04 Human-Powered Living and I-15 Human Scale and Humane Places (previously under the Equity Petal). This Imperative is now less prescriptive and provides project teams the flexibility to choose the combination of elements that will be most beneficial. EV charging stations and a few other elements within this Imperative may add a small amount of additional cost, but the majority of best practices indicated above will not have substantial financial impact (such as pedestrian route enhancement or advocating for bicycle routes).

SECTION 2
PLACE PETAL

OVERALL APPROACH

The requirements of Imperatives under the Place Petal align particularly well with affordable housing project goals with few associated barriers. Often affordable housing projects are located in previously developed and primarily urban areas that do not threaten sensitive ecological areas. The two Core Imperatives (required for all Core, LBC Petal, or LBC Living Certified projects), I-01 Ecology of Place and I-04 Human-Scaled Living, include elements that are typically already prioritized in affordable housing developments and, if not already explicitly in project plans, can be implemented at little or no cost to enhance the effectiveness of the building and organizational mission.

The other two Imperatives within the Place Petal (I-02 and I-03) are not Core Imperatives and are not required unless the project team is pursuing Petal certification, including the Place Petal, or Living certification. I-02 Urban Agriculture has historically been a popular Imperative among affordable housing project teams. The case studies below highlight two projects in nearly opposite climates that successfully integrated urban agriculture. Despite the interest, certain teams struggled with the site area required for urban agriculture under LBC 3.1. Under LBC 4.0, the required urban agriculture area is based on Transect rather than floor-area-ratio (as in LBC 3.1) and the percentages of site required for urban agriculture have been reduced. There is an additional pathway that allows for project teams to reserve a smaller portion of their site for on-site agriculture, along with providing community access to food through a community farmers market, a local CSA, or a similar approach. Under LBC 4.0, residential projects must also provide storage for a two-week supply of food in an emergency. The LBC 4.0 update has made Imperative I-02 more feasible for affordable housing project teams and will also help teams better integrate the benefits of this Imperative throughout the community.

BARRIERS + SOLUTIONS

SOCIAL BARRIERS

Place Petal Imperative requirements are unlikely to pose significant social barriers for affordable housing. Many relate strongly to the mission and best practices of most affordable housing developers to improve the overall quality of life of their residents by facilitating non-vehicular transportation and urban agriculture. However, there are a few requirements that relate primarily to improving and/or preserving the natural environment, notably I-03 Habitat Exchange, but also potentially the requirement to improve the ecological performance of the project site under I-01 Ecology of Place. Although the cost implications of these are likely minor, affordable housing developers are often under intense scrutiny regarding budgets and timelines. Therefore, it may prove challenging to allocate any amount of financial resources to items that do not appear to directly correlate with the primary mission to provide affordable housing.

SOCIAL SOLUTIONS

The project may choose to utilize the Habitat Exchange Exception for nonprofit organizations. In lieu of a financial contribution, small nonprofit organizations may volunteer a minimum of 200 hours with an approved land trust during the project design, construction, and performance period. This can be achieved either by volunteer hours accumulated by the nonprofit staff or by direct recipients of the nonprofit's services, in this case residents, or by a combination of both. The number of required hours shall be the greater of 200 hours, or 5 hours per full-time equivalent employee of the non-profit. The hours may be accumulated by immediate members of the non-profit, including employees, board members, or direct recipients of the non-profit's services, which means residents could volunteer as well.

REGULATORY BARRIERS

Some jurisdictions require parking that exceeds the surface parking allowances in I-04 Human-Scaled Living. A simple solution to this issue is to build structured or underground the parking; however, that is not always economically feasible for affordable housing.

REGULATORY SOLUTIONS

Project teams pursuing the Living Building Challenge have sometimes been able to negotiate with the city (or other authority having jurisdiction) to reduce on-site parking. Inclusion of several of the best practices within the Human-Scaled Living Imperative can help make the case (and the reality) that residents will be able and likely to take fewer single-occupancy vehicle trips than they would if they lived in a typical building. The 5th Avenue Apartments project in Maywood, Illinois, was allowed significantly less parking than usually required by the city. In the case of Othello Square, the project included structured parking and the city allowed them to build on-grade ADA van parking, rather than excavate deeper to build the larger structure that would be required for ADA parking with the parking deck. The project team then reallocated the money that would be required to build this deeper parking structure to building a healthier living space with Red List Free materials.

FINANCIAL BARRIERS

The Place Petal overall does not present significant financial barriers. If urban agriculture is not already a part of the project, which it often is in new affordable housing developments in order to mitigate the effects of food deserts and provide resiliency, there can be minor costs for the initial plantings and the operation. Habitat Exchange will also require an up-front investment to preserve natural habitats. Although the cost implications are minor, typically $2,000 for affordable housing projects on compact sites, affordable housing developers may struggle with justifying any added costs. EV charging stations will also have an added cost, although in this case, they also provide a direct financial benefit to residents and/or staff who are able to utilize them.

FINANCIAL SOLUTIONS

As demonstrated in the two case studies below, many teams have found that using native urban agriculture significantly cuts down on added costs for irrigation and maintenance. Additionally, the investment in urban agriculture can provide food security to the residents and reduce the financial strain on households to acquire local and healthy food. Although not easily quantifiable, the impacts of healthier food options and better health outcomes financially benefit both the individual households and society as a whole. These added individual and community benefits are the reason why many affordable housing developers choose to integrate urban agriculture. If additional funds for Habitat Exchange are problematic within the budget, specific funding support may be required. Alternatively, the project may choose to utilize the exception for nonprofit organizations. In lieu of a financial contribution, small nonprofit organizations may volunteer a minimum of 200 hours with an approved land trust during the project design, construction, and performance period.

CONCLUSIONS

The Place Petal provides a framework for project teams to consider the uniqueness of their own particular place, culturally and in terms of environmental resources. Overall, the Imperatives within this Petal harmonize well with the goals of affordable housing without resulting in significant hard or soft cost burdens.

CASE STUDIES
ECOLOGY OF PLACE

Identity Security
Unit Comfort **Accessibility**
Community Health + Well-Being
Skills + Job Training **Storage**
Food Communication

COMFORT, HEALTH + WELLNESS PRIORITIES
EXPRESSED DURING LAWSON HOUSE RESIDENT INTERVIEWS

LAWSON HOUSE YMCA DEVELOPMENT

Holsten Development
Chicago, Illinois

The Lawson House YMCA Renovation project is an example where user input became critical for the priorities and vision of the project overall. This project was planning the renovation of a 23-story building in downtown Chicago. The current building includes 538 single-resident-occupancy (SRO) units. Early on in schematic design, before any integrated design workshops took place with building professionals, the architectural firm, Farr Associates, spent an entire week engaging with residents on their own so that their thoughts could inform the workshops. The design team engaged in "Day-in-the-Life" exercises with a variety of existing residents, representing a broad spectrum of the building's population in terms of race, age, gender, and mobility. This tour was followed by a sit-down interview, where the design team was able to ask more detailed questions about how the building functions currently and how the residents hoped the renovation could improve building conditions. This process of engaging with residents was revelatory because it illuminated many concerns that otherwise might not have made it into a programming spreadsheet or budget. In addition, much of the resident's feedback reinforced LBC-related goals and strategies, particularly related to healthy lifestyles. For example, food security was a major concern for residents because they historically had not had cooking or food storage capabilities in their individual rooms. This forced residents to go to grocery stores on a daily basis and eat food immediately so that it would not spoil. To combat this burden, residents desperately wanted in-unit cooking and food storage, in addition to the opportunity to grow fresh produce on site. Residents also requested healthy alternatives in building vending machines and the opportunity to utilize the building's former recreation spaces for exercise. As the building was built by the YMCA, it had once included robust recreational programming, including amenities such as a pool, gym, and weightlifting area,

"The color and feel of the tile floors is not good, they just fall apart and get dirty. The building should be **bright and welcoming**."

Fasika, Lawson House Resident

It would be really cool to have a **community garden**... Selling some of that produce could be a **money making opportunity** for residents or for Holsten."

Doug, Lawson House Resident

Text and images courtesy of Farr Associates

but these features had been kept under lock and key and were inaccessible to residents for many years. The renovation will make these spaces accessible once again to residents.

Residents also expressed mental strain due a lack of acoustical separation between units that led to tense interactions between neighbors with conflicting schedules or preferences. Additionally, the materials were deteriorated and there were thermal comfort issues with the radiator. In general, the residents indicated that they would like to feel more comfortable within their units and have greater peace with their neighbors. These interviews and knowledge of resident concerns helped the project team make the case for prioritizing a healthy environment and centering equity in the vision. The plan for the project is to incorporate all of the aspects listed here in various ways—a reconfiguration of the units to allow for cooking, inclusion of urban agriculture, a focus on healthy interior materials, and the addition of insulation and other elements to improve energy efficiency and acoustical performance.

GILA RIVER INDIAN COMMUNITY SUSTAINABLE HOUSING

Gila River Indian Community and Arizona State University
Sacaton, Gila River Indian Reservation

The Gila River Indian Community Sustainable Housing is a joint project led by Wanda Dalla Costa and her students at Arizona State University and the tribal council, who are the eventual owners of the project and responsible for all final decision-making. As described below, previous housing built on the tribal lands did not sufficiently represent the desires or needs of the community. The process used this time, developed by Professor Dalla Costa and know as the Indigenous Placekeeping Framework (IPKF), sought to more fully assess the Ecology of Place before and during design, including natural, climatic, and cultural needs.

Business and architectural students at Arizona State University adjust designs in real time based on feedback from community members. Images courtesy of Wanda Dalla Costa, Arizona State University.

To aid this process, I developed the Indigenous Placekeeping Framework (IPKF). This framework can be used to instill more equitable design methods in architectural practice. In one of the pilot projects of the Indigenous Design Collaborative at ASU, students working on the Gila River Indian Community Sustainable Housing Initiative employed a series of practices from the IPKF. The overall aim of the IPKF is to design in place, directly with the people of the place. A description of two of the practices—a period of self-definition and a design-in-real-time studio—are shared here.

The first activity, a period of self-definition, aims to increase community-led visioning. Due to historical policy and regulations, tribal members have had little control of the design of their built environments. To counter the western influences associated in architecture, and to increase the relevance of design for tribal communities, the IPKF prioritizes tribal members' narratives. During the period of self-definition, the IPKF project team takes community members through an IPKF visioning session, where members are in the driver's seat, not only sharing their ideas, but engaged in user-friendly activities that allow members to co-design the project. Sample exercises include: small group conversations; exploring traditional forms and meanings; plan layout exercises; and prioritizing a list of needs or wants. The design team's role is to listen, but also to assist tribal members in communicating their ideas. The means of communication can include architectural form along with text and graphics, to make explicit the reasoning and importance of all nonstandard design approaches and features.

Another activity that was successfully utilized with the GRIC project was the mobile design studio (also known as the design-in-real-time studio). This involved the IPKF students taking the design studio into the reservation, co-designing in real time with community members. The aim was to have community members actively co-designing in the development of the form. Community members understand the site context (micro-climate) and cultural activities associated with form. Their direction is sought on all critical design features: roof slopes, materials, placement and size of windows, landscaping, outdoor gathering or play spaces, etc. The activity entails a series of small groups consisting of two or three design students (note-taker, 3D-modeler and someone to foster conversation) and two or three community members representing various segments of the community (elder, youth, veteran, parent, etc.). The group chooses a population segment or demographic they will design for and directs the 3D-modeling student. The conversations are open ended, leaving room for story and lived experience of this place.

WANDA DALLA COSTA
Institute Professor, The Design School & Associate Professor, Del E. Webb School of Construction
Arizona State University

SECTION 2
PLACE PETAL

The Gila River Indian Community, known as GRIC, has seen numerous developments on their lands led by external parties, some of which were contextually inappropriate, both climatically and culturally. These developments have resulted in residents left with utility bills soaring above $600 in the summer and building types that resemble Pueblo architecture, which was the historic architecture of a completely different first nation located hundreds of miles to the northeast. This is one reason why community engagement and a deep understanding of the history, needs, culture, and traditions of the community are not just ideals, but are actually critical to a project's success. When GRIC started undertaking their newest development project, the Living Building Challenge Sustainable Housing prototype intended to ultimately produce more than 500 new housing units, they used a completely different process. Indigenous architect and Arizona State University professor Wanda Dalla Costa created a design studio with her design and business students, many of whom also had indigenous backgrounds, to work collaboratively with the community to ensure that the tribe's voices were centered in the project's initial conceptualization and design development work.

Student renderings showing possible designs for future prototype housing on GRIC, incorporating feedback from the community while designing and utilizing various LBC Petal compliance pathways (Water, Materials, or Energy). Renderings courtesy of Wanda Dalla Costa, Arizona State University

These pictures show the housing stock designed by past building efforts that did not include input by the community. The community expressed that these houses have felt both culturally and functionally/climatically inappropriate for their context. One example (left) shows an attempt to incorporate indigineous elements, but utilized Pueblo-style architecture, the tradition of a completely separate nation located hundreds of miles away. Images courtesy of Wanda Dalla Costa

CASE STUDIES
URBAN AGRICULTURE

LAKELINE LEARNING CENTER

Foundation Communities
Austin, Texas

Lakeline Learning Center in Austin, Texas, is in many ways an ideal site for urban agriculture. The project serves as an educational and community hub for the surrounding affordable residential buildings. Landscape architecture team Studio Balcones drew inspiration from the central Texas location and specified succulents and other hardy plants that require little to no maintenance or resources to thrive. On-site agricultural plants were a mix of native plantings and others. The native edible plants include figs, blackberries, and prickly pear, a cactus that grows edible fruit eaten by local indigenous populations for thousands of years. Property manager Foundation Communities has discovered that the native agriculture has been the most successful on the site by far. As these plants have thrived, a formal harvesting program has proven unnecessary. The central location of the Learning Center within the residential campus encourages residents to pick and eat the various fruits and vegetables available in the garden.

The project site has had less success with agricultural plants not native to the area, so portions of the garden have thus far been unused. While the project team utilized an integrated design process, the owner did not include input from the on-site Learning Center Coordinator, who specializes in educational programs and does not have the knowledge base to manage non-native plants that require more cultivation. Although the building largely functions well in terms of programming, materials, and design, the potential of the edible landscape has not been fully realized as originally envisioned. This is not an unsurmountable problem, but the owner will need to strategize going forward in order to optimize the potential of the urban agriculture, whether by replacing all species with low-maintenance native plantings or designing a program that involves residents in managing the operations of the garden. Foundation Communities indicated that this obstacle underscored for them how involving the actual user in the design process early on was important to understanding how well certain aspects would function in reality.

This rendering shows the extensive native landscaping and urban agriculture planned for Lakeline Learning Center. The orchards and edible garden areas grow hardy plants such as blackberries and figs that are routinely harvested and utilized by residents living in the surrounding buildings. Rendering courtesy of Studio Balcones.

MULDOON GARDEN

Rural Alaska Community Action Program (RurAL CAP)
Anchorage, AK

Muldoon Garden is located in a nearly opposite climate from hot, dry Austin—the subarctic climate of Anchorage, Alaska. In this region, the only rain for the entire year (approximately 16 inches) falls in August and September (with frozen precipitation in the winter months). While it may sound challenging to effectively grow agriculture in this context, the project architect reported that urban agriculture was actually the easiest part of the project. Alaskan architecture firm McCool Carlson Green always prioritizes the use of indigenous, local plant species. This experience has taught them that in order for plants to thrive, it's important to let the natural ecosystem play out as originally intended.

Traditionally, property owners in Anchorage have fenced off private and community gardens in an effort to keep plants out of reach of the large mammals that are also native to the area. However, this strategy resulted in a situation where the local animals were not happy and the plants were not thriving. The architecture team discovered that, in fact, the local moose who had been suspected of stealing the vegetation were actually pruning it. In winter, moose bite the tips off of the plants, removing the dead portion and allowing new growth to emerge in the spring. Native plants and animals work in harmony when left to their own devices, which significantly reduces maintenance efforts (as well as the cost and time to build a fence). The gardens at Muldoon Garden are still in their establishment period but will eventually be turned over to the residents to become a permanent part of their community.

THE PROJECTS AT MILL CREEK

Community Rebuilds

Moab, Utah

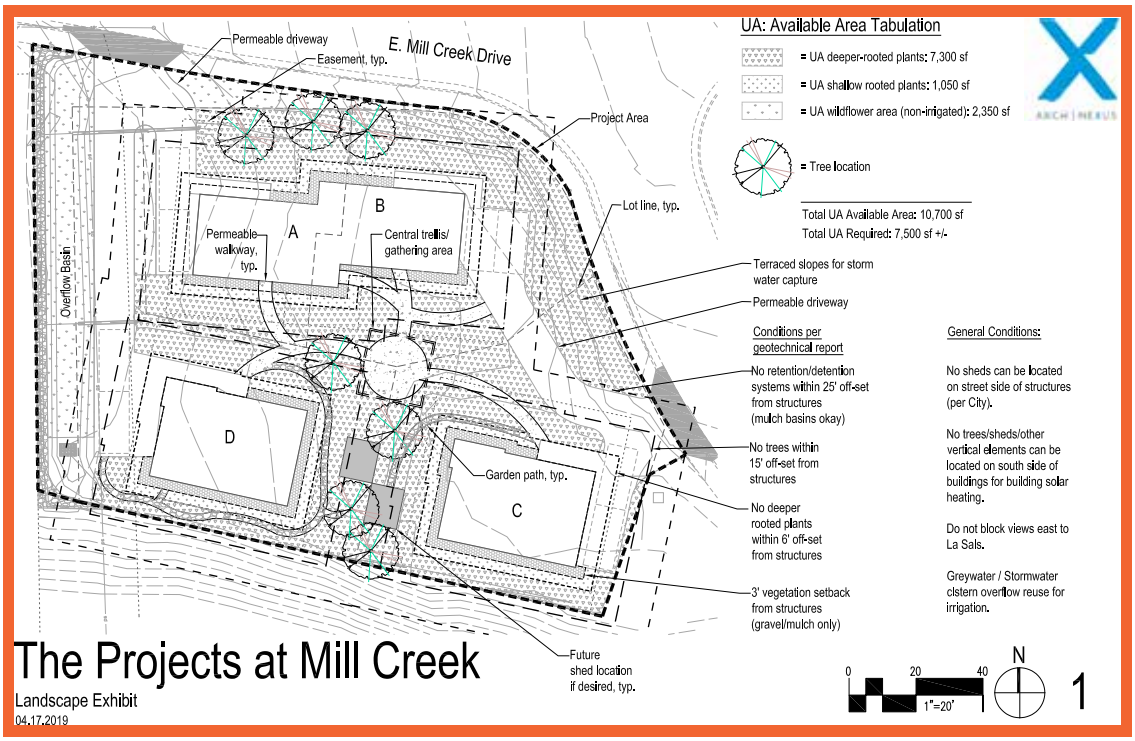
Agriculture and landscaping will be planted among the four single-family homes planned for the Project at Mill Creek, allowing residents to serve as stewards of their own land. The permaculture landscape will be integrated with outdoor living areas. Permaculture is a set of design principles centered around whole systems thinking simulating or directly utilizing the patterns and resilient features observed in natural ecosystems.

In the semi-arid context of Moab, Utah, plantings have been carefully chosen to mimic the historic, native landscape. Five agricultural strategies were used on site:

- **Forest gardens:** Fruit trees that are varied so as to have an extended harvest period will form a canopy over the site. An understory of polyculture plants that yield food and medicine and help meet the needs of the fruit trees without fertilizers will also be included. The berries and fruit from these trees will allow residents to create value-added products such as jams or pies.
- **Kitchen gardens:** Low-water culinary and medicinal herbs will be planted, including sage, rosemary, lavender, wormwood, oregano, hyssop, and mint.
- **Vertical gardens:** Grape, honeysuckle, and wisteria vines will be included along fences, sheds, and an arbor.
- **Habitat and pollinator gardens:** Berry and medicinal shrubs will be planted throughout the site to provide avian and pollinator habitats.
- **Tool shed:** Each residence is equipped with a tool shed to secure all needed gardening equipment, as well as sufficient space to store two weeks' worth of food.

The placement of pathways, waterways, communal spaces, and areas of refuge on site allows a variety of experiences with nature: active gardening areas, community and socializing areas, and places of individual peace and rest. Views of the nearby La Sal Mountains and canyon rim were also carefully planned so that residents feel a connection to the larger natural region that they inhabit.

While the project team is able to fit all of the required urban agriculture on site, they have elected to also add some to their office building. In the words of Reid Saunders, Community Rebuilds Planning and Development VISTA, "We are actually pretty excited to develop our campus more and have it be a working example of the permaculture we teach in our program. The campus is right off of the bike path that runs through town and could be a really cool community asset."



The current landscape design for the Projects at Mill Creek utilizes non-irrigated plants, such as wildflowers, as well agricultural areas grouped around a central trellis, providing a communal interior space for the neighbors. Drawing courtesy of Architectural Nexus, Inc.

Resources

Growing Urban Agriculture: Equitable Strategies and Policies for Improving Access to Healthy Food and Revitalizing Communities
This report examines how urban farming can improve communities by improving access to healthy food, improving economic health, and helping to revitalize communities. It reviews common challenges to urban agriculture for low-income and disadvantaged communities and offers strategies for overcoming those challenges. The report offers a sampling of potential policy approaches that help ensure benefits for low-income communities and communities of color by involving them in policy development and advocacy steps to identify and advance an urban agriculture policy agenda.
https://www.policylink.org/sites/default/files/URBAN_AG_FULLREPORT.PDF

Local Harvest
This website offers a search function to find farmers markets, family farms, and other sources of local, sustainably grown food in a given area.
www.localharvest.org

Enterprise Community Partners, "Fresh, Local Food Access Toolkit"
This toolkit is designed to provide step-by-step instructions and resources to implement a fresh food access model that meets the Enterprise Green Communities Access to Fresh, Local Food Criteria, best addresses the needs of your development, and leverages the assets of your organization and neighborhood.
https://www.enterprisecommunity.org/download?fid=8366&nid=3778

Land Trust Locator, Land Trust Accreditation
This tool allows users to locate accredited land trusts by location.
www.landtrustaccreditation.org/land-trust-locator

Land Trust Standard and Practices, Land Trust Alliance
This resource lists the established guidelines for running a land trust responsibly and ethically.
www.landtrustalliance.org/topics/land-trust-standards-and-practices

Living Future Habitat Exchange
The Institute exchange for Habitat Exchange donations.
https://access.living-future.org/exchange

King County Equity and Social Justice Tools and Resources
Tools for implementing social justice through building projects.
https://www.kingcounty.gov/elected/executive/equity-social-justice/tools-resources.aspx

Commute Seattle Property Management Best Practices
This tool provides graphics showing best practices for buildings to encourage alternative transportation.
https://commuteseattle.com/wp-content/uploads/2019/04/Property-Management-Best-Practices.pdf

To identify the project's reference habitat, project teams may use a variety tools. Two accepted tools are:

Ecoregions 2017
https://ecoregions2017.appspot.com/

Global Terrestrial Ecoregions as defined by The Nature Conservancy, 2009
http://www.arcgis.com/home/item.html?id=7791251e097a44a3a35d8fca7bd51078#visualize

WATER

Creating Developments that Operate within the Water Balance of a Given Place and Climate

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.

PETAL INTRODUCTION

The intent of the Water Petal is to realign how people value water; to address the energy and chemicals involved in transporting, purifying and pumping water; and to redefine "wastewater" as a precious nutrient and resource.

Recent catastrophic droughts across the United States (and especially in the West and Southwest) have highlighted the risks of our wasteful water practices and the substantial water insecurities that many communities face. During the peak of the 2012 drought, the U.S. drought monitor reported that over 81% of the country was experiencing, at the very least, "unnaturally dry" conditions.[11] As climate change induces global temperature rise, more snow will fall as rain, reducing the snowpacks that many regions—even those that have historically been thought of as water rich—rely on for fresh water throughout the dry seasons. Droughts and water shortages disproportionately affect low-income communities. The Gila River Indian Community, which once thrived agriculturally along the Gila River and their constructed canal system, faced widespread famine after the construction of upstream diversions and dams in the 1870s and 1880s. Still striving to fully restore their native ecosystem and economic prospects 150 years later, the community eagerly anticipates once again hearing the "sweet music of rushing water."[12]

The Gila River, pre-contact, allowed for extensive farming along thousands of acres within the Sonoran Desert with the assistance of an extensive canal system built by the ancestors of the current inhabitants of GRIC around 300 B.C. Image courtesy of Wanda Dalla Costa.

A century of deferred maintenance in water systems throughout the country also means that even cities located near abundant freshwater sources, such as Detroit and Chicago, face steep and rising water rates.[13] In Detroit, this has resulted in water shut-offs for more than 100,000 homes since 2014 (10-20% of all residences each year), a practice that the U.N. has called an "international human rights violation."[14] Local researchers have linked these shut-offs to increased incidences of skin and soft tissue diseases.[15] The Detroit shut-offs have resulted in additional social turmoil as Child Protective Services has removed children from homes when the custodian was unable to restore running water within 72 hours.[16]

Pollutants are degrading available fresh water 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 impact human and ecosystem health. Water reuse, stormwater management, and infiltration at the project site can minimize these environmental impacts while restoring a site's healthy hydrological cycle.

In light of these significant issues and accelerating climate change, the benefits of a new, decentralized approach to water procurement, use, and treatment—where buildings operate within the carrying capacity of their site—are becoming increasingly clear.

11 National Integrated Drought Information System (NIDIS), http://drought.gov/drought/
12 http://www.gilariver.org/index.php/about/history#1
13 https://www.npr.org/2019/02/08/691409795/a-water-crisis-is-growing-in-a-place-youd-least-expect-it
14 https://www.bridgemi.com/detroit-journalism-cooperative/detroit-shut-water-1-10-homes-year-yes-thats-progress
15 https://wethepeopleofdetroit.com/2017/08/10/detroit-news-experts-water-shutoffs-causing-public-health-emergency/
16 http://america.aljazeera.com/articles/2014/10/20/detroit-water-un.html

These decentralized systems have the potential to work in tandem with the larger, centralized systems in order to build resilience and help restore a sustainable water balance in the region by meeting some of an area's water demands, even a growing area's water demands, without utilizing the historic fresh water resources. In addition, decentralized water systems typically reduce greenhouse gas emissions compared to centralized systems because on-site systems eliminate the energy expended to pump potable and waste water over long distances. A report by the Institute determined that, on average, 44% of the energy used by an area's water system is for conveyance alone.[17] Small-scale, decentralized systems also add adaptability and resilience to our aging water infrastructure, especially in times of increasing drought and natural disasters.

Aerial photographs today show that decades of diverted water from the GRIC lands have left the area dry and less hospitable to flora and fauna, particularly compared to the relatively greener area of Phoenix located a few miles north. Image from Google Earth

The Water Petal offers a new vision for distributed water systems that treat water as a precious resource and reconnect our buildings and communities with natural hydrological flows.

WATER

CORE IMPERATIVE

05

RESPONSIBLE WATER USE

SCALE JUMPING PERMITTED

The intent of this Imperative is to encourage projects to treat water like a precious resource, minimizing waste and the use of potable water, while avoiding downstream impacts and pollution.

All projects must not use potable water for irrigation, and use less water for the project's other needs than a baseline regional building of the same type at the following rates:
- New Building: 50%
- Existing Building and Interiors: 30%

Affordable housing projects can use water handprinting combined with project efficiency to meet water savings goals.

All projects must treat all stormwater on site, through natural or mechanical means and without chemicals, and manage all stormwater based on both pre-development hydrology and current ecological conditions, as determined by a qualified professional.

All projects on a Combined Sewer Overflow (CSO) system, or in a floodplain (based on an exception), must incorporate stormwater detention and avoid sheet flow off the site.

17 Cascadia Green Building Council, https://living-future.org/wp-content/uploads/2016/11/Clean_Water_Healthy_Sound.pdf

Imperative 05 Responsible Water Use requires project teams to reduce their potable water use by 30% for existing buildings and 50% for new construction below a national or regional average baseline. For the purposes of this report, the baseline used is an average of the Seattle 2030 District data for multifamily residential buildings and the multifamily baseline drawn from Ronald W. Crites and George Tchobanoglous' book Small and Decentralized Wastewater Management Systems. This baseline sets the average water use per person in multifamily housing at 42.9 gallons per person per day. Should a project team desire, they are permitted to make a case that their region or specific programming requires a different baseline. Alternative baselines will be analyzed and approved by the Institute on a case-by-case basis.

In order to meet I-05 Responsible Water Use using this assumed baseline, new affordable housing projects must reduce their potable water use to 21.5 gallons per person per day. An investment in high-efficiency fixtures (see table below) will bring per capita water use to 25.07 gallons per day, nearly achieving the goal of 21.5 gallons per day. Note that irrigation for exterior landscaping is expected to rely on non-potable water for irrigation, and is therefore not included in the water reduction targets of this Imperative.

To fully achieve the 50% reduction, additional options will need to be pursued, such as handprinting the equivalent of about three and a half gallons per person per day, investing in foam-flush or vacuum-flush toilets, or shifting the water used in laundry and/or for toilet flushing to a non-potable water source. Shared laundry systems and water metering to detect leaks are also crucial to meeting this target.

Handprinting is a valuable tool for affordable housing project teams, especially those in areas where on-site water resources are scarce or unpredictable. There are many creative ways to approach handprinting, and project teams are welcome to contact the Institute with potential approaches.

END USE	Gallons per person per day	Proposed Flow Rate (gpm, gpf or gpc)	Uses (or cycles) per day (x) duration if applicable
Toilets	6.46	1.28	5.05
Kitchen Faucet	7.50	1.5	5.00
Lav Faucet	2.50	0.5	5.00
Showers + Bath	7.69	1.25	6.15
Dishwasher	0.30	3	0.10
Laundry (Common)	0.62	11.7	0.056
Total indoor use (daily per capita)	**25.07**		

Affordable housing project teams from California to Minnesota are showing that significantly reducing demand is possible without compromising occupant experience. Additionally, these projects are finding that reduced demand can result in significant cost savings over time. Responsible Water Use serves as a valuable starting point for project teams pursuing the Water Petal as a whole—a highly water-efficient building will be much better suited to make use of the resources available on site.

WATER

IMPERATIVE

06

NET POSITIVE WATER

SCALE JUMPING PERMITTED

The intent of this Imperative is for project water use and release to work in harmony with the natural water flows of the site and its surroundings.

All projects must supply one hundred percent of the project's water needs through captured precipitation or other natural closed-loop water systems, and/or through recycling used project water, and all water must be purified as needed without the use of chemicals.

Affordable housing projects can use water handprinting in lieu of on-site systems to meet the project's water needs.

No potable water may be used for non-potable uses.

All projects must address all grey and blackwater through on-site treatment and management through reuse, a closed loop system, or infiltration. Projects that are not able to treat and manage on site may use handprinting within their watershed and community.

Scale jumping strategies are allowed with some limitations. For example, connecting to a community or municipal facility is allowed only if the facility treats waste to tertiary levels, reuses or infiltrates all water in balance with the watershed, and has a biologically based treatment process with no chemicals. For all scale jumping, pump energy must be accounted for through renewable energy sources.

All projects must incorporate a resilience strategy to provide drinking water for up to a week for all regular building occupants through water storage on site.

Meeting the Net Positive Water Imperative in affordable housing requires careful design of three distinct but interrelated systems: water supply, water demand, and wastewater treatment. With regard to water supply, project teams are challenged to consider sources other than the municipal system for potable and non-potable water. Possible sources include: rainwater, groundwater, condensate, fog, atmospheric water, treated greywater, blackwater, or stormwater. With regard to water demand, project teams are challenged to reduce water use as much as possible. Minimum targets are set in Imperative 05 Responsible Water Use, but further water reduction may be required to meet Imperative 06 Net Positive Water. Water reduction can happen through efficient fixtures, waterless fixtures such as waterless urinals

required to meet Imperative 06 Net Positive Water. Water reduction can happen through efficient fixtures, waterless fixtures such as waterless urinals and composting toilets, drought-tolerant, native landscaping, and non-water-based HVAC and other building equipment. With regard to wastewater treatment, project teams are challenged to treat and manage all wastewater on-site. This means that greywater from sinks and showers and blackwater from toilets is treated on site. A variety of nature-based and mechanical systems exist to accomplish these goals, such as constructed wetlands, living machines, biomembrane reactors, and composting toilets. More detailed information about approaches to water supply, water demand, and wastewater treatment is included in the Overall Approach section below. Should a project team be unable to meet one or more of these goals on site, a number of alternative compliance pathways and exceptions are available specifically to affordable housing projects.

OVERALL APPROACH

The following section provides an overview of some of the best practice approaches to meeting the Water Petal on an affordable housing project.

ASSESSING CARRYING CAPACITY

The first step to designing a compliant Water Petal project is to assess the water resources available on site. The goal is to meet all the project's water needs on site. So understanding the water available will help determine the project's water budget and ultimately the design strategies needed to meet that budget.

Common on-site water resources include:

RAINWATER

Capturing rainwater and snowmelt provides the project with a relatively clean and predictable source of water. It also reduces the negative impacts of stormwater runoff, wherein rainwater hits impermeable surfaces and carries toxins and chemicals into natural waterways or overflows combined sewer systems, releasing untreated wastewater into those same waterways. Rainwater can be harvested from roofs. Codes often require that all surfaces involved in rainwater capture be NSF P151 and NSF 61 certified. The project team should avoid collecting rainwater from surfaces that might leach chemicals into the water over time, such as copper.

GROUNDWATER

Accessing groundwater is a common strategy used by project teams in rural areas. It is less common in dense urban environments that are served by centralized utilities and may have restrictions on new wells and/or groundwater that is contaminated by pollutants or saltwater intrusion.

Handprinting is a compliance pathway that acknowledges the net positive impacts a project can create in an entire watershed, beyond the boundaries of the project site. In this case, if an affordable housing project team is unable to reduce the project's efficiency below the 30% or 50% baseline as required on site, they would be permitted to make up the difference in water savings in other buildings within the watershed. Possible handprinting approaches include:

- Upgrading fixtures in another property within the developer's portfolio to reduce water use in that building; or
- Installing composting toilets in another property; or
- Sending a project's excess non-potable water to another nearby property to offset potable water use (e.g., for irrigation).

However, this important resource should not be overlooked. Additionally, nuisance groundwater from dewatering operations in urban locations may be a non-potable water resource for the project team after such water undergoes the appropriate treatment. Groundwater use is allowed under the Living Building Challenge, but the system must be designed to recharge the aquifer with an equal or greater amount of water as is withdrawn. Groundwater access was not included in the Net Positive Water modeling scenarios included in this report due to the extremely site-specific factors involved.

REUSED WATER

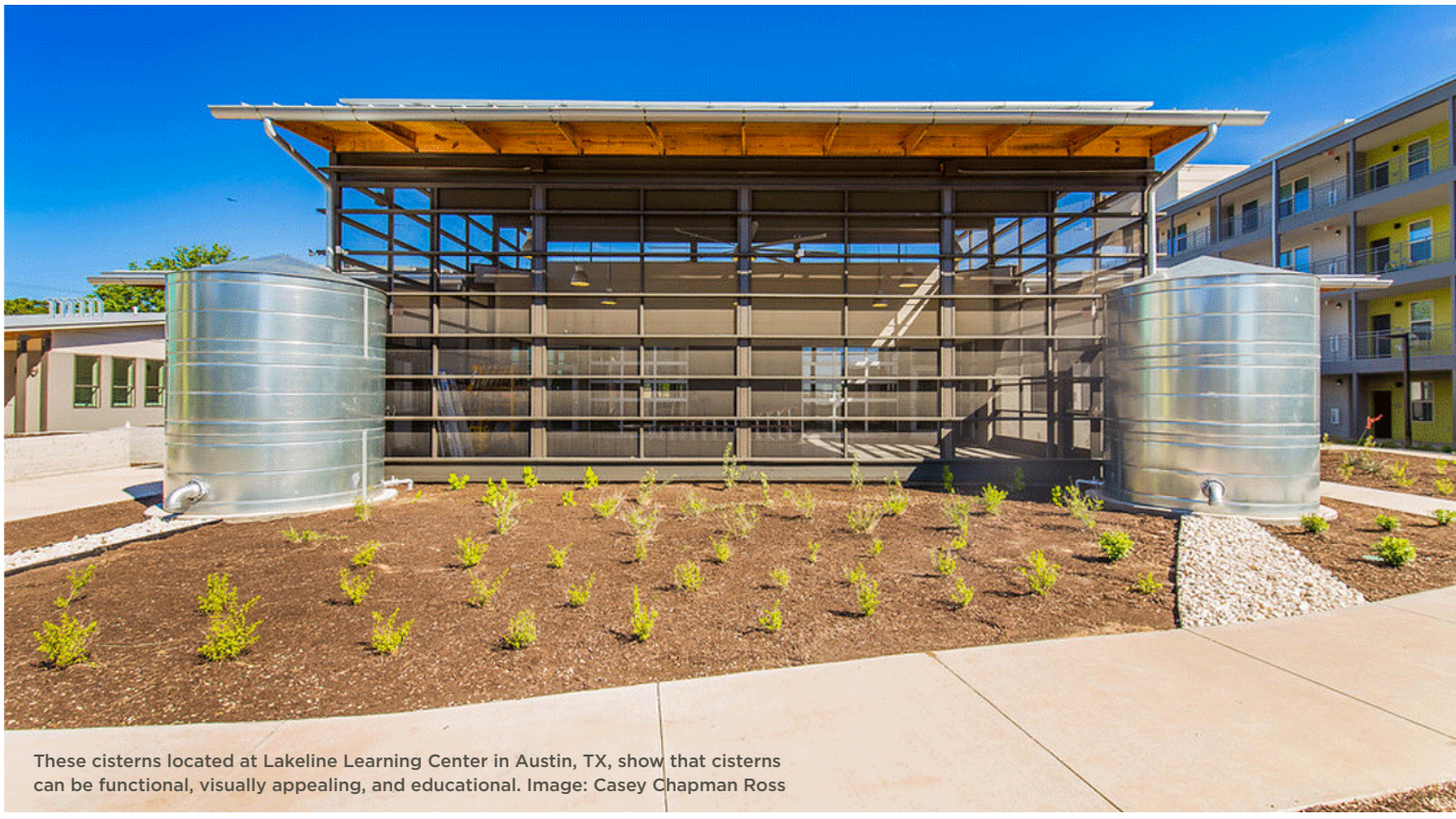
Water reuse is perhaps more properly considered an efficiency strategy, as it is necessary to source the water from somewhere to begin with. However, once potable water has been used initially for uses such as handwashing or showering, using it again to satisfy non-potable uses is good practice and will reduce the draw from on-site or municipal potable water sources. Sources for reuse include water from sinks, showers, and cooling towers. Water from toilets and urinals can also be reused, likely for non-potable uses, but will require more extensive on-site treatment.

MUNICIPAL-PROVIDED PURPLE PIPE

Some water utilities have a purple pipe system available to customers. These systems deliver non-potable recycled water in purple colored pipes to customers for non-potable uses such as irrigation and toilet flushing. In some cases, connecting to this system to provide or contribute non-potable water may serve as a compliant element within a project team's Water Petal strategy.

STORAGE FOR RAINWATER CAPTURE

Precipitation is typically distributed seasonally; many climates experience droughts or substantial periods of low to no precipitation. Project demand for water in affordable housing, however, tends to remain consistent throughout the seasons. Even if your location has evenly distributed seasonal rainfall, it is nonetheless important that a building relying entirely on site-harvested water ensures adequate supply throughout the entire year.



These cisterns located at Lakeline Learning Center in Austin, TX, show that cisterns can be functional, visually appealing, and educational. Image: Casey Chapman Ross

SECTION 2
WATER PETAL

The best way to ensure consistent supply throughout the year is to correctly size the project's water storage equipment. The right amount of storage is unique to each project and is influenced by many variables. Fundamentally, a project's water storage requirement is a function of demand, the available catchment area, and the consistency of precipitation. A project with a large catchment area, consistent rainfall, and minimal demand will require a much smaller volume of storage than a project with a small catchment area and large demand, for instance.

There are other variables that will influence the appropriate storage size, such as space and financial constraints. Additionally, if groundwater proves viable, it can be pumped from the ground more or less on demand, minimizing the storage needs. Designing for climate change is also important, as many areas will see dramatic changes in weather patterns that are likely to continue into the future. As part of this report, the Institute has modeled the approximate cistern size required to support the achievement of the Water Petal for a variety of compliance pathways.

Cisterns can take a variety of shapes and forms and can be located in a variety of locations. For example, many projects build cisterns into their basements or parking garages at the same time they are pouring the foundation. Other projects, especially those that want these systems visible for educational purposes, will locate the cisterns above ground.

REDUCING WATER DEMAND

Once a project team has assessed the on-site water available to the project, the next step toward achieving the Water Petal and keeping cost down is reducing consumption. Typically, projects will need to greatly reduce water consumption in order to ensure that usage is within the carrying capacity of the site.

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).

REDEFINING BEST PRACTICE

In order to meet the requirements of the Net Positive Water Imperative, project teams will need to strive for deeper conservation measures than those described in early parts of this chapter by capturing, treating, and utilizing on-site rainwater or greywater. Some of the highest-performing affordable housing projects today already collect rainwater and greywater for toilet flushing and irrigation. These practices and more will need to be incorporated to meet the Water Petal.

As demonstrated in the Net Positive Modeling below, the specific strategies used will depend on the climate zone, precipitation capture, and other particulars of the project. However, the Institute encourages all affordable housing project teams to explore the following water reduction strategies :

- High-efficiency toilets, which use no more than 1.28 gallons of water per flush. The next step in efficiency is dual-flush toilets (which allow users to choose between liquid and solid waste flush), followed by vacuum-flush composting toilets (which use roughly 0.13 gpf.).
- Showerheads that do not exceed a flow rate of 1.25 gallons per minute (gpm), while maintaining a pressure of 80 psi. High pressure ensures that users don't replace their showerhead with a high-flow unit or take a longer shower to compensate.
- 0.5 gpm bathroom faucets
- 1.5 gpm kitchen faucets
- Best market-available aerator for all faucets
- ENERGYSTAR and WaterSense certified dishwashers (maximum 3 gallons/use)
- ENERGYSTAR and WaterSense certified clothes washers (maximum 14 gallons/use)
- Rainwater harvesting and reuse
- Greywater and/or blackwater harvesting and reuse

On-site Greywater and Blackwater Treatment and Disinfection Options:

- ultraviolet (UV) disinfection
- reverse osmosis filtration
- membrane filtration
- sand filters
- charcoal filters
- biological systems, such as constructed wetlands and living machines

Effectively treating greywater and blackwater on site requires a combination of filtration and disinfection systems. For example, ultraviolet (UV) disinfection provides only disinfection and must be preceded by some type of filtration. UV alone is not adequate for treatment.

- Condensate capture and reuse
- Minimizing irrigation water use by creating landscaping with native and/or naturalized plants (as described in the LBC Place Petal) and specifically those plant species that require the least amount of water during establishment phases. Note that the Water Petal explicitly prohibits the use of potable water to irrigate landscapes.

As mentioned earlier, Imperative 05 Responsible Water Use requires a water demand reduction to 50% below the average regional baseline for new construction, and a 30% reduction for existing buildings.

FIT-FOR-PURPOSE WATER

A critical concept when considering Net Positive Water is that of fit-for-purpose water. In our current water paradigm, nearly all water is treated to potable (drinking) quality water standards regardless of use. In a fit-for-purpose water paradigm, water would be treated to the quality standard needed for the particular use. For example, toilets do not need potable water to do their job and preserve public health. Thus, all of the energy and time used to treat water to a potable standard is wasted on a task for which it is not required. The same is true for irrigation, cooling towers, and clothes washing (in most cases). Consider the ways in which non-potable water can be harnessed from on-site sources and used for these tasks in order to drastically reduce potable and overall water consumption.

ALTERNATIVE COMPLIANCE PATHWAYS FOR WATER SUPPLY

For some projects, including especially high density projects or projects facing low or unpredictable annual precipitation, it may not be possible to meet water demand solely with on-site resources. Even in locations where meeting water demand on-site is possible, the most sustainable option may be to connect to the municipality (for example, in situations where the embodied carbon of a potable rainwater system would far outweigh the carbon used to transport the water of a municipal system to the site, as is the case with some projects in Seattle). While the Living Building Challenge is intended to inspire change and push the industry as far as possible, the market (particularly as it relates to water regulation and pricing) is lagging behind the requirements of the Challenge. The Institute acknowledges these realities and has established two alternative compliance pathways that make achieving Water Petal certification possible despite density, climatic and regulatory barriers. These pathways recognize the leadership of early adopters that are challenging outdated codes, and project teams that have found alternative ways of demonstrating net positive impact in their watershed. In all cases on-site water efficiency needs to be maximized before any exceptions or alternative compliance paths can be utilized.

These two temporary pathways will be removed as alternative water system technologies become more commonplace and as projects are successful in overturning outdated water regulations. The language below is summarized—for full details and documentation requirements, please see the LBC 4.0 Water Petal Handbook.

MUNICIPAL POTABLE WATER SUPPLY EXCEPTION[18]

The Living Building Challenge recognizes that some state health departments and utility regulations will not allow the capture and reuse of rainwater for potable use. In this case, the project team can use the Municipal Potable Water Supply Exception (below) after they have advocated to the jurisdiction for regulatory change. Advocacy does not need to include a full system design – the Institute provides case studies, research and other tools to facilitate a compelling conversation with the authority having jurisdiction.

Municipal Potable Water Supply

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 project team must demonstrate through design drawings and calculations how the project is designed to meet the requirement for 100% site-sourced water.

18 Refer to the LBC4.0 Water Petal Handbook.

HANDPRINTING FOR AFFORDABLE HOUSING PROJECTS – ALTERNATIVE COMPLIANCE PATH

In response to the unique constraints of affordable housing and in order to provide developers with more flexibility, the Institute has introduced an alternative compliance pathway specifically for affordable housing. Under Living Building Challenge 4.0, affordable housing project teams may choose to connect to the municipal potable water system and handprint a commensurate amount of water within other buildings in the same watershed or aquifer, such that there is no increase in the total draw from the municipal system as a result of the project. Project teams can either do on-site water capture to meet their water supply or handprint. Teams can make this decision based on what is best for their watershed and for meeting the needs of their occupants. See below for further handprinting guidance.

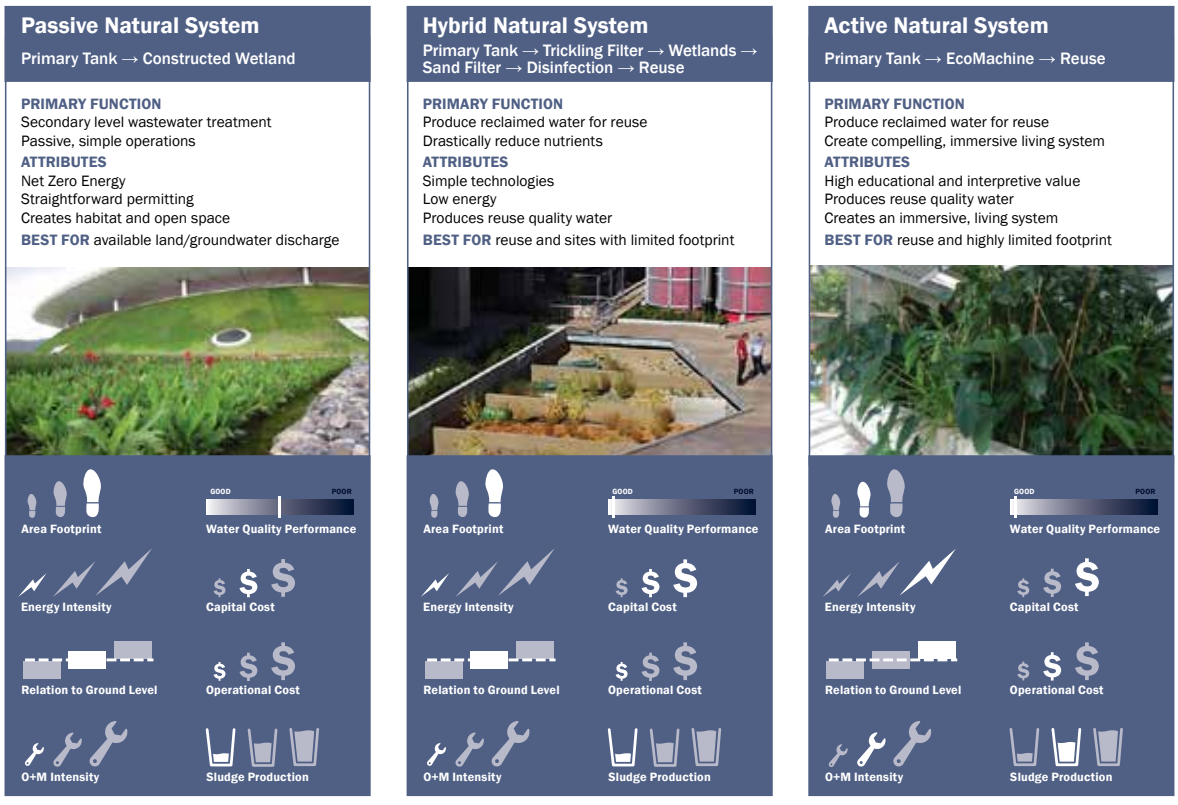
CLOSING THE LOOP – OPTIONS FOR WASTEWATER

After a project team has met the project's water demands with on-site resources, the project team has four options available for managing the wastewater in a sustainable way to meet the Water Petal. The term "wastewater" is a misnomer—this water is valuable and a viable resource for non-potable needs. These four options—on-site wastewater treatment, connection to a sustainable municipal system, handprinting, or using the Blackwater Exception—are described below.

ON-SITE WASTEWATER TREATMENT

Treating greywater and/or blackwater for use on site is a rapidly evolving field. Decentralized water treatment systems vary widely, but one of the most fundamental tradeoffs in their design is the balance between the systems' requirements for space and energy.

FIGURE 6: Living + natural treatment strategies for every site and challenge. Courtesy of Biohabitats, Inc.



ALL SYSTEMS–Living Building Challenge / LEED / provide beauty / appropriate for decentralized treatment

Some options for on-site water treatment, sorted by more space/less energy to less space/more energy, include:

- **Traditional septic system**
- **Constructed wetlands**
- **Living Machines™**
- **Composting toilets (for blackwater) with constructed wetland (for greywater)**
- **Moving Bed Biofilm Reactor (MBBR)**
- **Membrane Bioreactors (MBR)**

Generally speaking, the more space a system needs the less energy it will use, and the less space a system needs the more energy it will use. Systems based on biological treatment tend to need more space and less energy. Mechanically based systems tend to need less space and more energy. In dense urban developments, on-site water treatment will likely require a greater investment of energy and a more thoughtful integration into a design.

No matter where the project sits on the spectrum of invested space and energy, on-site treatment systems can deliver multiple benefits if infrastructure is integrated creatively. Natural treatment systems—such as constructed wetlands—can provide aesthetic amenities, incorporate and enhance gathering places, and offer wildlife habitat. Even mechanical systems can be artistic and showcased for educational benefits, providing value beyond water treatment. Living Buildings provide some of the best built examples of water treatment that is thoughtfully implemented in a way that creates appealing spaces and stacked benefits.

A treatment system that can provide aesthetics, education, and habitat must be integrated early into the project design. A traditional "end-of-pipe" design approach will rarely incorporate the full range of possible benefits. There is a growing sector that provides standardized on-site treatment systems, which may be adequate for some LBC situations. Exceptional systems can emerge using this early, integrated design approach. Fit-for-purpose reuse of water allows for potable water sources to then be used for their highest and best use. Co-benefits can be derived that can green the urban environment, improve habitat, and provide better health outcomes for communities, while also resulting in a cost-effective augmentation of the existing water supply portfolio. Additional benefits of these systems include, diversification of the water supply infrastructure, better preparation for utilities to deal with chronic and acute challenges, increased resiliency and adaptability, and stormwater management options.

The trickling filters shown in this image at Hassalo on 8th, apartments located in Portland, Oregon, bring the wastewater treatment system to the forefront and allow them to add to the aesthetic of the site. System design by Biohabitats, Inc. Image courtesy of Biohabitats, Inc.

There are an astonishing number of cost effective technologies and approaches emerging every day to treat wastewater on site for beneficial reuse or for safe discharge into the environment. Project teams can work with an engineer to explore all of the options and figure out the best fit for the project.

SUSTAINABLE MUNICIPAL SYSTEM

Some projects may be lucky enough to be located within a municipality that has already taken measures at the community scale to create sustainable water treatment systems. For projects to be able to use this as an option the municipal system must meet all the following conditions:

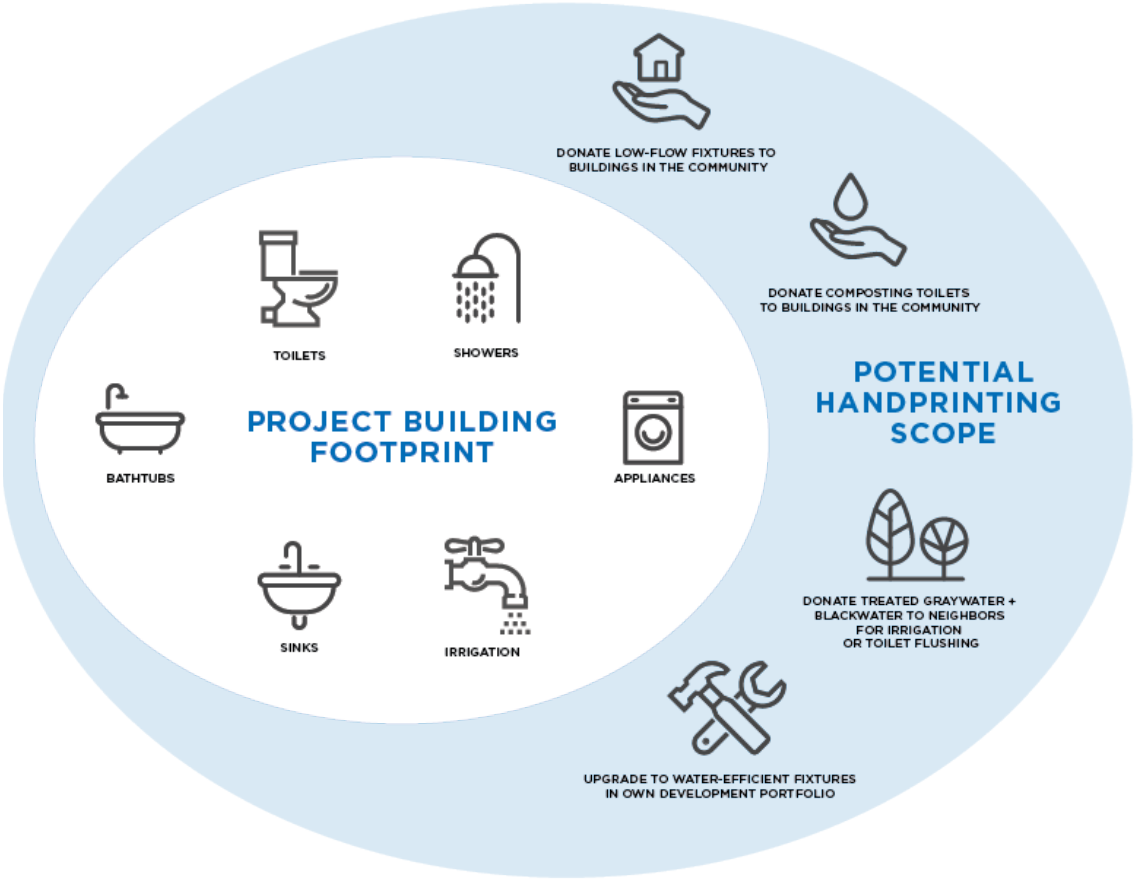
The treatment plant must:
1. Have a biologically based treatment process with no chemicals.
2. Be within 0.5 km of, and in the same watershed as, the project.
3. Treat water to tertiary levels and return water back to the project for use.

The project must:
4. Have a balance of sewage going out and water returning from the plant.
5. Not overtax an existing combined sanitary/storm system.
6. Not be separated from the plant by a lift station.
7. Include in its energy production, both a prorated amount of energy (i.e., kWh per gallon) from the plant treatment system, and all pumping energy required to move the sewage/ returned water to and from the project.

HANDPRINTING

Handprinting, described above, is also permitted as an option for managing wastewater to achieve Net Positive Water. In this scenario, projects would connect to the municipal sewage system, regardless of the municipality's treatment strategies, measure the amount of water flowing into the sewer connection, and offset the amount of water they are sending to the sewage by reducing the amount of water going into the sewage system on another project. This other project could be in their portfolio or within the same watershed or aquifer. For example, an affordable housing developer building a new building could install water fixture upgrades in existing buildings within their portfolio to reduce the water going into the sewage system by an amount equal to a greater than the amount in the new building pursuing the Water Petal. This approach ensures that, across the community, no additional water, and perhaps even less water, is going to the municipal sewage system than before the new project was built, thus reducing the overall burden on the municipal system.

FIGURE 7: Potential handprinting and project building fooprint scopes.



BLACKWATER EXCEPTION FOR AFFORDABLE HOUSING

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

Blackwater Treatment for Multifamily Affordable Housing

Multifamily affordable housing projects of three stories or more are allowed to connect to a municipal sewer system for blackwater treatment.

Single story and two story affordable housing projects may also use this exception on a case-by-case basis. Project teams facing density, regulatory or other barriers for on-site blackwater treatment must make their case through the Dialogue and receive approval from the Institute in order to receive an exemption and connect to the municipal sewer system.

All project greywater must be treated on site or by scale jumping to adjacent sites.

This exception provides an important path forward for many projects. Low-rise projects must still meet the full requirements of the Water Petal, and all projects must treat greywater on site.

NET POSITIVE WATER MODELING

To achieve Net Positive Water across the six climate zones, four different scenarios were modeled, each of which meets the requirements of the Water Petal through various compliance pathways. Each scenario utilizes different systems and different exceptions (when needed) in order to respond to a project's specific climactic, regulatory, or financial barriers.

SCENARIO 1:

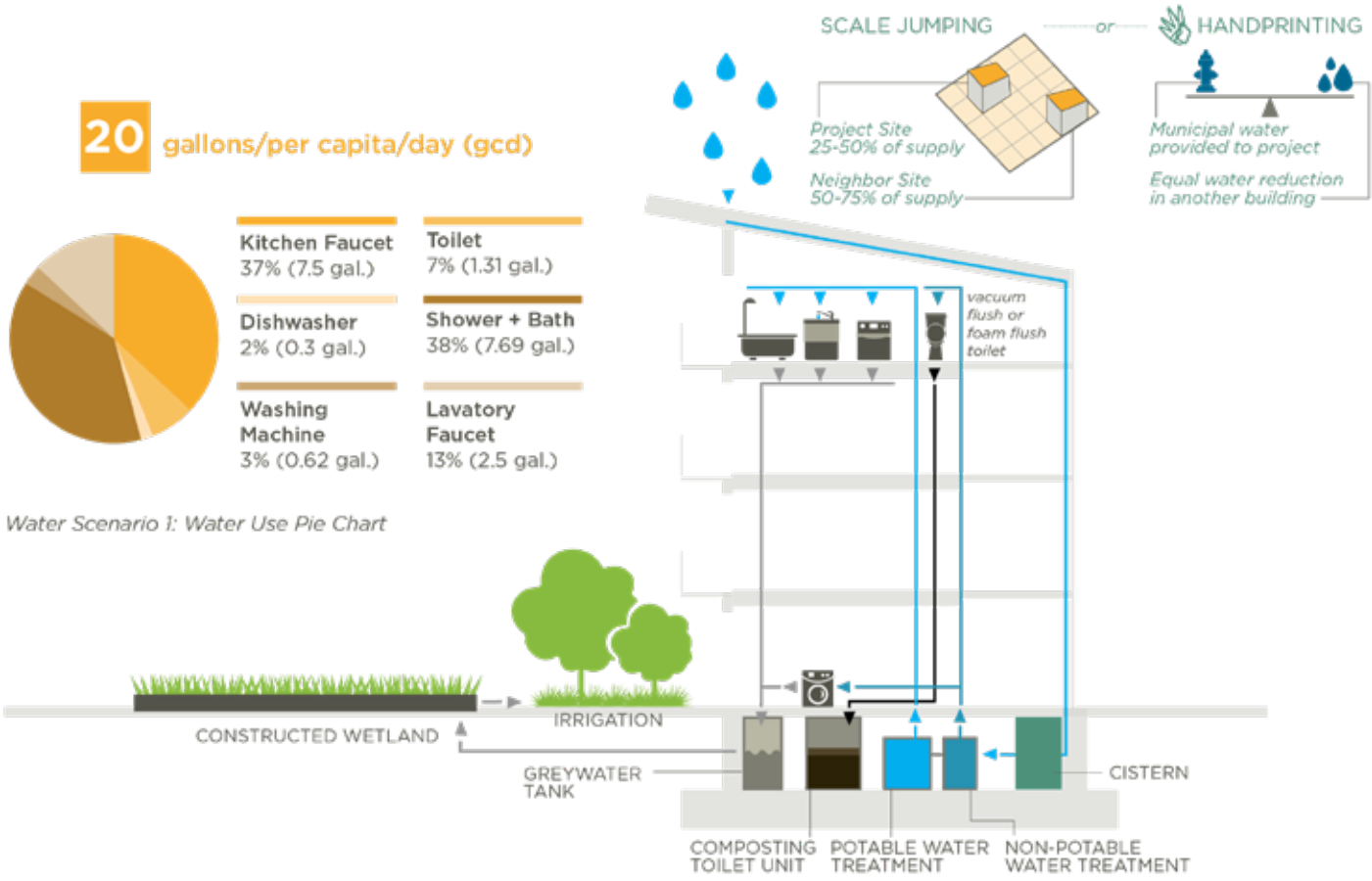
Closed Loop System with Rainwater Supply

Scenario 1 is the "closed loop" scenario, which assumes 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, and the size is given in dimensions assuming a height of ten feet. Due to the requirements of Net Positive Water, the rainwater must be treated to two different levels, according to its final use—potable water may not be used for non-potable uses.

In this scendario, greywater is treated on site through a constructed wetland and/or subsurface irrigation system. Blackwater is managed through an on-site composting toilet system using vacuum flush toilets, which helps reduce water demand to 20 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 25–50% of its water needs from rooftop rainwater collection.

FIGURE 8: Net Positive Water Modeling Scenario 1 - Closed Loop System with Rainwater Supply.



For the remaining 50–75% of the water needed, a project would either have to scale jump to utilize a nearby building's roof of equal or greater size, or connect to the municipality for all of their potable water and handprint using the alternative compliance pathway for affordable housing. In the sixth location, semi-arid San Jose, CA, the typical project could only meet 12.5% of its water needs from on-site rooftop rainwater collection. To meet the project's full water demand, seven additional similarly sized rooftops would need to be added through a scale jumping strategy, requiring cisterns above 350,000 gallons. Alternatively, the project could meet the requirements via handprinting using the alternative compliance pathway for affordable housing.

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

FIGURE 9: Net Positive Water Modeling Scenario 1 - Closed Loop System with Rainwater Supply 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	150,000	45′x45′
Christiansburg, VA*	50,000	40.73	15,000	14′x14′
Chicago, IL*	50,000	37.96	60,000	28′x28′
San Jose, CA	100,000	15.82	350,000	68′x68′
Austin, TX*	50,000	34.89	30,000	20′x20′
Vancouver, WA	50,000	41.63	115,000	39′x39′

*Scenario best suited for the following partner locations

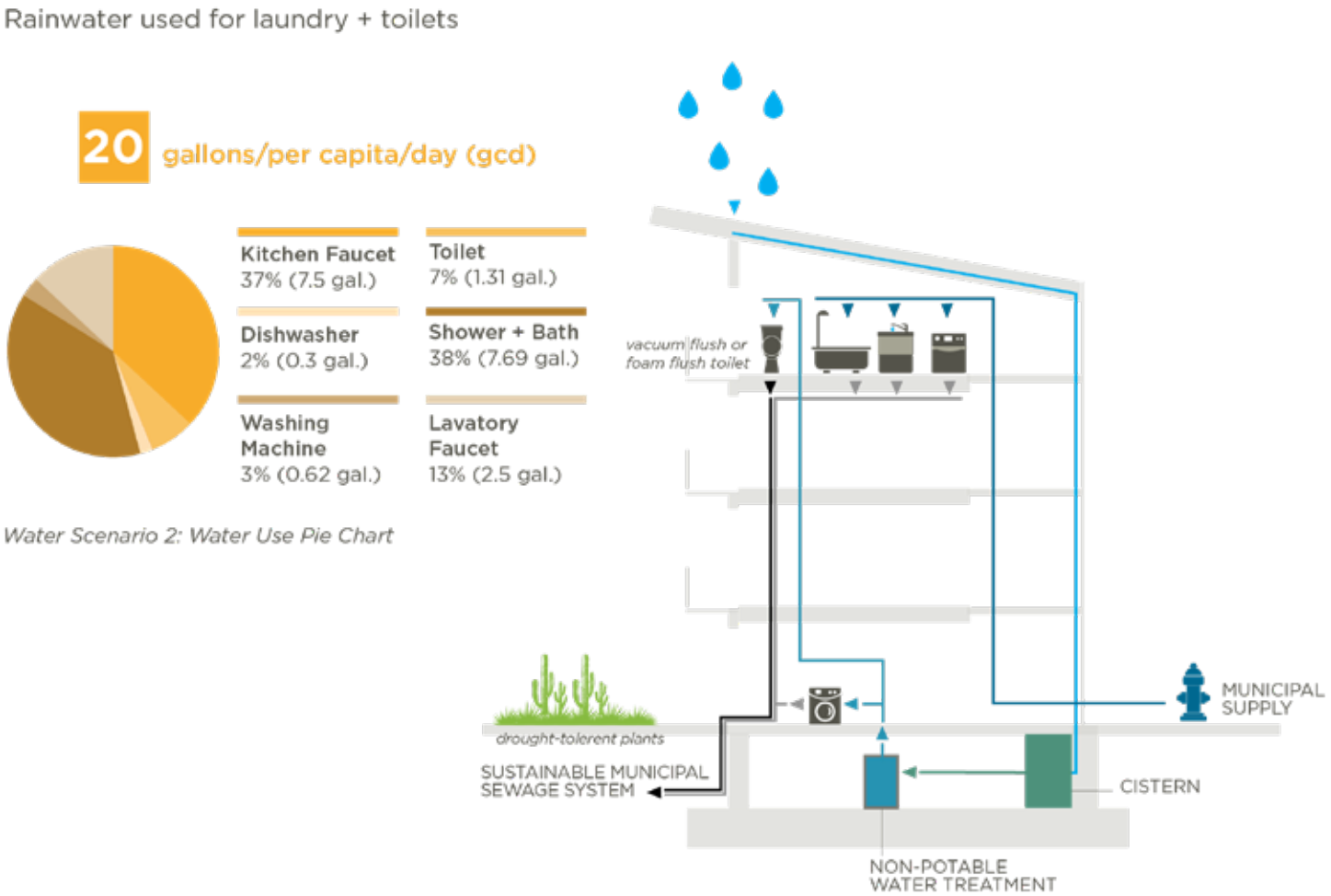
**Required catchment area to meet 100% of water demand in modeled project.

SCENARIO 2:
Municipal Potable Supply with Municipal Sewage Connection

In Scenario 2, regulatory barriers prevent rainwater collection for potable use; after a number of compelling but ultimately unsuccessful meetings to convince the authority having jurisdiction, the team elects to use the Municipal Potable Water Exception. Under this exception, municipal water provides all potable water use. Non-potable water demand (sufficient for use in laundry and toilet flushing) is met with rainwater captured from the roof, held in a cistern and filtered to an intermediate quality. Irrigation is not accounted for in the following rainwater calculations, but still must be met with non-potable water. Depending on the type and size of the landscape design, the project team might need to increase the cistern size to meet the irrigation demand. Alternatively, they might investigate native, drought tolerant species for use in the landscape.

The team in this scenario elects to connect to the municipal sewage system for grey and blackwater, but for good reason; their utility has just invested in a district-scale system that meets the sustainability requirements of the Municipal Sewage Connection requirements. The team retains the vacuum flush toilets in their design in order to reduce water demand for toilet flushing and maintain project water consumption at 20 gcd, as in Scenario 1.

FIGURE 10: Net Positive Water Modeling Scenario 2 - Municipal Potable Supply with Municipal Sewage Connection.



Water Scenario 2: Water Use Pie Chart

The modeling results show that in all locations, a typical project can easily achieve Net Positive Water when the Municipal Potable Water Exception and Municipal Sewer Exception is used.

The cistern size depends on the specific climate, but for all locations it is within a reasonable size range of 1,500 and 14,000 gallons, not accounting for irrigation demand.

FIGURE 11: Net Positive Water Modeling Scenario 2 - Municipal Potable Supply with Municipal Sewage Connection Cistern Sizing Table.

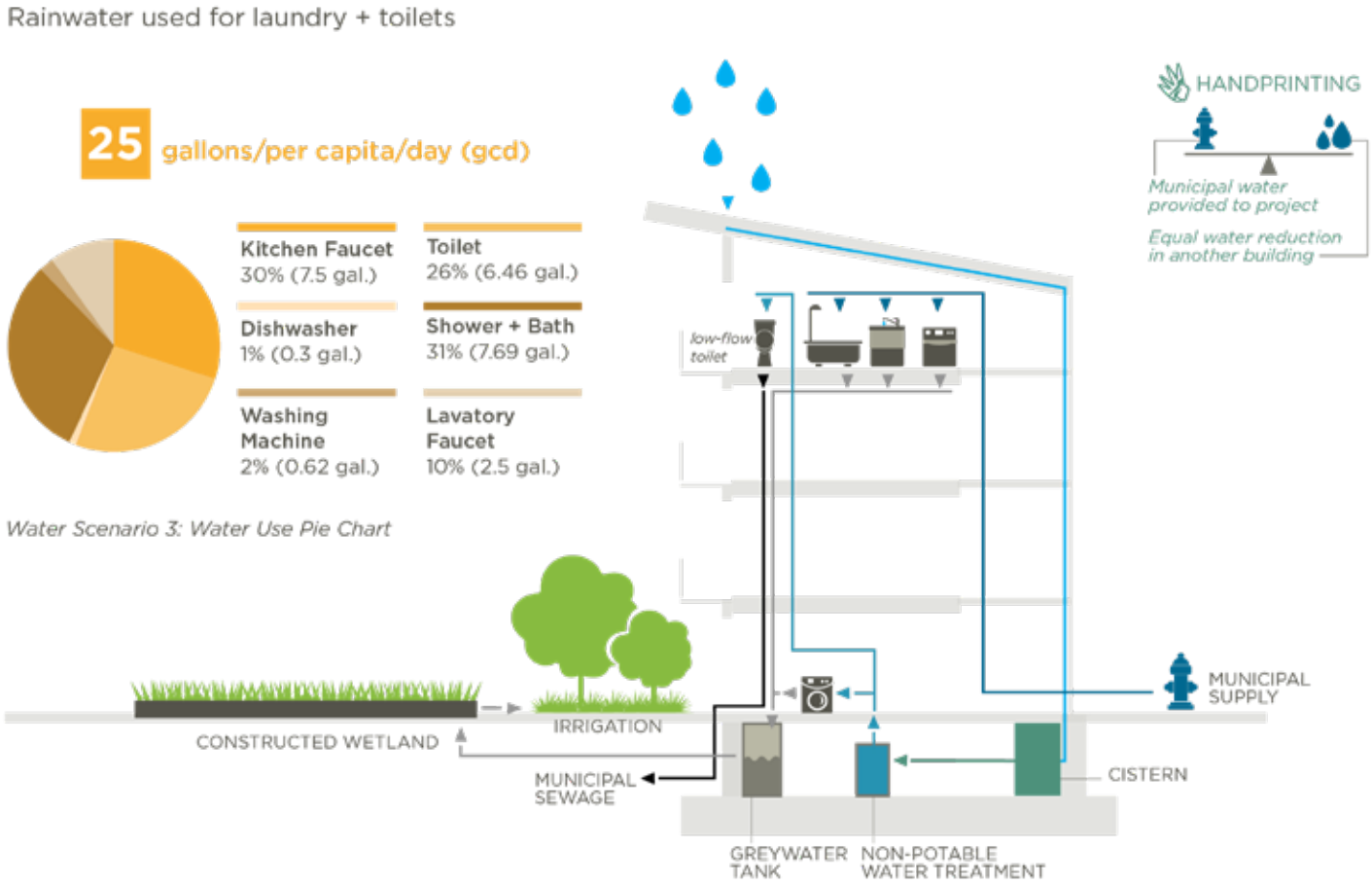
Partner Locations	Catchment Area (sq ft)	Rain Collection Resource (in/yr)	Cistern Size (gal)	Cistern Dimensions if 10ft tall
Minneapolis, MN	25,000	32.16	5,000	8'x8'
Christiansburg, VA	25,000	40.73	4,000	7'x7'
Chicago, IL	25,000	37.96	1,500	4'x4'
San Jose, CA	55,000	15.82	14,000	14'x14'
Austin, TX	25,000	34.89	1,500	4'x4'
Vancouver, WA	25,000	41.63	2,000	5'x5'

SCENARIO 3:
Handprinting Potable Supply with Rainwater Supply for Low-Flow Toilets

Scenario 3 assumes that regulatory and/or social barriers prevent the use of composting toilets, so the project has elected to utilize the Blackwater Treatment for Multifamily Affordable Housing Exception. Harvested rainwater is used for flushing toilets and laundry. Using low-flow toilets instead of vacuum flush composting toilets will bring daily water consumption per person per day to 25 gcd.

In lieu of designing and advocating for a rainwater to potable system, the project team in this scenario elects to handprint using the alternative compliance pathway for affordable housing so as to still have a net positive impact on the watershed. They reduce their water use as much as possible and then invest in water efficiency improvements in other buildings within their portfolio in order to have a net zero draw on the municipal potable water.

FIGURE 12: Net Positive Water Modeling Scenario 3 - Handprinting Potable Supply with Rainwater Supply for Low-Flow Toilets.



Greywater is treated on site through a constructed wetland and used for irrigation. This provides a benefit to the new project and to the residents in other existing affordable housing projects.

Due to the limited water resources in the region, San Jose is again an outlier in this scenario. With low-flow toilets specified instead of vacuum flush toilets (as in Scenario 2), the typical project in this area can only meet 62.5% of its non-potable water needs from on-site rooftop rainwater collection. Meeting the remaining water needs would require scale jumping, a community-scale rainwater catchment system, and/or capturing and reusing other site water, such as greywater.

Any greywater that is not used for these purposes must be managed on site, using one of the strategies listed above.

The projects in the other cities can meet these requirements easily, without greywater recycling, although all greywater is still managed on site.

FIGURE 13: Net Positive Water Modeling Scenario 3 - Handprinting Potable Supply with Rainwater Supply for Low-Flow Toilets 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	13,000	13'x13'
Christiansburg, VA	25,000	40.73	2,000	5'x5'
Chicago, IL	25,000	37.96	2,000	5'x5'
San Jose, CA	55,000	15.82	30,000	20'x20'
Austin, TX	25,000	34.89	4,500	8'x8'
Vancouver, WA	25,000	41.63	30,000	20'x20'

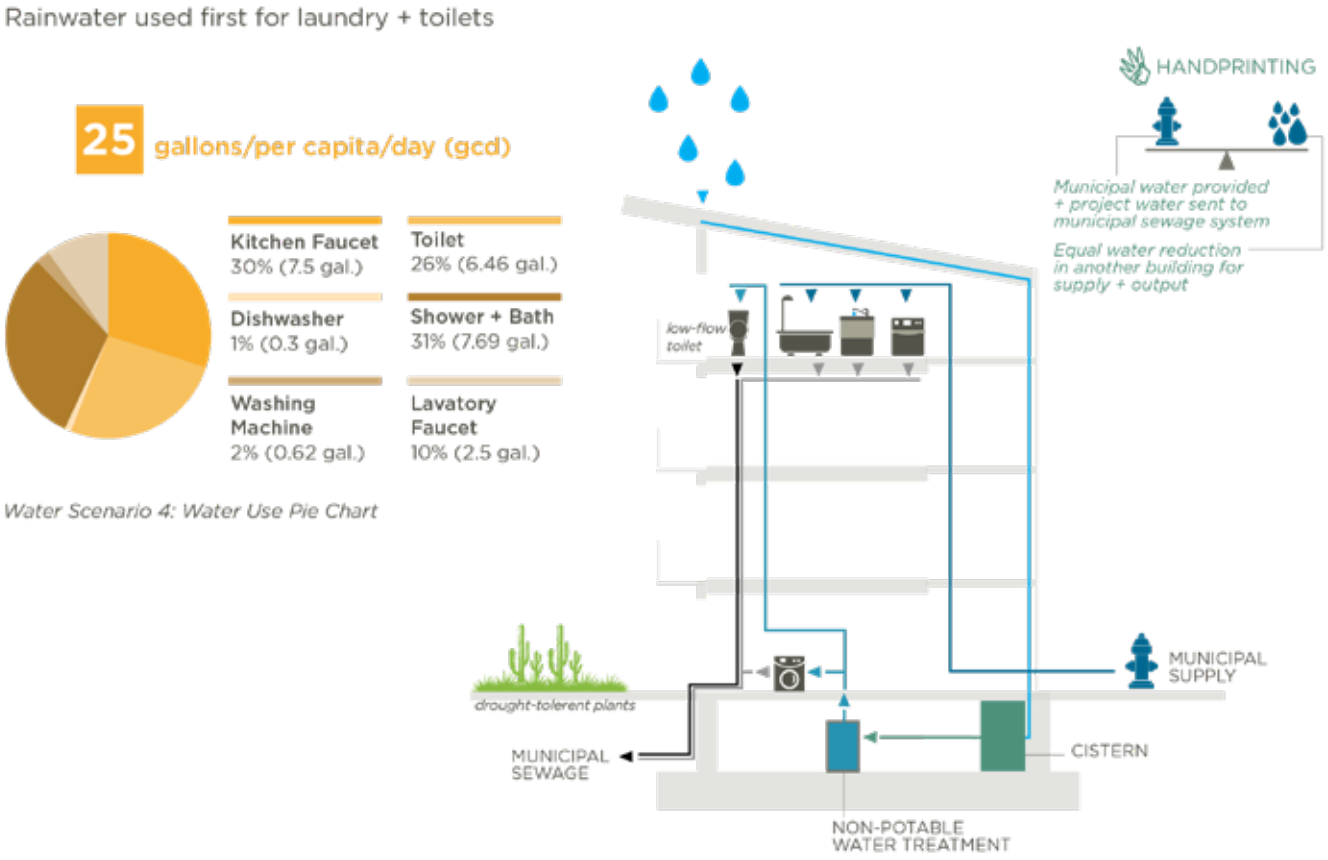
SCENARIO 4:

Handprinting for Supply and Output

In Scenario 4, the project team is extremely limited on site due to their high-density location. Their roof space is too small to support their potable water demand through rainwater alone, and there is not enough space inside the building for composting toilets or outside the building for a constructed wetland. The team does not have the funds, energy supply, or maintenance staff to support investment in a technical solution, such as MBBRs or MBRs. However, they still want to achieve the Water Petal and demonstrate a net positive impact on their watershed. They elect to handprint their potable supply using the alternative compliance pathway for affordable housing and handprint their grey and blackwater output using the alternate compliance pathway provided in the Imperative language. Non-potable demands (excluding irrigation) are met using rainwater harvesting, similarly to Scenario 2. Irrigation can be accounted for with rainwater if the project team increases the size of the cistern, or greywater could be treated with a constructed wetland and used for irrigation. Alternatively, the project team could use native, drought tolerant plants to decrease or eliminate irrigation demand.

Because each project uses roughly the same amount of water regardless of location, the handprinting strategy looks similar across all climate zones. Project teams reduce water demand as much as possible, metering their potable water use and the water sent to the sewer. Over the course of the performance period, the project team makes enough improvements in water efficiency within their own portfolio or in other buildings in the watershed that they completely offset their building's impact on the municipal potable water system and the municipal sewer system.

FIGURE 13: Net Positive Water Modeling Scenario 4 - Handprinting for Supply and Output.



Water Scenario 4: Water Use Pie Chart

Scenario 4 uses the same amount of rainwater as Scenario 2; for all non-potable water uses. In all locations, a typical project can easily achieve Net Positive Water when the team handprints their municipal connections to the potable water system and the sewer system.

The cistern size depends on the specific climate, but for all locations it is within a reasonable size range of 1,500 and 14,000 gallons. Again, irrigation is not accounted for in this sizing.

FIGURE 14: Net Positive Water Modeling Scenario 4 - Handprinting for Supply and Output 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	5,000	8'x8'
Christiansburg, VA	25,000	40.73	4,000	7'x7'
Chicago, IL	25,000	37.96	1,500	4'x4'
San Jose, CA	55,000	15.82	14,000	14'x14'
Austin, TX	25,000	34.89	1,500	4'x4'
Vancouver, WA	25,000	41.63	2,000	5'x5'

MODELING CONCLUSIONS

To achieve the Water Petal, affordable housing projects must reduce water consumption to roughly 20 gcd and utilize reuse or handprinting strategies along with various LBC exceptions. This will require innovative water reduction strategies and, in some cases, tenant education about composting toilets and other cutting edge technologies.

The 20 gcd may sound extreme, especially considering that most U.S. multifamily apartments are designed to consume 40 gcd.[19]

However, there is a precedent for this reduced level of water consumption. An affordable housing community in San Juan County, WA, has a measured water consumption of around 20 gallons per day per resident.[20]

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 these six climate zones.

19 Grondzik, Walter T., Alison G. Kwok, Benjamin Stein, and John S. Reynolds. Mechanical and Electrical Equipment for Buildings (MEEB). Eleventh ed.
20 Refer to appendix C: Water Statistics + Specifications

BARRIERS + SOLUTIONS

SOCIAL BARRIERS

Many people have concerns about the use of treated rainwater and greywater, even though the treatment technologies are proven and established. In addition, nontraditional means of treating blackwater, 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 perceive that their homes 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. Visiting existing composting toilet systems, such as those in the Bullitt Center in Seattle, WA, can shift perceptions.

Every potential project team that tours the Bullitt Center is impressed by their cleanliness and ease of use, and many of them commit to incorporating a similar system into 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 multifamily housing.

REGULATORY BARRIERS

The Water Petal requirements remain some of the most difficult requirements of the Living Building Challenge from a permitting and regulatory standpoint. Restrictions in planning, implementation, and use of decentralized water strategies vary by jurisdiction, building type, and city and state regulatory regimes. When rainwater is used for potable uses, some jurisdictions require chemical treatments, such as chlorination. Many jurisdictions simply do not allow potable water to be supplied from rainwater in public buildings. Building an on-site wastewater treatment system can also be a regulatory challenge. Utilities often require projects to connect to the municipal sewer system and to pay a service fee even if the project does not actually use the connection.

REGULATORY SOLUTIONS

Long-term coordinated advocacy will be critical to overcoming persistent regulatory barriers to decentralized water systems. In addition to the water policy research and education completed by the Institute, the Living Building Challenge requires that project teams advocate to their authorities having jurisdiction whenever one of the exceptions described earlier 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 adoption.

Some states, such as Massachusetts, are taking a leadership role and can serve as inspirational models for other jurisdictions. Three projects in Massachusetts (the Living Certified Class of 1966 Environmental Center at Williams College, the Living Certified Kern Center at Hampshire College, and the Living Certified Hitchcock Center for the Environment in Amherst, MA) have recently overcome regulatory and social hurdles to implement 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 greywater and blackwater 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.

In January of 2019—in response to the permitting barriers experienced by our project teams—the Institute published the Water Petal Permitting Guidebook, which was released in January of 2019. This guidebook is a reference for project teams in pursuit of the Water Petal, or for any project team that is implementing on-site water capture, treatment, and reuse systems of any type or scale. The guidebook provides general guidance for the permitting process of each category of water system that your project may incorporate in pursuit of the Water Petal, as well as tips for working with local jurisdictions and regulators. Given the variation in local and state laws and interpretations around the country, as well as globally, this guidebook cannot be a definitive or comprehensive resource for all situations. Rather, it is meant to offer general guidance and tips for navigating the permitting process based on the experience of other project teams. See the Resources Section for the link to the Water Petal Permitting Guidebook and other resources.

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 generally 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 and the natural environment, making water very inexpensive to project owners. Compared to on-site energy generation, there is little payback for on-site water systems. That being said, as water availability shifts across the country in response to climate change, and as utilities are faced with maintaining or replacing $1.1 trillion worth of pipes reaching the end of their life cycle, this dynamic is likely to shift.[21]

Furthermore, 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. 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 blackwater treatment in multifamily 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.

Projects may also have success working with the local water utility to reduce charges for connecting to the system in the supply and demand side. As mentioned earlier, many utilities will require teams to connect to the local water supply and sewage system even if they do not use them. Project teams can try to negotiate for the fee to be waived, reduced, or only charged if the system is used. The Brock Environmental Center in Virginia Beach, VA was able to work with their local utility to have the sewage connection downsized from that required for an institutional building to that required of a single-family home, because they were able to demonstrate that sewage generation amounts would be equivalent to that of a single-family house due to extremely low water use and composting toilets. This reduced the connection fee from $381,200 to $1,200, saving the project $380,000, more than enough to pay for all the on-site water systems.

In the long term, in order to achieve all Water Petal requirements, there will need to be significant changes to utility regulations and incentive programs, as well as to the tax credit allocation system. While water prices remain very low in many areas of the United States, climate change and continuing drought in the American West are likely to push prices higher as potable water sources are depleted.

21 Bruce Hollands, "Procurement Practices that Impede Rehabilitation of Underground Water Infrastructure," Mayors Water Council, Summer/Fall 2010, p. 4.

Additionally, as regions grapple with the economic and environmental impacts of stormwater runoff, some jurisdictions are starting to fund local projects working to mitigate the impacts of this runoff. 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.[22] As water rates increase, alternative water systems will become more financially viable, and water efficiency measures will mitigate the risk of rising utility bills for low-income tenants.

CONCLUSION

As climate change impacts accelerate and water resources become increasingly stressed—particularly in drought-prone regions—there is an increasing need for decentralized, resilient water infrastructure. Net Positive Water modeling suggests that it is feasible to achieve the Water Petal in a variety of climate zones across North America if water demand is reduced through the combination of high-efficiency fixtures and composting toilets. However, there are different technical challenges in each of the climate zones modeled that demand a place-based approach.

While Water Petal technical challenges are surmountable, financial and regulatory barriers persist and prevent the widespread adoption of innovative, decentralized, regenerative water systems. The Institute will continue to pursue coordinated action and advocacy to change utility business models and overcome regulatory barriers to pave the way for decentralized water system adoption.

The affordable housing project that demonstrates Net Positive Water is practical and feasible, while meeting tenant needs, will have a transformative effect on the development community. This pioneering project would pave the way for future leading affordable housing developers to pursue innovative Responsible Water and Net Positive Water strategies, and to continue pushing the industry forward. The following case studies start to illuminate a way forward.

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

CASE STUDIES
WATER

BY THE NUMBERS: BLOCK PROJECT	
FIXTURE TYPE	**AS DESIGNED**
Toilets	0.0 gpf
Kitchen Faucet	0.5 gpm
Lavatory Faucet	-
Shower	1.0 gpm
Bath	-
Laundry	-
Dishwasher	7 g/use
TOTAL	**15.3 g/person/day**

BLOCK PROJECT

Facing Homelessness and BLOCK Architects
Seattle, WA

The BLOCK Project invites community into the task of ending homelessness by building small homes in residential backyards for those who are living unsheltered. The vision is to place one on every residentially zoned block within the city of Seattle. This innovate solution believes that these homes should be integrated, dignified, and sustainable, giving the resident a place they can be proud to call home.

The BLOCK Project team hopes to make use of the latest cutting-edge technology for living responsibly on our planet. The goal is to have each home Living Building Challenge certified, which means that their goal is to have all of the water, including drinking water, come from roof-water catchment and purification. All of the wastewater is treated on site with a composting toilet, and sub-surface irrigation Is used for shower and sink greywater.

RAINWATER

Rainwater runoff will be collected from the roof of the BLOCK home, screened, and conveyed into a cistern for storage. When the sink or shower fixtures are turned on in the BLOCK home, a pump will draw rainwater from the cistern through a screened floating intake hose, which draws water from just below the water surface, excluding any particles floating on the surface or settled at the bottom of the tank. The rainwater will be pumped through a series of filters to remove contaminants before reaching the fixture for use by the occupant.

Rainwater consumption within the BLOCK home will be limited based on a timer on the supply pump to ensure that fixtures are not left on for an extended period of time. Each BLOCK home will have only one occupant with modest water demands, estimated to be 15.3 gallons per day.

When the cistern is full, excess rainwater will be discharged from the cistern through an overflow pipe onto a splashblock, where it will be dispersed into existing vegetation on site.

GREYWATER

Greywater generated from sink and shower fixtures within the BLOCK home will be collected by interior plumbing and conveyed to an underground septic tank. Effluent will pass through an effluent filter (Orenco Biotube, or similar) before exiting the septic tank and being conveyed to a drainfield for further treatment through infiltration.

With a safety factor of 1.5, the average daily flowrate is 23 gallons per day. At the prescribed 0.8 gallons per day per square foot, the minimum drainfield area is 29 square feet. The proposed gravity drainfield consists of a 2-foot-wide, 15-foot-long gravel trench containing a 4-inch diameter perforated pipe along its length with cleanouts at each end.

BLACKWATER

Human waste will be collected in a self-contained composting toilet, such as the Sun-Mar Excel NE. This specific model has capacity for two to three full-time residential users, which exceeds the single occupancy of each BLOCK home. Ventilation for the toilet will be provided via a fan in a vent stack extending thru the roof of the structure.

Composted material will be removed annually, bagged, and disposed of in municipal solid waste or sent to an approved processing facility to be reused as a soil amendment. Any excess leachate will be

conveyed to the greywater tank, where it will be filtered and conveyed to the drainfield and will then infiltrate into the soils below, receiving additional treatment.

Water supply: Rainwater

Greywater treatment and reuse:
Filtered and infiltrated through drainfield + used for subsurface irrigation

Blackwater treatment: Composting toilet

Stormwater treatment:
100% of stormwater to be retained on site

PERMITTING

The design above reflects the ultimate intent of the BLOCK project team, but their efforts have so far been stymied due to current permitting realities in Seattle and greater King County. However, the inventiveness and simplicity of the idea (a small home in the backyard of one house on every residential block in the city), coupled with its comprehensive community-based approach to serving the previously homeless resident, has garnered interest and support from citizens, industry professionals, government workers, and elected officials alike.

One such advocate is City of Seattle Councilmember Sally Bagshaw. With her commitment to community, people, and equity, as well as her ability to envision a future where all people are housed, she helped spearhead a process with BLOCK Architects, ILFI, and Herrera Environmental Consultants to convene all the key permitting stakeholders from the city, county, and state to work together to collaboratively develop an approach to successfully permit the project while meeting all agencies' concerns. This approach gave everyone a voice, ensured that all ideas and concerns were heard, and allowed those involved to engage meaningfully in a process to address an important local and global issue. As this is not something that permitting officials and regulators often get to do, many were excited to use their experience and expertise in a positive way to craft a path forward.

As of the date of publication, the language for a proposed pilot program is being drafted for Council review and (hopeful) approval. Until then, the BLOCK Project will be using the alternative compliance pathway for affordable housing to account for their municipal water connection by investing in efficient, low-flow fixtures in the host's home.

Neighbors enjoy a meal outside the first BLOCK home, built for Robert "Bobby" Desjarlais, in the backyard of Kim Sherman and Dan Tenenbaum. Image courtesy of BLOCK Architects + Facing Homelessness

CEDAR SPRINGS

A Community of Friends
La Verne, CA

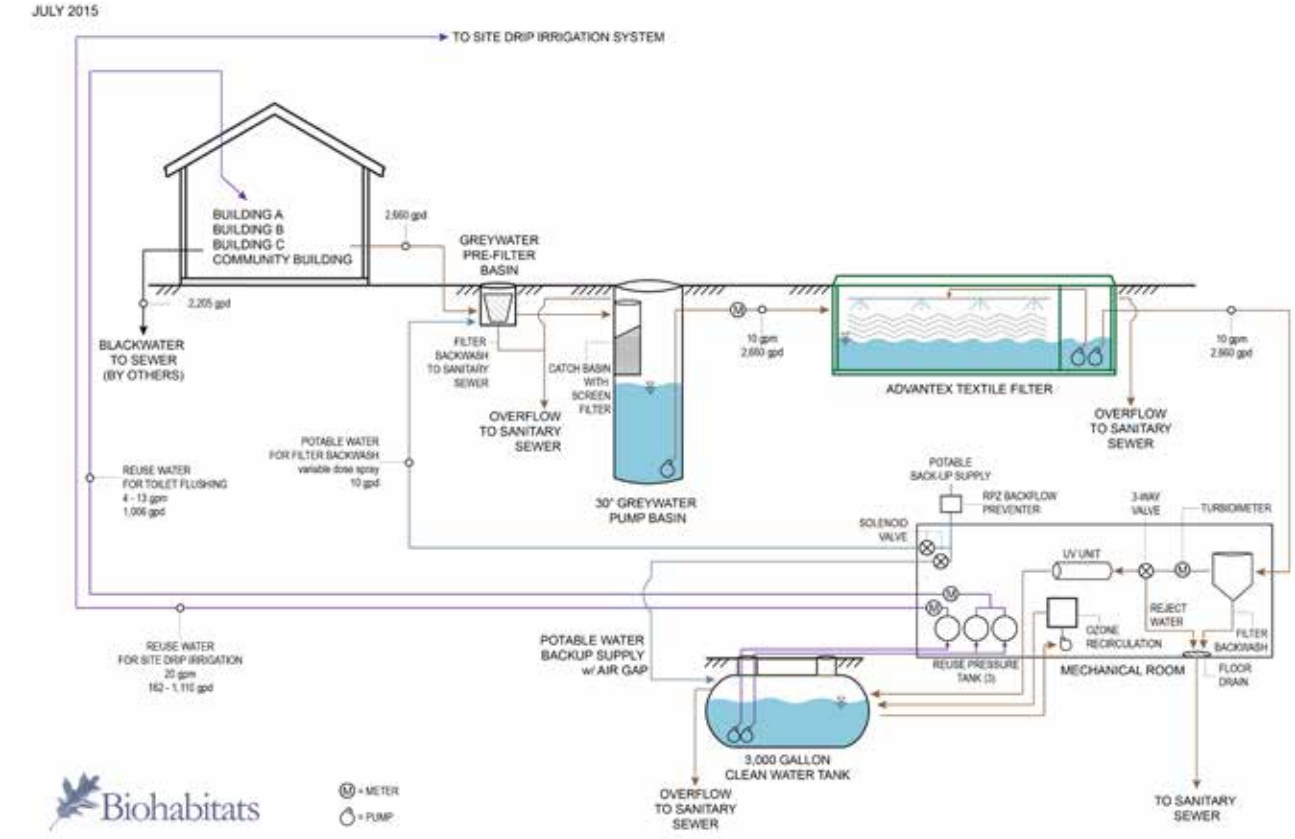
By the time California Gov. Jerry Brown announced the end of a six-year drought in his state in April of 2017, hundreds of thousands of acres of farmland had gone unplanted and 70 million trees in the Sierra Nevada had fallen to pine beetles. While the impacts of the drought and lack of affordable access to clean water were unprecedented, the situation also presented an opportunity to the state—in an increasingly hot and unpredictable world, how can California ensure that everyone has access to affordable and clean water? One answer: aggressive water reuse piloted by those who can benefit most.

Affordable housing developers have been early advocates of high-efficiency systems. Many of them are nonprofit owners, so savings on energy and water bills help their projects pencil and reduce long-term utility costs. In some cases, it even allows them to pass financial benefits directly on to the tenants.

Though they were committed to integrating greywater infrastructure into their projects, A Community of Friends (ACOF)—nonprofit affordable housing developers in the Los Angeles area—discovered that one primary barrier was the convoluted and occasionally prohibitive regulatory process. Greywater reuse guidelines were adopted into the state's plumbing code in the early 1990s, but it was up to each individual jurisdiction to permit the systems. More often than not, cities were too concerned with liability and operation to allow installation of these systems.

The drought created a renewed interest in preserving potable water and using fit-for-purpose water—the right water for the right task. In the case of Cedar Springs, ACOF was able to partner with the County of Los Angeles and the City of La Verne in order

FIGURE 15: Cedar Spring's greywater system, designed by Biohabitats, captures 2,660 gallons per day of greywater and treats it with a textile filter, UV, and ozone, before it is used for irrigation and to flush toilets. Diagram courtesy of Biohabitats, Inc



to implement programs and create regulatory pathways to deploy next-generation water systems. Located just outside of Los Angeles, Cedar Springs was ACOF's first Living Building Challenge registered project. The target population is very low-income households earning less than 50% of the average median income. The project team worked to permit and install greywater collection, treatment, and reuse systems for internal toilet flushing and external irrigation.

Cedar Springs. Image courtesy of Biohabitats, Inc.

GREYWATER

In general, the greywater system is composed of a secondary treatment process to treat biochemical oxygen demand (BOD) and total suspended solids (TSS), mechanical filtration, and disinfection. Greywater from the residential and community buildings will gravity flow to the treatment system via a pre-treatment cascade filter to remove hair, lint, and other coarse particles. Greywater will then gravity flow to a pump basin equipped with an additional basket filter to remove any residual hair, lint, and other coarse particles. Greywater will be pumped/metered to a moving bed-membrane bioreactor, where it will be recirculated through an aerated reactor with high surface area membranes. From there, it will be pumped to a mechanical room for final filtration and disinfection before entering a clean water reuse tank. If there is a shortage of treated greywater to meet non-potable demands, potable makeup water will be added to the clean water tank. The potable makeup line will have an air gap with the maximum high water level in the clean water tank to prevent cross contamination. All blackwater from West Villas buildings will be plumbed to the sanitary sewer.

PERMITTING

Working in a small city outside of Los Angeles had its perks—the small local government possessed more flexibility when looking at new and innovative systems and were less concerned about liability. In fact, when the project team could only cover a fraction of the system cost, the LA County Community Development Commission increased their funding to cover the remaining expenses. The amount of face-to-face time that the project team was able to cultivate with the regulators was hugely beneficial in bringing them onboard. They were all experiencing the same drought and all possessed the same vision—it was only a matter of problem-solving together.

ACOF additionally intended to use treated greywater in the building's laundry machines, which is allowed under state plumbing code, but weren't able to permit it in time. However, the education and groundwork has been laid for future project teams, and ACOF is confident that non-potable sourced laundry machines will be coming to LA County soon.

Water supply: Municipal

Greywater treatment and reuse:
Filtered and infiltrated through drainfield

Blackwater treatment:
Municipal

Resources

Enterprise Green Communities Criteria
The principal set of design guidelines for U.S. affordable housing development types (single-family and multifamily) and construction types (new construction, rehabilitation), which provides a methodical checklist of cost-effective strategies. These criteria deliver 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.
enterprisecommunity.com/solutions-and-innovation/enterprise-green-communities/criteria

U.S. 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.
www.epa.gov/watersense

American Water Works Association: Affordability Assessment Tool
This resource provides workbooks for comparing the affordability of water mandates. 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

Urban Fabrick's Onsite Non-Potable Water Reuse Practice Guide
This practice guide is a fantastic resource to orient designers and occupants alike to the science, benefits and opportunities associated with on-site water reuse. It includes definitions, design guidelines, best practices for communicating with tenants, permitting tips, and maintenance information.
https://www.collaborativedesign.org/water-reuse-practice-guide

ARCSA
The American Rainwater Catchment Systems Association provides training for on-site rainwater capture, educational videos, rainwater calculators, and other resources. They can also provide region-specific guidance and connect your project team with professionals and products in your area.
https://www.arcsa.org/

Handprinting Guidebook
Although it is specifically designed for the Living Product Challenge, the Handprinting Guide explains the thinking behind handprinting and how it can be applied. It inspires designers to think about how they can approach their footprint, reduce it, and look beyond to create products and buildings that give more than they take—creating handprints bigger than their footprints.
https://living-future.org/product/lpc-handprinting-guide/

Water Policy Guide
The Water Policy Guide is an advocacy resource focused on net positive water. We know from Living Building Challenge teams that water regulations make it difficult for projects to utilize resilient, integrated systems. Thanks to the generous support of the Kresge Foundation, this document includes our assessment of existing regulations in the United States, highlights current policy precedents and calls for three critical policy changes. We hope to continue this research across our global network to ensure that all water is used and reused as a precious resource in all of our buildings and communities.
https://living-future.org/policy-advocacy/

ILFI Case Studies
Though designing a net positive water system can be complicated, it's the permitting of the system that is often the most challenging aspect for project teams. These nine water policy case studies document the regulatory successes achieved by several project teams and regulators around the country. Their accomplishments are crucial steps forward in the story of restorative, integrated water management. Their lessons learned can assist future projects in their own regulatory partnerships.
https://living-future.org/policy-advocacy/

Resources cont.

On-Site Water Reuse Permit Map
Water permit maps are available for five states—Oregon, Washington, Idaho, California, and Utah. This site also provides instructions and tools for making permit maps for your area. We are asking partners, peers, and community members to self-report their knowledge of barriers and pathways to next-generation water systems. These are systems where the use of water, nutrients, and energy resources are optimized to provide for the needs of people and watersheds. This includes water conservation, rainwater harvesting, and the on-site treatment and reuse of greywater and blackwater.
https://living-future.org/policy-advocacy/

Water Petal Permitting Guidebook
This guidebook is a reference for project teams that are pursuing the Water Petal, or for any project team that is implementing on-site water capture, treatment, and reuse systems of any type or scale. This guidebook provides general guidance for the permitting process for each category of water system that your project may incorporate in pursuit of the Water Petal, as well as tips for working with local jurisdictions and regulators.
https://living-future.org/wp-content/uploads/2019/02/WaterPetal_PermittingGuidebook_FINAL.pdf

National Blue Ribbon Commission
The National Blue Ribbon Commission advances best management practices to support the use of on-site non-potable water systems within individual buildings or at the local scale. The commission is committed to protecting public health and the environment, and sustainably managing water—now and for future generations.
http://uswateralliance.org/initiatives/commission

ENERGY

Relying on Renewable Resources

Solar panels on the roof of Archictectural Nexus' Living Certified office in Sacramento, CA. Image courtesy of Architectural Nexus

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

PETAL INTRODUCTION

The intent of the Energy Petal is to create new sources of renewable energy that allow projects to operate year-round in a resilient, carbon pollution-free manner. In addition, the Energy Petal prioritizes energy efficiency as a means to reduce wasteful spending of energy, resources, and capital.

As the cost of living rises in most North American urban centers and income inequality grows, it is critical that we achieve financial stability in housing to maintain a livable standard for all economic classes. The US Department of Housing and Urban Development (HUD) reports that 12 million American households pay more than 50% of their annual income on housing[23] and are considered extremely cost-burdened. According to HUD, homeowners and tenants should pay at most only one-third of their income on housing to keep from being financially burdened.[24] Additionally, low-income families have a far higher cost burden for utilities, spending, on average, 17% of their income on utility bills.[25] This causes significant stress for some of the most vulnerable communities: low-income, seniors, veterans, and those with disabilities. This is not only a matter of income; affordable units tend to be older and less energy-efficient, meaning that low-income households pay more for utilities on a square foot basis – up to twice as much as median-income households and three times as much as high-income households.[26] Nationwide one in five families miss utility payments each year, 70% of which have their utilities shut off. Researchers in Milwaukee even found that eviction rates tracked seasonally with utility bills. The American Academy of Pediatrics in 2004 issued findings that households receiving Low-Income Home Energy Assistance benefits showed lower rates of undernutrition and lower incidences of acute emergency room visits among children than similar households, suggesting that access to affordable energy is also a public safety concern.[27] Within the Gila River Indian Community in the Sonoran Desert south of Phoenix, location of the Gila River Indian Community Sustainable Housing, nearly 50% of the community lives below the federal poverty line of $12,490 for an individual while residents face utility bills of up to $600 per month.

Utility bills remain an inconsistent variable in many family budgets. As we continue to deplete our store of fossil fuel resources, energy prices will rise, while prices for renewable energy systems, especially solar photovoltaic (PV) panels and energy storage systems, will continue to decline.[28] The International Renewable Energy Agency (IRENA) reports that the cost of PV electricity has fallen 73% by 2010. Globally, the price of electricity generated from wind and solar is now on par with fossil fuels.[29] The cost of utility-scale solar is now between $0.08-0.11/kWh[30] (with onshore wind coming in at around $0.06/kWh), as compared to $0.05 to $0.17/kWh for fossil-fuel derived power.[31] IRENA issued a report in January 2018 indicating that the cost of solar is likely to halve in just two years.

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 price spikes in grid provided, non-renewable energy. 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 Carbon strategy offers a realistic solution for affordable housing in an age of energy volatility and climate risk.

23 https://www.hud.gov/program_offices/comm_planning/affordablehousing/
24 U.S. Census Bureau. http://www.census.gov/hhes/www/housing/special-topics/files/who-can-afford.pdf
25 Walsh, Bryan. "Building Green Houses for the Poor."
26 http://energyefficiencyforall.org/sites/default/files/Lifting%20the%20High%20Energy%20Burden_0.pdf
27 https://www.ncbi.nlm.nih.gov/pubmed/17079530
28 Rocky Mountain Institute. https://rmi.org/insight/economics-grid-defection
29 https://www.forbes.com/sites/dominicdudley/2018/01/13/renewable-energy-cost-effective-fossil-fuels-2020/#181c73084ff2
30 https://www.energy.gov/eere/solar/sunshot-2030 / https://www.solar-estimate.org/news/2018-03-08-how-are-solar-panels-changing-america
31 https://www.forbes.com/sites/dominicdudley/2018/01/13/renewable-energy-cost-effective-fossil-fuels-2020/#4d611fba4ff2

ENERGY

CORE IMPERATIVE

07

ENERGY + CARBON REDUCTION

SCALE JUMPING PERMITTED

The intent of this Imperative is to treat energy as a precious resource and minimize energy- related carbon emissions that contribute to climate change.

All projects must achieve a specified reduction in total net annual energy consumption as compared to a typical existing building with comparable climate, size, use, and occupancy, and combustion must be limited as follows.

- All projects must meter energy used by the project.
- New and Existing Building projects must demonstrate a twenty percent reduction in the embodied carbon of primary materials compared to an equivalent baseline. Existing Buildings may count in-situ materials against the required twenty percent.
- All projects (except Landscape + Infrastructure_ must select interior materials with a lower than industry average carbon footprint for product categories for which embodied carbon data is readily available.
- All projects must be designed to be “zero ready” through strategies such as designing area(s) and pre-installing wiring and connections for both electric vehicle charging and future installation of renewable energy systems.

	NEW BUILDING	EXISTING BUILDING	INTERIOR
ENERGY PERFORMANCE REQUIREMENT	70% reduction from an equivalent building baseline	50% reduction from an equivalent building baseline	35% reduction from an equivalent building baseline
COMBUSTION LIMITS*	Not Allowed (except through existing exceptions)	Allowed for HVAC systems that are not in project scope. Phase out plan and advocacy are required.	
RENEWABLES	Must be on-site to count towards the efficiencies above.		

* The allowance for Existing Buildings & Interiors is only for Imperative 07, Energy + Carbon Reduction. Combustion is not allowed, except through an exception, for Imperative 08, Net Positive Carbon.

I07 Energy + Carbon Reduction is a core Imperative required to be achieved by all project teams. Using tools such as Zero Tool, World Bank EDGE, or other established baselines, the project must demonstrate a reduction in energy consumption of 70% for new buildings, including any on-site renewable sources of energy. As in previous versions of the standard, energy must be metered either by end uses or by unit.

EMBODIED CARBON

The Energy Petal under LBC 4.0, including the core Imperative, requires that project teams account for both the operational energy use and the embodied carbon within the materials required to build the structure; the latter being an increasingly significant portion of the overall carbon footprint of a building project. Under Imperative I-07, projects must reduce the embodied carbon of primary materials (foundation, structure and enclosure) by 20% and select interior materials with a lower than industry average carbon footprint for certain product categories (see LBC 4.0 Materials Petal Handbook for more details). For affordable housing project teams, the embodied carbon evaluation required by this Imperative can be a beneficial exercise in seeking to streamline and reduce the use of materials and thereby lower the overall costs to the project. Using methods such as advanced framing or Lean construction principles can help to reduce the materials palette. Using FSC wood can also contribute, as FSC wood has been shown to sequester 30% more carbon than traditional forestry. Reduction of the use of cement in concrete, such as through supplementary cementitious materials (fly ash, slag, silica fume, etc.) and recycled aggregates may also reduce embodied carbon. For other materials the project team may also seek out local, natural materials used by indigenous cultures inhabiting the area. Many of these materials are also likely to provide climate-appropriate options and avoid toxic chemicals, aiding in achievement of the Materials Petal and helping to create healthier housing.

APPROVED CARBON CALCULATORS

- Athena Impact Estimator
- Environment Agency's Carbon Calculator for Construction Activities
- One Click LCA
- eTool
- EC3 Tool
- Tally

ZERO READY

Imperative I-07 requires that buildings be "zero ready," which means pre-wiring for the future installation of renewable energy systems and electric vehicle charging. Affordable housing projects often struggle with up-front cash outlays for PV. Although pre-wiring will be an additional cost, it allows the Owner the flexibility to raise money in later years to add solar to the building without the burden of costly retrofits to the building's electrical infrastructure. As the efficiency of PV panels rise and the installed costs fall, this flexibility could enable greater access to the benefits of PV, including lifecycle cost payback within a shorter time frame.

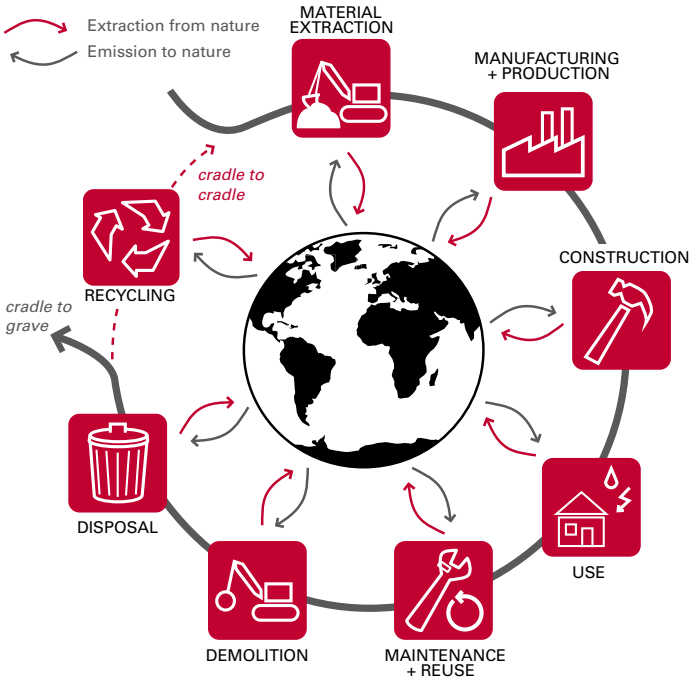


FIGURE 16: The life cycle of a product and how carbon becomes embodied throughout its stages of life. The Energy Petal accounts for carbon reduced through the first three stages - material extraction, manufacturing + production, and construction. Image from: 2014 Life Cycle Assessment: Pocket Architecture Technical Design Series, Simonen, K., Routledge, London, UK. Used with permission.

ENERGY

IMPERATIVE 08

NET POSITIVE CARBON

SCALE JUMPING PERMITTED

The intent of this Imperative is to foster the development and use of carbon-free renewable energy resources while avoiding the negative impacts of fossil fuel use, primarily the emissions that contribute to global climate change.

All projects must supply one hundred and five percent of their project's energy needs through on-site renewable energy on a net annual basis, without the use of consumption.

All projects (except single-family residential) must sub-meter major energy uses.

All single-family residential projects must develop a method to understand and trouble
shoot energy use.

All projects must account for total embodied carbon emissions (tCO_2e) from its construction (including the energy consumed during construction) through the utilization of carbon-sequestering materials and/or through a one-time carbon offset purchase through an ILFI-approved carbon offset provider.

All projects must develop and incorporate a resilience strategy to allow the building to be habitable for one week, or otherwise participate in the support for the local community in a disaster, through the use of batteries, storage, etc.

BATTERY STORAGE + RESILIENCY

Under LBC 3.1, resiliency was defined solely as battery storage. Several affordable housing projects, along with other types of buildings, struggled to install batteries due to their high cost, variable market availability, and space requirements. Resiliency is now defined more holistically and spread across several Imperatives. Under I-08 Net Positive Carbon, the project will be required to develop a plan so that the building can be habitable for one week or otherwise contribute to a community-scale resiliency effort. The resiliency plan may include other means of storage or passive systems to sustain life safety and critical operations, but need not be limited to battery storage.

EMBODIED CARBON OFFSET

Project teams will need to purchase a Certified Emission Reduction (CER) or Verified Emission Reduction (VER) from renewable sources (including methane gas capture, tree planting, solar, and wind) equal to the embodied carbon of the project.

There are a variety of ILFI-approved calculators that can be used to calculate embodied carbon. Some calculators are more general, meaning they focus on major structural elements, require fewer inputs, take less time and effort, and yield general results which are likely a bit higher. Other calculators allow for a fairly granular assessment, inclusive of all materials. The intent is to use embodied carbon as a design decision driver to help achieve the required embodied carbon reductions in Imperative 07.

OVERALL APPROACH

An integrated design process is critical to meeting either the Energy + Carbon Reduction or Net Positive Carbon Imperative. Most affordable housing projects are designed to meet building energy code criteria that are stated as a prescriptive set of design strategies and component-level performance factors. In contrast, each Living Building project must develop place-based solutions that meet a whole-building energy performance target, one that is determined by analyzing the climate and the solar carrying capacity of the site. Living Building project teams must analyze the available renewable energy resources on the site and then collaborate across multiple disciplines to optimize building form, daylighting access, and construction assemblies to meet an equivalent energy budget.

The first step is to determine the energy budget that must be met to achieve a net positive energy balance. This budget may be set by evaluating two things: how much renewable energy can be generated on site as well as what efficiency levels are possible in the building's specific location and climate. A renewable energy output feasibility study may be conducted by assessing the area available for PV placement, determining the rated capacity of modules that would fit there, and then estimating their annual output using tools such as NREL's PVWatts (see appendix D). Converting this estimated PV output to kBtu and dividing it by the building area can help determine the equivalent energy budget in terms of energy use intensity (EUI), which is the measure of energy consumption per unit of floor area per year. Alternatively, an approximate energy budget can be assessed by investigating comparable zero energy projects in the region or using baseline tools such as Architecture 2030's Zero Tool. By entering project size, location, and building use into this tool, the project team can assess how much savings beyond an average building are required to meet the renewable energy budget. Each of these evaluations should be conducted in consultation with energy consultants or mechanical engineers that can advise on analysis assumptions and offer perspective on the findings.

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, even after deep reductions in energy usage, there are two options:

SCALE JUMPING

Scale jumping is a method that allows projects to locate some of their renewable energy systems off site. The intent is to facilitate cooperation and better solutions by placing systems offsite in locations which are more optimally situated that the project, or to promote district scale solutions which result in lower net cost or higher efficiency for a community of stakeholders.

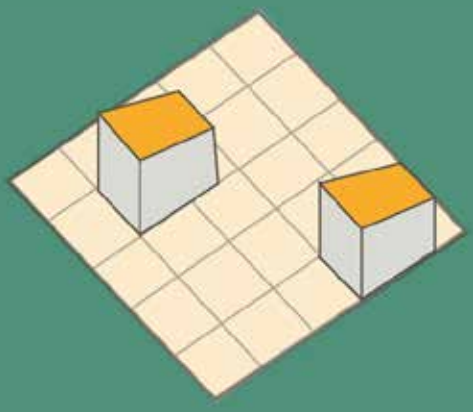
Scale Jumping must not be used to simply enlarge the energy footprint of a project, but instead must result in a net benefit, including one or more of the following:

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

OFF-SITE RENEWABLES

Tenant improvements, high-density/high-EUI projects, and/or utility-constrained projects can utilize off-site renewable energy sources located within the same regional grid. Requirements for efficiency, some portion of on-site placement, ecologically sensitive siting of the renewables, additionality, attribution and metering must also be met.

Refer to the LBC 4.0 Energy Petal Handbook for more information.



SCALE JUMPING

Once a target EUI is determined, the project team should utilize energy modeling or analysis tools to determine which efficiency measures have the highest potential to reduce the energy consumption of the project in a cost-effective manner. Several energy conservation strategies that have been used successfully on past projects are listed in the Redefining Best Practice section below and discussed in more depth in the case studies. It is recommended, particularly for affordable housing projects, that project teams first focus on optimizing the building siting and orientation to maximize "free" energy benefits before focusing on investments in the building envelope and mechanical systems. Iterative energy modeling, such as the process used by Coliseum Place and Hopeworks Station Phase II, can help the project team determine a realistic EUI for the building based on energy conservation strategies and available roof space for photovoltaics. If the roof space alone is not sufficient to generate 105% of the energy on site, past project teams have investigated the use of solar canopies above the roof or structured parking, or from overhangs beyond the building footprint. The cost of additional PV systems such as these should always be weighed against the cost of additional energy conservation measures.

NET POSITIVE CARBON ANALYSIS

The chart below shows the required energy target for several pilot projects of varying densities in different regions. This analysis was determined based on building areas and unit numbers reported by the project teams, with each case utilizing the following assumptions for renewable energy systems:

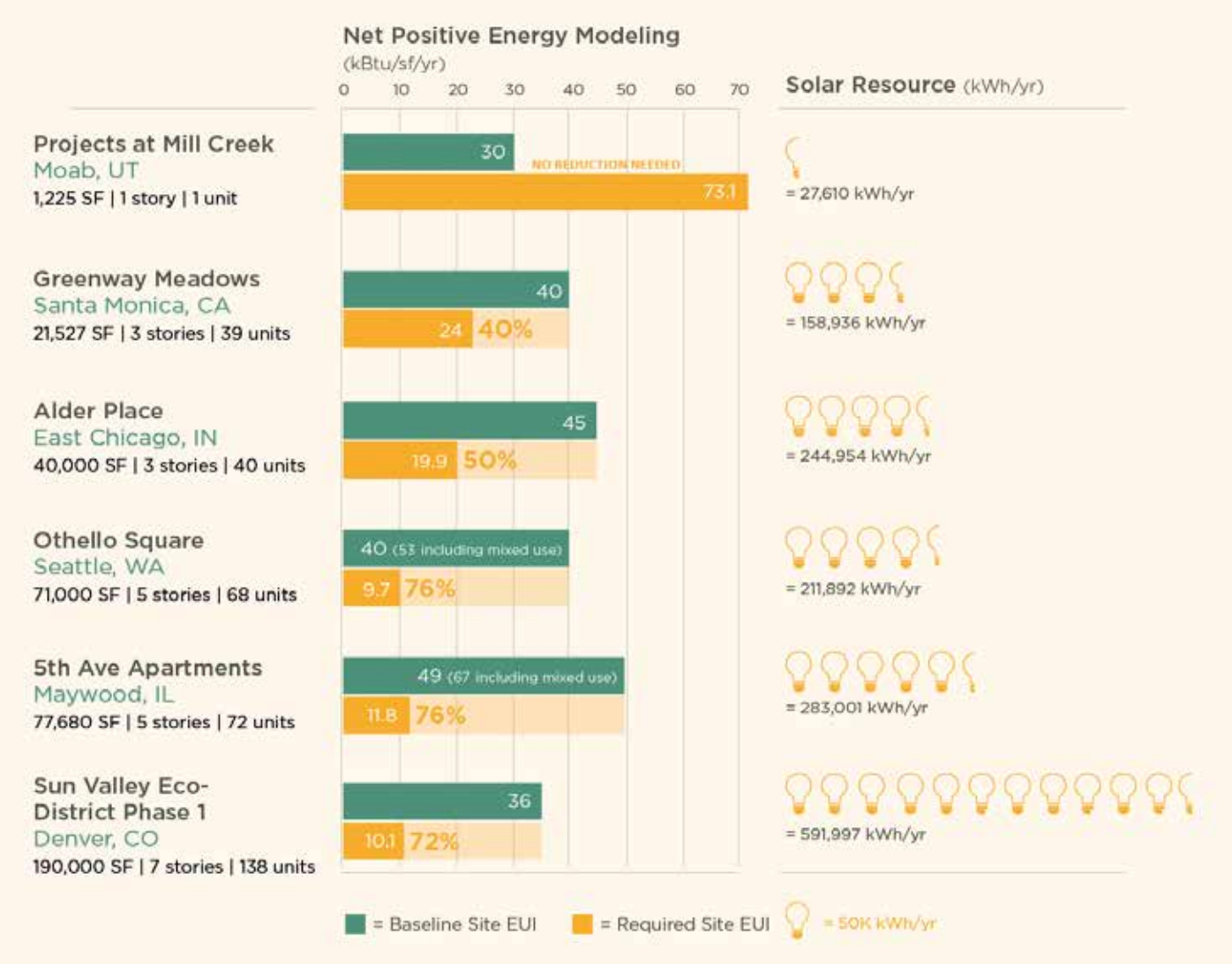
- Roof canted at a 10-degree angle
- Photovoltaic array installed with an additional 10-degree tilt (20-degree angle total)
- Photovoltaic panels installed on 80% of the roof area (to allow for access and maintenance)

The baseline energy use targets, or "Baseline Site EUI" values, represent the EUI of a typical existing building that is derived from data in the 2003 Commercial Building Energy Consumption Survey (CBECS) or the 2001 Residential Energy Consumption Survey (RECS). These baselines are normalized by climate, weather, space type, building size, occupancy, and schedule.

Target Site EUIs are calculated based on meeting the Net Positive Carbon balance, where renewable energy generation is equivalent to 105% of building energy use.

	Location	Building Area	Height	Housing Units	Baseline Site EUI (kBtu/sf/yr)	Solar Resource (kWh/year)	Required Site EUI (kBtu/sfyr)	Energy Use Reduction
Projects at Mill Creek	Moab, UT	1,225 SF	1 story	1	30	27,610	73.1	No reduction needed
Greenway Meadows	Santa Monica, CA	21,527 SF	3 stories	39	40	158,936	24.0	40%
Alder Place	East Chicago, IN	40,000 SF	3 stories	40	45	244,954	19.9	50%
Othello Square	Seattle, WA	71,000 SF	5 stories	68	40 (53 incl. comm. use)	211,892	9.7	76%
5th Ave Apartments	Maywood, IL	77,680 SF	5 stories	72	49 (67 incl. comm. use)	283,001	11.8	76%

FIGURE 17: EUI needed for Net Positive Energy on several pilot projects.



MODELING CONCLUSIONS

As demonstrated in the table above, achieving Net Positive Carbon will often require deep energy consumption reductions compared to a typical building. The outlier to this is the Projects at Mill Creek, which could actually achieve net-zero energy with an EUI of 73.1 kBtu/sf/year, more than twice the baseline EUI of 30 kBtu/sf/year and far higher than the actual modeled EUI of the building, 11 kBtu/sf/year. This shows how feasible it is to achieve net-positive energy for small, single-family structures. Though this project is located in the advantageous climate of Moab, Utah, even less sunny climates would likely be able to achieve net-positive energy at similar densities without aggressive levels of energy efficiency. Affordable housing developers building single-family structures should consider net-positive energy as a cost-efficient route to long-term utility savings and resiliency. However, even though net-positive energy could technically be achieved with few energy conservation measures, this is not to say that energy-efficiency measures are not useful in projects. By driving the EUI of this structure down to nearly 1/3 of the baseline, the project required far less photovoltaic panels, thus saving money in the project budget for other sustainable measures.

Projects of moderate densities—two to three stories—will require reductions in energy consumption in order to achieve net-positive energy.

Greenway Meadows and Alder Place would require EUIs of 24 kBtu/sf/year and 19.9 kBtu/sf/year, respectively. The differences in the EUIs needed for these projects are due to their climates—though Alder Place has a larger roof area, Greenway Meadows is located in a more temperate climate, making the required EUI less aggressive. Though the EUIs shown in the chart above for these buildings are a significant reduction from the baseline, they is likely achievable using the best practice strategies shown below and in the case studies at the end of the chapter. Hopeworks Station Phase II and Othello Square both currently have a modeled EUI of approximately 18 kBtu/sf/year, showing that this EUI is achievable within affordable housing with deliberate and careful planning.

Several projects shown in the table represent the higher range of densities, including ILFI's pilot projects Othello Square, 5th Avenue Apartments, and Sun Valley Eco-District Phase I. These structures range from five to seven stories. In order to achieve net-positive energy on these buildings, an EUI of between 9 and 12 kBtu/sf/year would be necessary. While this performance range is clearly class-leading, it is technically feasible to achieve. In order to achieve on-site net-positive energy for an affordable housing project of this density, intensive and innovative energy reduction measures would be necessary, such as ground-source heat pumps, advanced lighting and HVAC controls, ultra-high-efficiency appliances, and controlled outlets. Additionally, it is likely the projects would need to take advantage of either a solar canopy or ground-mounted solar on other areas of the project site. Projects in this circumstance may find it most cost-effective to utilize the roof space of nearby existing buildings within their portfolio via the off-site exceptions explained at the beginning of this section.

One key finding from this analysis is that density, rather than height and climate, has the largest impact on the energy reduction needed for net-positive energy. However, as shown by the drastically differing climates in the projects represented above, most multifamily projects that are less than three stories (or possibly four) in height will likely be able to achieve net-positive energy utilizing strategies found feasible by the pilot projects. Affordable

"Our homes are not only affordable to build, but the affordability continues through the life cycle operation of our homes over the years to come. To combat high utility costs to our homeowners, we combine passive and active solar design—standard on every home—with highly insulating straw bale wall systems, significantly decreasing future heating and cooling costs."

Rikki Epperson, Acting Executive Director, Community Rebuilds

housing projects at low densities, such as single-family detached or attached, should be able to easily achieve net-positive energy. At this time, projects that are more dense than this will probably require off-site options and/or more intensive energy reductions. However, photovoltaic technologies are becoming more efficient (and cheaper) each year, and energy reduction strategies are quickly advancing. It is possible that over the next decade, net-positive energy will become more feasible on site for these structures as well.

REDEFINING BEST PRACTICE

The Energy Petal is historically the most frequently adopted pathway for affordable housing projects pursuing the Living Building Challenge. Of the thirteen projects in the newest cohort, twelve of them plan to achieve Energy Petal (nine under Petal Certification and three under Living). The remaining project, which is pursuing Materials Petal certification, has an EUI below 20 and, if funding is available for PV, plans to offset 60% of the energy generated from the five-story building through roof-mounted photovoltaics. The case studies below for Lakeline Learning Center, Coliseum Place, and Hopeworks Station Phase II provide detailed information about the systems and envelope used on several projects.

A few key strategies have emerged among these projects. The first step is to look at all energy use reductions that cost no money. These relate to architectural moves of massing, orientation, and daylighting. Maximizing the potential to use the building fabric as a passive conditioning system through solar gains, preconditioning, convection,

FIGURE 18: Energy use chart for zHome, an Energy Petal Certified townhome development in Issaquah, WA, compared to a typical townhome.

evacuation, air separation, and other methods means that the loads on mechanical systems will naturally be lower, requiring less expensive design interventions.

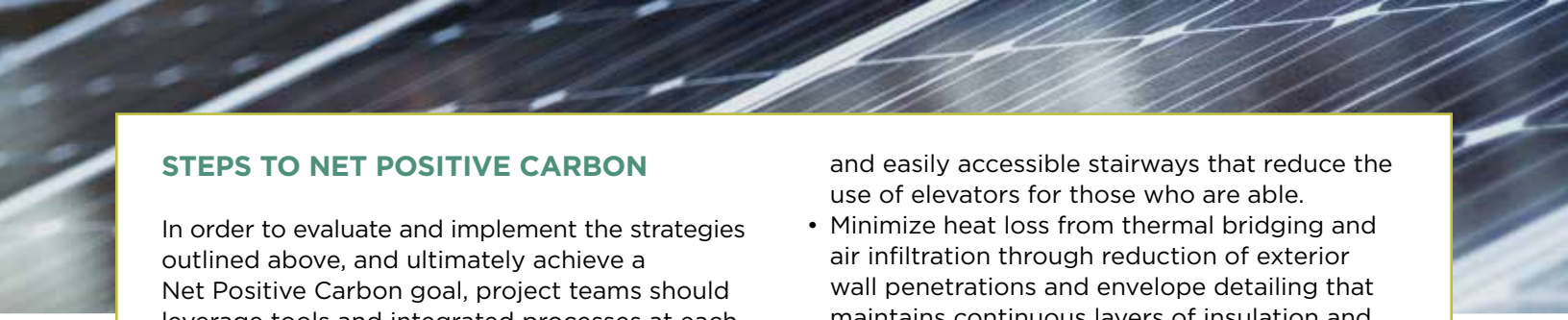
Common spaces within multifamily buildings account for a large portion of the energy consumption—based on project team reports, approximately 20–30% of the energy use of the entire building is associated with these areas. Ventilation and lighting systems within corridors are sometimes over-designed or not thoroughly commissioned. The energy demands of corridors and vertical circulation can be reduced drastically for zero or negative cost through a detailed evaluation of service levels and conditioning expectations in each space. For example, moving a corridor to the exterior of the conditioned envelope may permit the downsizing or removal of lighting and conditioning loads associated with these spaces. This has the additional benefit of giving units direct access to outside air for cross-ventilation, which is otherwise not possible in an interior layout, particularly as a double-loaded corridor. Exterior corridors also allow residents to feel more connected to the natural world as they circulate throughout the building because they experience the time of day, weather, and lighting levels that are occurring in their own climate.

Similarly, creating attractive and pleasant stairwells that are also ideally open to the air and can provide views help decrease the energy associated with the elevator, which runs throughout the day and can be difficult to model accurately. This also has the added benefit of promoting a healthy and active lifestyle—as Farr Associates says, "burn calories, not energy." Ensuring that the stairwell is featured prominently in relation to the front entrance of the building is critical and also does not represent any added cost.

The original inhabitants of a place can often provide simple, time-tested, climate-appropriate solutions. Muldoon Gardens, located in Anchorage, Alaska, utilized native Alaskan design principles to drive their EUI down from 120-160 (the typical range in Anchorage) to 33. The indigenous tribes in Alaska traditionally used thermal mass, sod roofs, arctic entries (a kind of vestibule that isolates the cold and particulates from entering the rest of the house), and local building materials (which also decreases the embodied carbon of the building).

Domestic hot water systems have been shown, through a number of affordable housing pilot projects, to represent a disproportionately high relative percentage of energy consumption. Focusing on reducing energy costs associated with domestic hot water use—by choosing more water-efficient fixtures, shorter distribution runs, and the inclusion of electric heat-pump-based water heating units—should be considered by all project teams.

The building envelope should not be overlooked. Simple investments in additional continuous insulation and best-practice detailing to yield a tighter envelope can make a long-lasting reduction in the building's energy demands as well as an increase in comfort. These investments in the envelope help reduce the amount of heating and cooling energy that is required. While tenant energy use behavior can be variable, affordable housing developers can set residents up for success by providing efficient appliances or equipment. For example, installing and providing LED lightbulbs, ENERGY STAR appliances, and high-efficiency rated laundry systems can significantly reduce the plug load energy use associated with each unit. Some developers have found it prudent to even purchase consumer appliances such as televisions for each unit, particularly when energy costs are included in the rental agreement, not an unusual situation in affordable housing.



STEPS TO NET POSITIVE CARBON

In order to evaluate and implement the strategies outlined above, and ultimately achieve a Net Positive Carbon goal, project teams should leverage tools and integrated processes at each phase of development. Recommended processes and strategies that should be explored by affordable housing projects during each phase of a project seeking the Energy Petal include:

PRE-DESIGN

- Conduct a detailed analysis of the local climate and project site conditions, including any solar and wind resources available, adjacent daylighting obstructions, or sources of noise and pollution that should be accounted for during the design phase.
- Set an energy use target based on an evaluation of comparable buildings of the same size, type, and use in the area (refer to building energy database tools such as Zero Tool).
- Evaluate the service levels and conditioning required in each space type specified in the building program. Make a formal record of the spaces that receive first priority access to daylight or natural ventilation in a document such as an Owner's Project Requirements (OPR).
- Specify system-level performance targets (e.g., lighting levels, comfort levels, controls, etc.) in the OPR document.

DESIGN

- Conduct a preliminary energy assessment (via calculations or an energy model) to identify the major energy end uses and the highest potential impact areas for reductions.
- Conduct a feasibility study of renewables (e.g., solar potential) to identify the approximate quantity of energy that can be generated on site, and which surfaces or areas of the site are highest priority for these systems. Compare this energy generation estimate with the energy target and preliminary energy assessment.
- Develop a Basis of Design (BOD) document that summarizes the primary strategies and packages of systems (passive and active elements) that together will achieve the energy target. Example design considerations include:
- Maximize daylighting through the optimization of building form, orientation, and interior layouts to place high-priority spaces adjacent to the exterior.
- Design the program and building layout to promote occupant health and energy conservation, such as the design of attractive and easily accessible stairways that reduce the use of elevators for those who are able.
- Minimize heat loss from thermal bridging and air infiltration through reduction of exterior wall penetrations and envelope detailing that maintains continuous layers of insulation and air barriers.
- Minimize unwanted heat loss/gain through passive solar heating, effective solar shading, increased wall and roof insulation, and high-performance glazing.
- Incorporate operable openings (windows, louvers, etc.) and fans to permit the use of mixed mode conditioning or passive natural ventilation to eliminate air conditioning.
- Utilize high-efficiency heating and cooling systems, such as hydronic systems and dedicated outside air systems that separate heating and cooling from ventilation.
- Capture and reuse heat through systems like energy recovery ventilators (ERVs) or ground-source heat pumps.
- Utilize high-efficiency (e.g., ENERGY STAR) and combustion-free appliances such as induction cooktops.
- Design solar energy systems for power and water heating.

CONSTRUCTION

- Ensure that any substitutions of materials or systems are evaluated for their impact on building energy performance prior to approval.
- Ensure that metering systems are installed that permit the future assessment and troubleshooting of energy end uses.
- Incorporate educational elements in the building to engage tenants in understanding and improving energy performance; these may include dashboards, signals, or signage that visually explain how systems work or are operated.

OCCUPANCY

- Allocate project team scope and time to conduct building operator training, including development of a self-guided systems manual and performing a physical walk-through of building systems.
- Plan building tours and/or tenant engagement programs to foster pride and excitement for the project's net positive energy target.
- Develop tenant guidelines with simple, accessible resources for users to support the project energy goal, operate the building and appliances, and make other energy-smart lifestyle choices.

BARRIERS + SOLUTIONS

There are unique barriers to achieving Net Positive Carbon 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 multifamily projects due to a variety of factors, including increased occupant density and less efficient appliances. It is not uncommon for multigenerational families to live in one apartment, which promotes density but also increases energy consumption, making it more difficult to achieve Net Positive Carbon. Additionally, there are often split incentives present regarding utility bills within affordable housing. The utility bills are sometimes paid by the affordable housing owner of the project or paid through Federal Vouchers for Utilities. Federal housing programs restrict rents to 30% of a specified income level, typically 60% or less of average median income for rental projects utilizing the Low-Income Housing Tax Credit. This 30% cap on rent is inclusive of utility bills through a utility allowance—an amount that owners must subtract from a tenant's total rent contribution. This means that, even if utility bills are decreased through energy efficiency (or even brought to zero through an achievement of net-positive energy), the tenants may see no direct financial benefit. In this case, however, the owner will still see a benefit as the common-space energy bills are reduced.

SOCIAL SOLUTIONS

To overcome the issue of high EUI that comes from higher occupant density, owners can install sub-meters to measure the energy consumption of individual units and provide a financial incentive for tenants to limit their energy consumption, such as allowing tenants to directly pay their portion of energy bills. Educational programs that emphasize conservation and ways to efficiently operate the building and its systems in different weather conditions can also help to reduce tenant energy consumption. If the owner of the property pays the utility bills, it may make the most financial sense to meter by end use only and avoid the cost of metering each unit. The drawback of this method is that issues causing spikes in energy demand can be harder to trace to a particular unit, so this approach should most likely be used when unit electricity and plug loads are a smaller portion of the overall predicted energy consumption of the building.

The issue of split incentives identified above can be mitigated by finding alternative ways for tenants to benefit from the energy savings in the building, even if not directly through their bills. This can include an investment in building assets that are desired by residents or gift cards for low energy users. Some project teams have found that gamifying the energy use can be an effective means of reducing consumption. Tenant education on saving energy is important regardless of who pays the utility bills and can help foster a sense of investment in the energy savings by residents.

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.

REGULATORY BARRIERS

There are two significant regulatory barriers to achieving the Energy Petal for affordable housing projects. The first is that some utilities do not allow net metering (i.e., payment for energy returned to the grid) or do not have policies in place to accommodate it. Because the utility grid serves as an 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 the Energy Petal 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 multifamily project's needs. For example, incentives are limited to photovoltaic installations of 50 kW and smaller in Minnesota and to 200kW in Austin, Texas. While these sizes of solar installations are sufficient to satisfy smaller low-rise projects, larger projects may encounter barriers to meeting their energy budget with renewables.

REGULATORY SOLUTIONS

Political advocacy and legislative change are often needed to overcome barriers or restrictions to net metering. In the short term, individual affordable housing developers should coordinate with utilities earlier in their development process to explore the opportunity for exceptions or make alternative arrangements to stay under the cap by scale jumping renewables across multiple properties. In the long term, affordable housing developers would benefit from working together to systemically address this issue, both locally and regionally. Advocacy work can occur with individual utility companies by encouraging them to change their policies, or at the local, state, or federal government level. Organizations like the Alliance for Solar Choice (TASC), founded by rooftop solar companies like

Solar World, are working both nationally and state-by-state to promote net metering policies.[32]

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 photovoltaic arrays located on neighboring buildings or on other buildings within the affordable housing developer's portfolio. 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.[33] California has also recently begun charging much higher prices for electricity sold back to the grid during peak hours, thereby incentivizing on-site storage. While this does pose an up-front cost for project teams, this may push the battery market to develop more economical and better solutions for multifamily housing, which would allow for greater built-in resiliency.

FINANCIAL BARRIERS

There are two significant financial barriers to achieving the Energy Petal on affordable housing projects. The first is a focus on first costs that is typical in the design and construction process. Sensitivity to incremental 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—which is often less expensive than electricity for providing heating, cooling, and cooking—is not permitted to be used by Living Building Challenge projects; it represents a transitional strategy instead of an endgame strategy for a renewably powered future.[34] The reality or perception of lower natural gas prices in some regions can make it economically or politically 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 key financial barrier is linked to accessing incentives. 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 multifamily 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 nonprofit 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.

Solar panels on the roof of the Bullitt Center, a Living Building in Seattle, WA. Image courtesy of the Bullitt Foundation

32 The Alliance for Solar Choice. http://allianceforsolarchoice.com/
33 Solar Gardens Community Power. http://www.solargardens.org/
34 Jason F. McLennan, "Burning Questions."

FINANCIAL SOLUTIONS

Both of the financial barriers identified above relate to the increased first cost associated with photovoltaic systems and the difficulty in accessing funds available to offset the added first cost. A variety of solutions are available to affordable housing developers to 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 ten years.

Another option, implemented by 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.[35] 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.

Lastly, there are now utility and municipal incentive programs in cities throughout the nation that can be used by multifamily and affordable housing projects. The PACE program mentioned in the Strategies for Success section of this document is increasingly available in states throughout the nation and reduces the up-front burden of energy incentives by allowing the costs to be paid back gradually over time through property assessments—meaning that projects maintain net-positive cash flow from the first year of operations. Fannie Mae's Green Lending programs, also described in the Strategies for Success section can provide lower long-term interest rates for projects certified Zero Energy or Energy Petal.

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 integrated design processes focused on energy-efficient design, the EUI of projects can be greatly reduced, which in turn reduces the required amount of photovoltaic panels, and therefore, the first cost. Though there are some barriers to net positive energy in affordable housing, including net metering policies in certain jurisdictions and financing the up-front cost of photovoltaic arrays and energy conservation measures, net positive energy strategies within affordable housing have gained significant momentum and are becoming far more common.

Although climate does impact a project's ability to reduce its EUI, unless a project is located in a truly extreme climate, net positive energy is generally achievable with little to no effort at very low densities. In this case, conservation measures should still be pursued to lower the amount (and cost of solar panels needed), particularly since many energy reduction measures can be done for no cost or even lower overall costs. Moderately dense multifamily projects (generally three to four stories in height) can typically also achieve net positive energy if combustion equipment can be eliminated and best-in-practice energy measures (such as the insulation values and other measures detailed in this chapter) are integrated into the project. At higher densities, intensive energy conservation measures, additional on-site array options (such as a solar canopy or ground-mounted array), and/or off-site photovoltaic options will likely be necessary. In cases where these options are cost-prohibitive, designing projects that already incorporate deep energy reduction strategies and have roof structures that can easily integrate photovoltaic panels or can install a limited array that is not sufficient to offset 100% of the energy is still a valuable strategy.

35 https://living-future.org/wp-content/uploads/2018/04/180425_Solar-Tax-Credit-Handout.pdf

CASE STUDIES
ENERGY

HOPEWORKS STATION PHASE II

Hopeworks Social Enterprises and Housing Hope
Everett, WA

DESIGN APPROACH TO NET-POSITIVE ENERGY

Hopeworks Station Phase II includes three floors of affordable housing and extensive commercial training kitchens on the ground floor, which provide job training programs intended to break the cycle of poverty among residents and others in the community. Hopeworks and Housing Hope decided to take on the Living Building Challenge in order to serve as a model for future affordable housing projects, to allow their residents and job-training participants to become immersed in a sustainability culture that can prepare them for future job markets, and to inspire a transit-oriented, bicycle, and renewable-energy culture within downtown Everett. Due to the high energy loads associated with the commercial training kitchen, as well as the availability of state funding specifically for ultra-efficient affordable housing (UHEE) but not for commercial spaces,[36] the design team decided to focus primarily on achieving Net Positive Energy for the residential portion of the building (the upper three floors). Although one building, it was determined that the residential and commercial portions of the project effectively functioned as separate buildings because they were separately funded, owned, and managed, as well as physically distinct.

The program team began the process by determining their target EUI for net positive energy in the residential portion. The project team determined they would be able to fill approximately 45% of the roof with photovoltaic panels, which would then require the building to achieve an EUI of 10 in order to achieve net zero.

MODELED EUI = 18
TOTAL ARRAY AREA = 10,850 SQ. FT.
TOTAL ARRAY SIZE = 191 KW

A conceptual design of Hopeworks Station Phase II. The final design included roof-mounted PV panels, as well as the PV canopy over the structured parking. Rendering courtesy of GGLO Design.

36 http://www.commerce.wa.gov/wp-content/uploads/2013/01/COMMERCE-UHEE.pdf

The project team decided to install a solar canopy above the parking structure as well, effectively doubling the amount of solar on site and subsequently requiring a building EUI of 20.5, a more feasible goal. The EUI on a typical mid-rise in the Pacific Northwest is around 40, however, so the project team still faced an enormous challenge to halve this EUI on an affordable housing budget.

PATHWAYS TO NET POSITIVE CARBON

COMMON SPACE ENERGY LOADS

Starting with the end-use assumptions in the chart above, the project team first strategized on how to reduce energy where it would have the most impact. Seeing that common space heating and electric uses comprised more than one-third of the energy use, the project team first chose to eliminate most common areas inside the building envelope by instead relying on exterior corridors. Although this increased the amount of exterior wall area within each unit, this potential issue was solved with increased insulation at exterior walls. As the units are not air-conditioned (as is typical in the region), this also allows for the units to effectively cross-ventilate and function better.

DOMESTIC HOT WATER

Domestic hot water systems account for nearly 25% of the energy used in a typical building and were the largest end use that could be impacted by a single device. The project team found that utilizing a central heat pump water heating system, rather than natural gas boilers or individual unit-by-unit electric systems, delivered a COP (coefficient of performance) of 3 to 3.5, rendering them effectively three times as efficient. Because one-third of the energy tied to the domestic hot water system is related to distribution, the project team strategically distributed 13 Sanden systems throughout the building, each serving an average of five apartments, which eliminated most distribution piping and the need for a continuous recirculation pump.

UNIT CONDITIONING (HEATING)

The project team modeled four scenarios for conditioning the units. The first two were to install ductless heat pumps, which would provide both high-efficiency heating and cooling. The second two focused on a near Passive House–quality envelope with only heating. Both options were modeled with or without heat recovery ventilators (HRV). Both the ductless heat pump option (without HRVs) and the efficient building envelope with HRVs would result in an EUI of approximately 19, which would bring the building to net positive energy.

FIGURE 19: Energy distribution usage for an EUI of a typical mid-rise building in the area. Diagram courtesy of Ecotope, Inc.

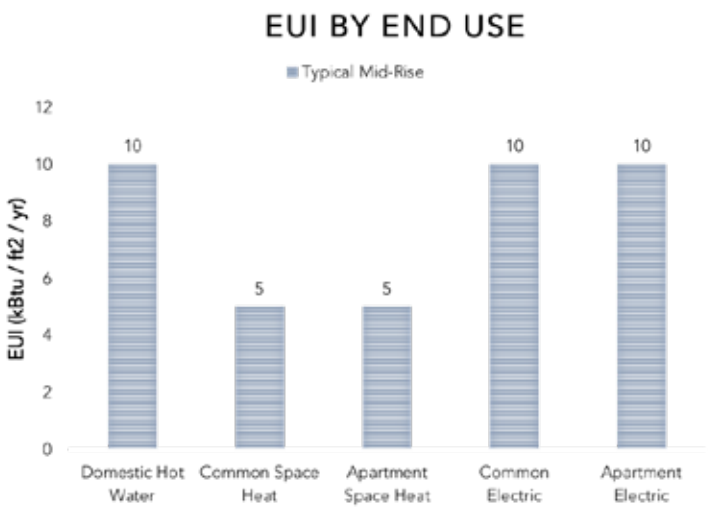
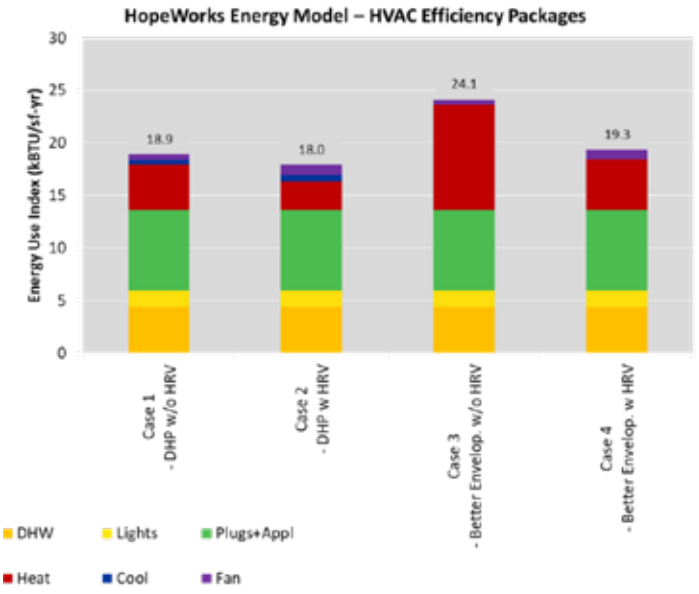


FIGURE 20: Four HVAC + envelope options. Diagram courtesy of Ecotope, Inc.



Ultimately, the owner preferred to invest in the building envelope rather than in ductless heat pumps since the building envelope seemed to be a longer-lasting investment when compared to equipment that would need to be replaced in the future. The triple-pane windows and additional insulation meant that the heating demand would be very low.

APPLIANCES

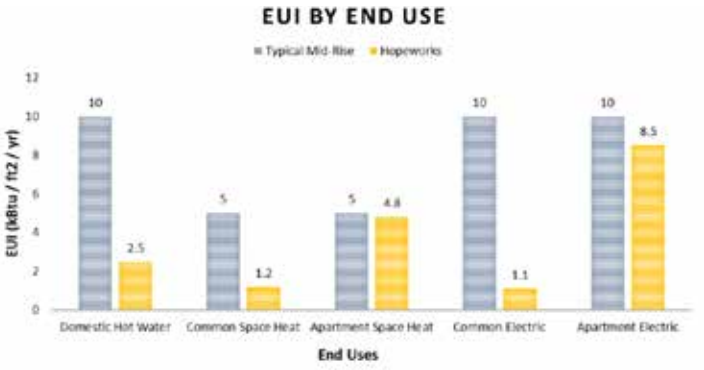
The last efficiency measure within the building focused on energy-efficient appliances. LED lighting and ENERGY STAR appliances were used throughout the building, but the most significant intervention related to clothes dryers. Dryers were found to be the biggest energy use among appliances, even when using centralized laundry on each floor. The project team specified dryers utilizing heat pump technology, which cut the energy consumption in half. Although these have a price premium, they pay off quickly due to the high energy savings.

LESSONS LEARNED

The project team learned that if the array was larger than 200 KW, a regional impact study would be required to determine the impact of that amount of energy being fed back into the grid. Similarly, the local utility would also require an impact study if any single meter was connected to more than 100 KW of solar. This reinforced the project's limit of approximately 200 KW of photovoltaic panels, now determined by regulatory requirements in addition to physical roof and site area. The building also installed two separate meters to avoid having more than 100 KW on any one meter and triggering the impact study. Regulatory barriers related to net-metering and array limits can prove prohibitive for net-positive energy. Fortunately, this was not the case here.

The construction site of Hopeworks Station Phase II as of May 2019. Image courtesy of Susan Puri.

FIGURE 21: Energy usage for a typical mid-rise apartment, as compared to the usage in Hopeworks Station Phase II. Diagram courtesy of Ecotope, Inc.



While the thru-wall HRVs installed in pairs eliminated the need for ducting, the subsequent coordination needed to minimize potential acoustic and aesthetic impacts related the number of exterior wall penetrations was time-intensive. The project team felt retrospectively that semi-central systems may have cut costs and maintenance requirements, although they would require ductwork.

CONCLUSION

With the energy-efficiency measures described above, the project ended up with a modeled EUI of approximately 18, distributed as shown in the chart below. The plug loads associated with each unit were modeled conservatively to account for variations in individual tenant energy use. The energy use of the building as of now is only modeled, which is not sufficient to achieve Energy Petal. Once the building has completed construction (anticipated in September 2019), the project will begin their one-year performance period, which is expected to include a focus on resident education around energy use. Once completed, this project has the potential to become the first Energy Petal Certified Affordable Housing Pilot Project.

"Through our analysis we learned that electrification, combined with eliminating hot water recirculation, has perhaps the greatest impact of any individual measures on overall carbon over 20 years for no added cost, and that a tight envelope is the single most cost-effective way to reduce resident loads. These benefits are realized regardless of whether we ultimately match total energy demand with on-site generation."

Katie Ackerly and Chelsea Johnson, David Baker Architects

COLISEUM PLACE

Resources for Community Development
Oakland, CA

DESIGN APPROACH TO NET POSITIVE ENERGY

The Coliseum Place started out with end-use assumptions shown in the pie chart below. Unlike Hopeworks Station II, which assumed a common-space energy usage of nearly 1/3 of the total energy, the initial common space usage for Coliseum Place was assumed to be around 20%. This is because the project team had already assumed exterior corridors, stairs, and a common courtyard above the podium. Similarly, the mild climate meant that the architectural moves of massing and orientation did not have as large an impact as with projects in other locations.

While in-unit electricity also accounts for variations in plug loads and tenant energy demands, David Baker Architects and mechanical consultants Redwood Energy and EDesignC Engineers focused their strategies on what remained firmly in the designers' control: building envelope and systems. Three key decisions drove their approach to energy reduction and did not include additional costs:

1. Making the building all electric.
2. Designing a decentralized hot water system with no recirculation loop.
3. Creating a tight building envelope with efficient in-unit balanced ventilation.

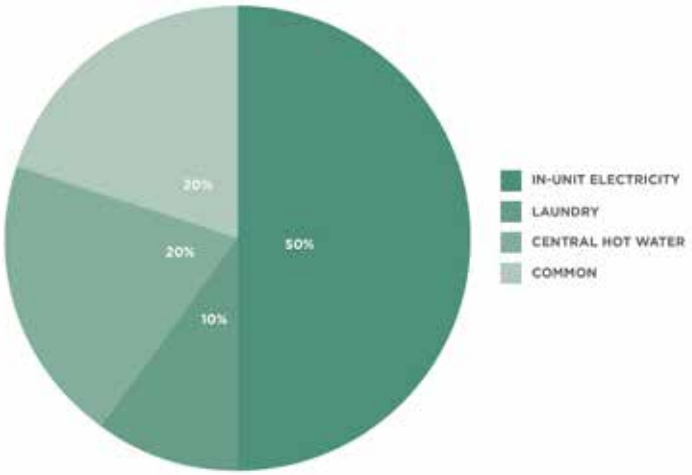
An early conceptual design shows Coliseum Place, including a PV canopy over the roof. The two options of roof-mounted or PV canopy are still being discussed. Rendering courtesy of David Baker Architects.

In the modeling process, these three strategies, combined with an assumption of LED lighting, Energy Star appliances, and efficient laundries, brought the building very close to being able to achieve net positive energy, which is impressive for a six-story multifamily building in an urban setting. Several of these additional strategies (efficient appliances for example) proved to be cost-positive when the project team got further in the design process. These strategies are shared hot water heat pumps with no recirculation loop, replacing mini-splits with PTACs, and eliminating gas service. The chart below summarizing initial costs and funding sources for energy efficiency and renewable energy systems.

DOMESTIC HOT WATER

As with Hopeworks Station II, savings associated with the domestic hot water system proved to have a very significant impact on the energy consumption. Specifically, eliminating the recirculation loop for domestic hot water was the single biggest energy reduction measure. In order to balance costs and maintenance, the project team chose to install single-family-style heat pumps serving two units each, which was a compromise between a single central system and installing a system in every unit.

FIGURE 22: Breakdown of energy uses in a typical mid-rise apartment in the region, as determined by the project team. Information courtesy of David Baker Architects.



This strategy allowed the project team to cut 40% of the hot water load, all while installing a cheaper system with fewer efficiency losses. The design had to be carefully articulated in order to minimize hot water wait times and did result in four apartments that will have an approximately 30-second wait time for hot water.

BARRIERS + LESSONS LEARNED

It was discovered through further energy modeling that the energy loads associated with common areas, particularly the structured parking, had been underestimated in the initial model. The project team had also initially devised a plan to install a solar canopy above the building that would capture enough energy to offset 105% of the modeled energy load. Due to constructability, property line encroachment issues, fire department set-asides, and cost, the canopy shrunk in size. This means that the project is not as close to achieving net positive energy on site as initially projected.

The domestic hot water system has also faced quite a bit of resistance on behalf of numerous project team members, from engineers to plumbing subcontractors to even members of the architectural team. The issue was not cost, but a fear of using such an innovative strategy with the thought that "if it has not been done elsewhere, there is probably a reason." Ultimately, the energy savings associated with the system won out. This again underscores the need to assure an integrated design process, as this project team did, so that all parties can agree on decisions being made, particularly those that may differ from their industry's business as usual.

CONCLUSION

Due to the density of the project, it is not feasible to achieve net positive energy through PV mounted on the roof structure alone. This project is precisely the type of project that would be able to benefit from the Off-Site Renewables Exception described in this chapter, due to its high-density and best-in-class EUI. The project team will ultimately decide whether to install PV on a canopy, which would cost more, but may qualify them for additional state funding that would offset the cost, or mount directly to the roof. If roof-mounted, it is anticipated that PV panels would cover approximately 45% of the roof and would generate enough electricity to cover 30% of the building's energy loads, enough to offset the common areas. If the solar canopy is pursued, the offset generated by the PV is approximated at 65-70%. The final decision between these two options will come down to the availability of funding and bottom-line cost of both options.

Information courtesy of David Baker Architects

ENERGY MEASURE/INCENTIVE	ASSOCIATED COST/SAVINGS
Rooftop PV (80% roof area/ 325kW array)	+ $710,000 (80% ZNE offset)
Steel Canopy Structure	+ $425,000
Shared hot water heat pumps with no recirculation loop	- $174,000
Replace Mini-splits with PTACs	- $240,000
Eliminate Gas Service to Building	- $32,000
Additional Financing from Zero Energy Bills (California Utility Allowance Adjustments)	- $613,000
30% Solar Tax Credit	- $340,000
TOTAL SAVED	**$264,000**

LAKELINE LEARNING CENTER

Foundation Communities
Austin, TX

DESIGN APPROACH TO NET POSITIVE ENERGY

The project team felt that the Lakeline Learning Center design was appropriate for the Living Building Challenge for a number of reasons. First, it was a stand-alone single-story building with low water needs, making it possible to experiment with new techniques, strategies, and systems at a comfortable scale. Second, it was not a residence, meaning staff had complete operational control. Third, learning centers are the community hub, designed to inspire and educate, and to offer a place for community engagement, social events, and activities.

The original goal was to achieve full Living Building Certification. But due to financing availability and issues related to battery storage, the project team ultimately decided to pursue Zero Energy Certification. Nevertheless, deep and thoughtful analysis went into all decisions, with Foundation Communities' mission carefully weighed against the goals and ambitions of the project. When it became clear that achieving the full Materials and Water Petals was no longer feasible, the project team remained focused on selecting the healthiest materials for children and staff, and tailoring water strategies to maximize rainwater collection to meet the needs of all non-potable uses inside and outside of the building.

The original goal of the Learning Center was to be as efficient as possible to achieve net zero energy. However, energy modeling results made it clear that the project did not need to pursue all possible energy efficiency measures to achieve net zero energy. Design decisions emphasized efficiency, durability, and replicability, as well as cost.

ENVELOPE

The exterior wall system is similar to a typical residential system, with Zip R-Sheathing, blown-in cellulose in the cavity, and a combination of Exterior Insulation and Finish Systems (EIFS) and Hardie cement board siding. The original intent was for thermal mass infill walls between classrooms to help improve passive cooling and heating. Energy modeling results showed this method was unnecessary to achieve net zero, and the cost became prohibitive.

ZERO ENERGY PERFORMANCE

Actual energy use during performance period: 86,600 kWh

Actual energy produced during performance period: 86,840 kWh

Net Energy Use: -240 kWh

EUI: 43 kBTU/sf/yr

SOLAR ELECTRIC (PV) PANEL

PV Array Size (kW): 70.4

PV Output Per Capacity Nameplate (W): 1502

Panel Quantity: 220

PV Type and Brand: JA SOLAR JAP6-72-320/4BB

PV Inverter Quantity: 9

PV Location: Rooftop

PV Ownership Details: Building Owner

HVAC

The building utilizes a single, roof-mounted, 25 Ton High Efficiency Direct Expansion Variable Air Volume (VAV) system. A VAV box and thermostat in each classroom allow precise occupant comfort and control. Utilizing zone demand control ventilation along with supply air temperature setback control, the unit can continuously monitor the building's HVAC needs and cut back on capacity and usage when possible to save energy. An energy recovery wheel allows the unit to capture waste heat from the building, which is used to pretreat the ventilation air. Ceiling fans in each classroom, the main gathering room, and the screened porch, increase airflow and extend the days in the fall and spring when HVAC can be turned off. A heat pump provides water heating for restroom fixtures, handwashing troughs, and the STE(A)M (Science, Technology, Arts, Engineering, and Math) classroom sink. The project team chose to use a point-of-use water heater for the kitchen, located on the opposite side of the building from the rest of the plumbing, to reduce plumbing lines throughout the building.

LIGHTING

Lighting is 100% LED throughout the Learning Center. Daylighting analysis revealed inadequate daylighting in the main gathering room in the original design. The addition of skylights and slight shifting of clerestories made significant improvements. Plug loads are independently monitored per room, allowing opportunities for students to engage in monitoring through energy-use competitions among classrooms.

Typical Foundation Communities learning centers include a dedicated computer lab with desktop computers. To reduce load and provide more flexible classroom space, this learning center shifted to a mobile laptop cart.

BARRIERS + LESSONS LEARNED

The Lakeline Learning Center is the first net zero commercial building in the City of Austin (COA). The COA does not allow for net metering for commercial systems larger than 20 kW, preferring reduced consumption for large arrays, rather than net zero. Typically, a commercial system under 20 kW that overproduces will receive money back from the COA, but if the array is over 20 kW, the energy goes back to the grid with no payback.

BATTERY STORAGE

In addition, the battery backup system created ongoing challenges, and the project team is still working to implement a backup system that meets both local codes and the needs of the Learning Center. The original battery system was designed for Aquion batteries, which met the Materials Petal requirements. But prior to placing the order for the batteries, Aquion filed for insolvency. An alternate solution using lithium ion batteries by Tesla sited inside the building faced permitting obstacles because the City lacked integration requirements and was particularly concerned about battery storage within occupied space. Meanwhile, it was learned that the batteries would not be available from Tesla until Q2 of 2018, a timeline that was subsequently not met. Ultimately, the project team decided to settle on being "battery-ready" so that when the technology catches up with the industry demand, it can pursue battery storage at that time.

The building is capable of having a 40.5 kWh battery storage system. If it can be added in the future, the system would provide essential power during emergencies for refrigeration, a place to charge phones, and a safe place to come together as a community. Batteries would also provide built-in peak reduction, with the ability to use battery capacity during the day to shave peak consumption.

BUILDING ENVELOPE

- Walls: R31/R25 Zip R-Sheathing, blown-in cellulose cavity insulation, and EIFS or Hardie siding.
- Roof: R-29
- Air infiltration rate and sealing protocol: Energy recovery ventilation
- Floor: Modular construction above concrete podium
- Windows: Double-paned with SunCoat Max low-e coating

SPACE CONDITIONING + DOMESTIC HOT WATER

- HVAC: roof-mounted, 25 Ton High Efficiency Direct Expansion Variable Air Volume (VAV) system.
- Domestic Hot Water (DHW): Heat pump for restroom fixtures, handwashing troughs, and the STE(A)M (Science, Technology, Arts, Engineering, and Math) classroom sink; point-of-use water heater for the kitchen

CONCLUSION

While the project has not been able to achieve Energy Petal yet due to the battery storage issues described above, it was the first certified Affordable Housing Pilot Project, achieving Net Zero Energy Certification in 2018. Demonstrating that net-positive energy is a feasible goal for affordable housing developers, the systems and strategies described above can be replicated on other projects. Additionally, should the project install battery storage in the future, as is their plan, the project should also be able to achieve Energy Petal due to their accomplishments in other Petals.

The completed Lakeline Learning Center building showing the PV placement that helped them achieve Zero Energy certification. Image: Casey Chapman Ross

Resources

Affordable Housing Solar Investment Tax Credit
The federal government's Renewable Energy Tax Credit (RETC) program includes a variety of incentives to subsidize renewable energy technologies. The Investment Tax Credit (ITC) portions of this program provide a mechanism to help finance solar energy systems used to provide electricity or solar hot water.
https://living-future.org/wp-content/uploads/2018/04/180425_Solar-Tax-Credit-Handout.pdf

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.
www.ases.org/solar-home-basics

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.
https://openei.org/doe-opendata/dataset/buildings-energy-data-book

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 Multifamily Housing in the United States
An assessment of the energy performance of multifamily 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 U.S. affordable housing development types (single-family and multifamily) 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.
https://www.enterprisecommunity.org/resources/incremental-costs-measurable-savings-update-14174

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/

PV Watts Calculator
Refer to appendix H of this report for directions on use.
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 guide to design using natural renewable resources for heating, cooling, lighting, and ventilation, featuring illustrations on how to successfully integrate the strategies.
Available on wiley.com or amazon.com

Resources cont.

Zero Energy Project – Affordable Zero Energy Home Construction & Design in 12 Steps
Simplified guidance on steps to be taken in developing zero energy or zero ready residential construction.
zeroenergyproject.org/build/twelve-steps-affordable-zero-energy-home-construction-design/

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

Zero Tool – Architecture 2030
Architecture 2030 developed the Zero Tool for building sector professionals, 2030 Challenge and 2030 Commitment adopters, 2030 District Network Members, and policymakers. The Zero Tool is used to compare a building's design or an existing building's energy use intensity (EUI) with similar building types, understand how a building achieved its EUI (via energy efficiency, on-site renewable energy, and/or green power purchases), and set EUI targets.
https://zerotool.org/zerotool/

HEALTH + HAPPINESS

Fostering Environments that Optimize Physical and Psychological Health and Well Being

PETAL INTRODUCTION

The intent of the Health + Happiness Petal is to create healthy spaces that allow all species to thrive by connecting people to nature and ensuring that our indoor spaces have healthy air and natural daylight.

The West Calumet Housing Complex in Gary, Indiana, was evacuated and demolished in 2017 after the EPA discovered significant lead and arsenic contamination in the soil and declared it a Superfund site. 1,000 residents, who had been exposed to these toxic heavy metals for years, were faced with the choice of leaving their community altogether or trying to secure one of the scarce affordable units in the area, many of which also had significant environmental toxins present. The Alder Place and Broadway Lofts projects will, together, provide approximately 80 units of critically needed affordable housing with possible additional single-family and townhouse units dispersed throughout the community. The projects are priotizing he need to create healthy and safe housing in the area and will be designed with a focus on wellness, with the intent to increase quality of life and decrease the cost of living for low and moderate income individuals and families.

The situation in Gary, Indiana plays out in communities, especially communities of color and low-income communities throughout the country. The built environment often exacerbates these inequities as lower-income communities are disproportionately located in fenceline communities near highways and industrial sites, isolated from healthy food options and recreational activities, and exposed to mold, mildew, pest infestation, and hazardous materials such as lead. The CDC estimates that there are 1.1 million low-income homes with children under age six (the ages most sensitive to lead poisoning) with one or more lead-based paint hazards.[37] So-called Fenceline communities, such as Gary, are not uncommon either. Studies have shown that the greater the concentration of poor residents in an area, the more likely that dangerous compounds such as vanadium, nitrates, and zinc, are in the mix of fine particles that residents breathe, often due to nearby industrial pollutants.[38] The Robert Wood Johnson Foundation website includes a tool predicting life expectancy by address, which shows that the life expectancy in East Chicago, IN, is just 66 years, while the life expectancy in wealthier Hammond, less than five miles away, is more than 79 years.[39] Inequities in health among lower-income populations include higher rates of chronic diseases (including asthma, allergies, obesity, and cancer).

Affordable housing developers assert, and the Institute agrees, that 'housing is healthcare.' As the built environment has been the cause of many of these issues, it has a significant role to play in solutions that move towards healthy and thriving communities. Low-emitting interior materials, coupled with indoor air quality monitoring, has been shown to reduce rates of asthma and other airborne illnesses. Seattle Public Housing Authority's Breathe Easy Homes study found that installing just a few healthy building materials (marmoleum flooring, low-emitting carpet, low-VOC paint, and low-emitting cabinets) and adding air filtration significantly reduced asthma-related urgent care visits and increased symptom-free days among children living in two separate affordable housing developments.[40]

There are a variety of strategies that can be employed that offer significant health and wellness benefits to occupants. For example, operable windows and other passive ventilation strategies, in addition to decreasing HVAC energy use, also improve occupant comfort by allowing occupants control over their environment. In addition, greater access to nature has been shown to provide a myriad of health benefits, including: reduced stress, better sleep, improved mental health, reduced depression, reduced anxiety, greater happiness and life satisfaction, reduced aggression, reduced ADHD symptoms, increased social connectedness, lower blood pressure, improved postoperative recovery, improved birth outcomes, improved congestive heart failure, improved child development, improved pain control, reduced obesity, reduced diabetes, better

37 https://www.cdc.gov/nceh/lead/publications/blood_lead-prevalence_studies.pdf
38 https://www.scientificamerican.com/article/people-poor-neighborhoods-breate-more-hazardous-particles/
39 https://www.rwjf.org/en/library/interactives/whereyouliveaffectshowlongyoulive.html
40 https://www.seattlehousing.org/breathe-easy-homes

eyesight, improved immune function, and reduced mortality.[41] At limited additional cost, achieving the three Health + Happiness Imperatives can significantly improve occupant health and well-being for our most vulnerable populations.

HEALTH + HAPPINESS

CORE IMPERATIVE

09

HEALTHY INTERIOR ENVIRONMENT

The intent of this Imperative is to promote good indoor air quality and a healthy interior environment for project occupants.

All projects must:

- Comply with the current version of ASHRAE 62, or international equivalent.
- Prohibit smoking within any buildings or enclosed spaces and within 25 feet of building opening, including air supply vents.
- Develop a Healthy Indoor Environment Plan specific to the project's building type and location. The plan must address cleaning protocols, the prevention of particulates and toxins through an entry approach, and implementation of at least one strategy to improve air quality.
- Provide views outside and daylight for 75% of occupants.
- Provide direct exhaust for kitchen, bathroom, and janitorial areas.

Imperative I-09 Healthy Interior Environment helps to define the minimum standards for a healthy interior environment. Keeping the interior space clean of particulates, improving air quality, and instituting healthier cleaning protocols, as well as ensuring sufficient outside views and daylight for occupants will serve to improve the physical and mental health of residents with minimal additional cost or time expenditure. Many of these specific requirements will likely be met as a matter of course and in some cases code by most affordable housing developers. The requirement to prohibit smoking inside the building and thus inside someone's own home can be challenging in some circumstances, but many affordable housing developers and providers already include this policy in their rental and lease agreements to ensure there is not cross contamination from unit to unit.

41 https://ehp.niehs.nih.gov/doi/10.1289/EHP1663

HEALTH + HAPPINESS

IMPERATIVE 10

HEALTHY INTERIOR PERFORMANCE

The intent of this Imperative is to demonstrate ongoing high-quality indoor air and a healthy indoor environment.

To promote good indoor air quality performance, all projects must:

- Provide the results from an Indoor Air Quality Test one to six months after occupancy, or provide readings from an ILFI-approved continuously monitored indoor air quality system .
- Comply with the CDPH Standard Method v1.1-2010 (or international equivalent) for 90% of interior building products that have the potential to emit volatile organic compounds (VOCs).
- Implement a cleaning protocol that uses cleaning products that comply with the EPA Safer Choice label (or international equivalent, such as Globally Harmonized System [GHS]).

All projects must provide 95% of regularly occupied spaces with access to views and daylight and opportunities for the remaining five percent of occupants to move to compliant spaces for a portion of their days.

In addition, all projects must provide at least two of the following:

- Sufficient operable windows to provide natural ventilation for at least six months of the year.
- Ability for the occupants to influence their local airflow and temperature through direct input or controls.
- Flexible options for working and learning such as sit/stand options and/or varied sensory experiences for living, working, or learning.

Residential projects must provide operable windows for 100% of the project occupants.

Imperative I-10 Healthy Interior Performance includes performance-based measures to ensure an optimized healthy interior environment. Providing sufficient operable windows, access to views and daylight, and controls are likely to not prove challenging for residential projects. Care should be taken to ensure that any regularly occupied common spaces provide sufficient access to views and daylight.

For affordable housing projects, the most challenging aspect of this Imperative will be ensuring compliance with the CDPH Standard Method v1.1-2010 or approved equivalent. However, more and more manufacturers are making this data readily available to design and construction teams. In addition, the Declare Product Database is one tool that makes it easy for project teams to select CDPH-compliant interior materials. All Declare products

with a Declaration Status of Red List Free comply with the CDPH emissions testing requirements. As many affordable housing developers are particularly interested in healthy materials in the interior environment, meeting these requirements is a critical first step to ensuring safe and healthy homes. Compliance with CDPH can be researched and vetted at the same time as compliance with I-13 Red List, streamlining the process and reducing the time. The Institute also has plans to compile lists of CDPH-compliant materials appropriate for residential projects as a resource for the affordable housing sector. When available, this resource will be found on the LBC Resources page of the Institute's website.

ILFI acknowledges multiple standards as equivalent to the emissions testing requirements of CDPH Standard Method v1.1-2010 including: CDPH Standard Method v1.2-2017, AgBB Scheme 2009, and AgBB Scheme French A+. Product emission certifications that meet and exceed the emissions referenced standards include, but are not limited to: SCS Indoor Advantage Gold, EC 10.2 Standard Addendum; Floorscore, EC 10.2 Standard Addendum; Collaborative for High Performance Schools, Procedures and Standards for Product Inclusion Version; CSF 332; UL Greenguard Gold, UL 2818 and UL 2821; and Intertek Sustainability, Clear Air. Project teams can use materials meeting any of the above listed standards.

Cleaning products used post construction and during occupancy are another potential source of indoor air contaminants. To avoid the negative impacts of harsh cleaning chemicals, product teams must draft a plan to minimize the exposure of VOCs and harsh chemicals from cleaning products. The plan must include the proposed list of cleaning products that comply with the EPA Safer Choice program standard. EPA Safer Choice products are evaluated through a rigorous chemical analysis process to ensure that only healthy, effective ingredients are included in compliant products. The list of products includes, but is not limited to: glass cleaners, general purpose cleaners, washroom cleaners, carpet cleaners, laundry detergents, graffiti removers, boat and car care, drain cleaners, personal care, floor care and other industrial products. EPA Safer Choice products are clearly labeled, easily identified, and can be sourced from most residential cleaning

CDPH APPLICABILITY BY CSI DIVISION
For purposes of overview and general guidance, the following is a list of CDPH applicability to various CSI divisions and certain products within these divisions. This guidance may not be comprehensive, but is a good start for project teams in knowing which products to research and vet.

Div. 03: If interior concrete sealers or epoxy coating will be specified under Div. 03, these products will require CDPH compliance.

Div. 04: Same as Div. 03, sealers and epoxy coatings will require CDPH compliance.

Div. 06:
- Dimensional Lumber and solid wood products do not require testing.
- Interior applied plywood, MDF, OSB, particle board, and other composite wood must be CDPH compliant.
- Casement products must be CDPH compliant either tested as a finished product, or substrates require testing to confirm CDPH compliance of each component individually.

Div. 07:
- All thermal and acoustic insulation, including batt and loose fill insulation, require testing.
- Firestopping does not require testing.
- Interior applied adhesives and sealants require CDPH compliance.

Div. 08:
- All interior doors require CDPH compliance.
- Door hardware does not require testing.

Div. 09:
- Includes gypsum board, joint compound, paint/primer, synthetic flooring, acoustic ceiling tiles, acoustic insulation, wall coverings (and adhesive), composite and synthetic baseboards, high-performance coatings, and any other materials with the potential to emit..
- The following are not considered to have the potential to emit: metal framing and metal ceiling suspension systems, natural stone products, ceramic and porcelain products.

Div. 12: Millwork and systems furniture require CDPH compliance.

Div. 22: All plumbing sealants, adhesives, and pipe insulation require testing.

Div. 23: Duct sealant, adhesives, and HVAC insulation require testing.

supply stores and commercial cleaning supply distributors. Note that these requirements apply to both the individual units and the common areas, so resident education and access to appropriate cleaners is an important part of compliance.

With regard to indoor air quality testing, a one-time test ensures that post-construction and move-in, the building meets a certain level of indoor air quality related to a variety of contaminants. Ongoing, continuous monitoring allows project owners and occupants to track in real time the quality of the indoor and outdoor air and to make adjustments to the building's HVAC systems or status of any operable windows to ensure ongoing maintenance of high quality indoor air. This could prove especially helpful for affordable housing projects in fenceline communities where the outdoor air may be compromised on an ongoing or short-term basis. Ongoing monitoring equipment has advanced considerably over time, while also coming down in cost. Many systems allow for tracking from desktops, laptops, or smartphones.

MAXIMUM ALLOWABLE CONCENTRATIONS
The following thresholds are intended to serve as a guide for IAQ professionals. Though these concentrations may not be exceeded, there may be circumstances in which smaller concentrations of certain substances pose a health risk, in which case the Institute recommends project teams meet the lower levels. If the IAQ testing reveals concentrations of any substances exceeding the limits listed below, the project team must put in place an action plan to reduce exposure to requirement levels and retest to show compliance:

Formaldehyde:
less than 50 ppb (parts per billion)

PM2.5:
less than 12 micrograms per cubic meter

PM10: less than 30 micrograms per cubic meter

Total Volatile Organic Compounds (TVOCs):
less than 500 micrograms per cubic meter

4-Phenylcyclohexane: less than 3 micrograms per cubic meter

Carbon monoxide: less than 9 ppm

Ozone: less than 51 ppb

Carbon dioxide: less than 750 ppm

Nitrogen dioxide:
less than 0.053 ppm over a 24-hour period

HEALTH + HAPPINESS

IMPERATIVE 11

ACCESS TO NATURE

The intent of this Imperative is to provide opportunities for project occupants to directly connect to nature, and to assess the success of the Health + Happiness Imperatives.

All projects must connect people and nature through the provision of sufficient and frequent human–nature interactions in both the interior and exterior of the project to connect the majority of occupants to nature directly.

All projects must complete a post-occupancy evaluation that addresses the health benefits of the project, including the benefits of daylight, fresh air, and access to nature at least once within six to twelve months of occupancy.

Imperative I-11 Access to Nature aligns with the goals of affordable housing to ensure a health-promoting, often healing, space with sufficient direct access to nature. All too often, urban communities, and lower income communities in particular, lack nature such as parks, trails, street trees, and gardens. It is not uncommon for children growing up in these communities to have never seen a forest or a beach. This lack of access to nature at any scale has a profound deleterious effect on mental, emotional, and physical health and well-being. Numerous studies confirm this to be true.[42] Within the last two decades, more and more research is being conducted into the positive health effects that access to nature can have. For example, one study found a 25% decrease in aggression toward partners when public housing buildings are located in green surroundings.[43] Another study found that greater amounts of vegetation reduced property crimes by 48% and violent crimes by up to 56%.[44] Another study found that children ages seven to twelve years old diagnosed with ADHD concentrate better after a walk in an urban park.[45] Exposure to nearby green space and trees may have a positive effect on infant birth weight, particularly for lower socioeconomic groups.[46] The list of studies and benefits of access to nature go on and on.

This Imperative can be coordinated with I-01 Ecology of Place and I-02 Urban Agriculture to concurrently install healthy food options and promote a low-maintenance contextual landscape. The projects below demonstrate a few examples of how affordable housing teams have promoted access to nature at minimal added cost.

42 https://depts.washington.edu/hhwb/
43 Kuo, F.E., and W.C. Sullivan. 2001. Aggression and Violence in the Inner City: Effects of Environment Via Mental Fatigue. Environment and Behavior 33, 4:543-571.
44 Kuo, F.E., and W.C. Sullivan. 2001. Environment and Crime in the Inner City: Does Vegetation Reduce Crime? Environment and Behavior 33, 3:343-367. online summary
45 https://journals.sagepub.com/doi/abs/10.1177/1087054708323000?journalCode=jada&
46 Donovan, G.H., Y.L. Michael, D.T. Butry, A.D. Sullivan, and J.M. Chase. 2011. Urban Trees and the Risk of Poor Birth Outcomes. Health & Place 17, 1:390-93. and Dadvand, P., A. de Nazelle, F. Figueras, X. Basagaña, J. Su, E. Amoly, M. Jerrett, M. Vrijheid, J. Sunyer, and M.J. Nieuwenhuijsen. 2012. Green Space, Health Inequality and Pregnancy. Environment International 40:110-15.

CASE STUDIES
HEALTH + HAPPINESS

OTHELLO SQUARE HOMEOWNERSHIP BUILDING

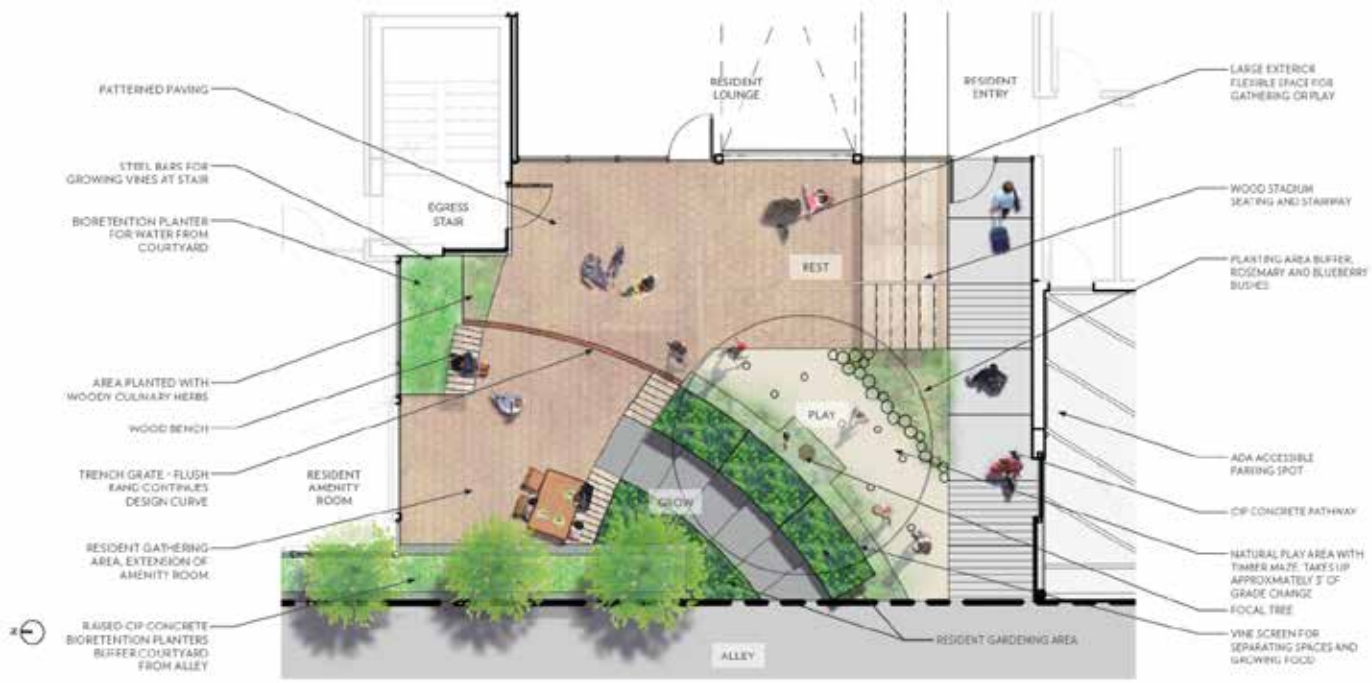
Homesight
Seattle, WA

Through community workshops and engagement, the Othello community expressed an enthusiasm for growing their own food to supplement their daily diet. In response, the project team integrated agricultural areas throughout the building and site as a major design focus. Agricultural areas were placed in the ground floor courtyard, designed as a "big backyard" for residents, and on sun decks added to every other unit to provide communal space for socializing and growing vegetables. Additionally, vertical cable systems for climbing and vining vegetables will be hung along the sun decks and exterior stairs. As sunlight will be diffused through these vines, residents will experience a direct connection to the natural world through the building's circulation space.

The integration of nature between the resident balconies and sidewalk allows for a greater degree of privacy, as well as the benefits of additional access to nature within an urban core neighborhood. Image courtesy of Sundberg Kennedy Ly-Au Young Architects.

The large sun decks and vines integrated through the open stairwells provide for a connection to the natural environment throughout resident daily life. The communal spaces become activated by the presence of gardening. Image courtesy of Sundberg Kennedy Ly-Au Young Architects.

The corridors have been deliberately placed to also allow views of the sun deck planting areas and the landscaped courtyard. The ground floor courtyard has been zoned to support a variety of activity levels. Along a tiered path are planter boxes allowing residents to actively plant and harvest fruits and vegetables. A vine screen separates this area from the children's play area, which is surrounded on the other side by rosemary and blueberry bushes. Finally, a woody culinary herb garden is placed adjacent to an exterior extension of the resident amenity room, intended to provide a place of respite, and the courtyard and residential porches are protected from alley and street noise by raised bioretention planters.



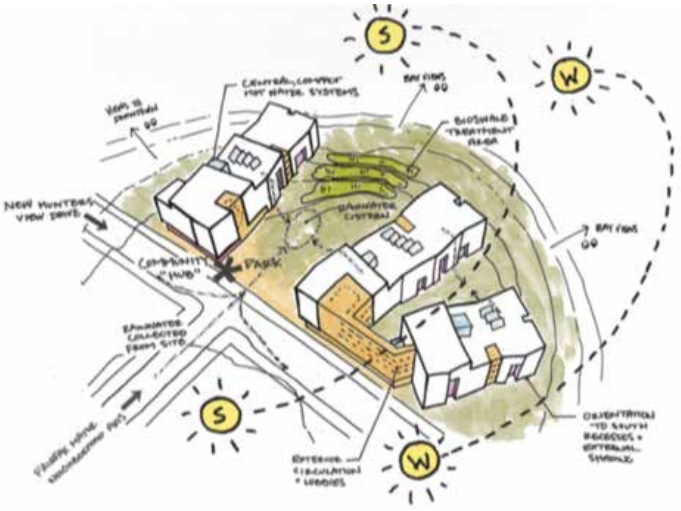
Landscape plan for the courtyard at the Othello Square Homeownership Building showing the different zones and related landscaping for each area of the ground floor courtyard, serving as a "big backyard." Image courtesy of Sundberg Kennedy Ly-Au Young Architects.

HUNTERS VIEW PHASE III

John Stewart Company
San Francisco, CA

The site for Hunters View Phase III has been deliberately configured to work with the natural topography to maximize views of San Francisco Bay and allow abundant, communal open space. The three wings of the building, each with slightly varied orientations, will flank park space. By programming this park as multigenerational, this space will serve as an engaging, social hub for the community. The park will include gardening areas in addition to areas that offer a feeling of peace and refuge with the intent of promoting community health and well-being.

Exterior lobbies and exterior vertical circulation in all buildings will further promote a connection to the outdoors and to nature, allowing residents views of both the park space below and the bay beyond. Bioswale treatment areas and rainwater cisterns will also be integrated into the landscape, allowing the site to serve as a communal asset and an active component of the water system infrastructure.



Conceptual drawing of Hunters View Phase III showing the location of the large park central to the buildings and accessible to the larger community, as well as showing the bay views and bioswale areas on site. Image courtesy of David Baker Architects.

Resources

U.S. EPA Safer Choice Overview
The Environmental Protection Agency (EPA) website provides a description of the Safer Choice Label and related programs.
https://www.epa.gov/saferchoice

U.S. EPA Safer Choice Product Database
The EPA's Safer Choice Product Database allows users to search for products that meet the standard by product name, company name, or product type.
https://www.epa.gov/saferchoice/products

U.S. EPA Safer Choice Chemical Ingredient List
The EPA's Safer Choice Chemical Ingredient List provides a searchable database or downloadable spreadsheet that allows for users to safer chemical alternatives, grouped by functional use classes.
https://www.epa.gov/saferchoice/safer-ingredients#searchList

MATERIALS

Building with Products that are Safe for All Species Through Time

A mural at the Etsy headquarters, a Petal Certified building. Image: Emily Andrews

"Pursuing the Materials Petal is more than hitting or not hitting a benchmark; it opens up an ongoing dialogue about materials throughout the design process."

Katie Ackerly, Associate/Sustainability Lead, David Baker Architects

PETAL INTRODUCTION

The intent of the Materials Petal is to help create a materials economy that is non-toxic, ecologically restorative, and transparent. Throughout their lifecycle, building materials are responsible for many adverse issues, including personal illness, habitat and species loss, pollution, and resource depletion. The Imperatives in this section aim to remove the worst known offending materials and practices and to drive business toward a truly responsible materials economy.

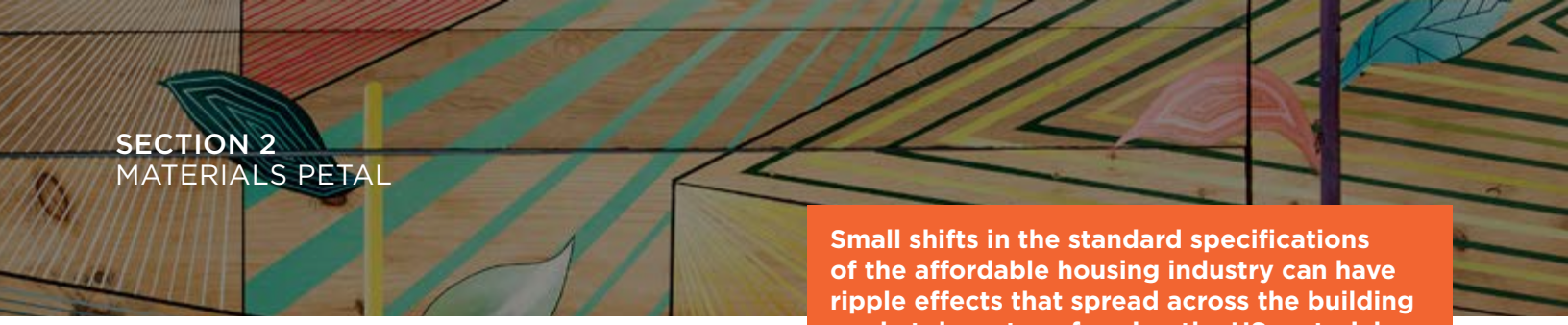
The Materials Petal is one of the more challenging Petals within the Living Building Challenge because it requires more than a technical or engineering solution. It requires a change in the manufacturing industry overall to embrace transparency and toxic chemical avoidance. The Red List Imperative offers a framework to ensure healthy, non-toxic affordable housing projects. The Living Economy Sourcing Imperative 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 Responsible Sourcing Imperative promotes transparency in the market while ensuring the sustainable harvest and extraction of wood products and other raw materials. 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.

While challenging, meeting the Materials Petal is also critical to protecting occupant and environmental health. As we spend more than 90% of our time indoors, the built environment has a significant impact on our health and wellness. Neighborhood and built environment are one of five social determinants of health defined by the Centers for Disease Control and Prevention (along with education, health care, economic stability, and community), which together account for 80-90% of modifiable contributing factors to health outcomes.[47]

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. For example, 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, as well as contaminated groundwater and soil.[48] Furthermore, a report from the Healthy Building Network identified a number of common building materials that have been linked to a growing epidemic of asthma in the U.S., with the greatest impact on poor and minority populations.[49]

The number of Red List Free products (i.e., products free of the worst-in-class chemicals) available in the marketplace has significantly increased over the past six years. There are currently nearly 900 products available in Declare (compared to 115 when this report was last published) and 23 Living Product Certified products. However, there is still a need for more readily available Red List Free–products for the multifamily market, particularly those that are at an accessible price point for affordable housing price point. Of these nearly 900 Declare products, 739 are appropriate for use in the residential sector. In In order to facilitate the broader market transformation that will make Red List–Free products commonplace, the Institute has engaged with several strategic partners working toward the same vision. The Declare program is an officially recognized compliance path in LEED v4 under the Building Product Optimization credit with additional value for Declare Third Party Verified Red List Free products under LEED v4.1. In addition, the Institute is actively engaged with Enterprise Community Partners on their forthcoming update to Enterprise Green Communities. Since its launch in 2004, the Enterprise Green Communities standard has resulted in significant changes to both the affordable

47 https://www.cdc.gov/socialdeterminants/
48 National Center for Biotechnical Research, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447157/
49 Sarah Lott and Jim Vallette, Full Disclosure Required: A Strategy to Prevent Asthma Through Building Product Selection, Healthy Building Network, Dec. 2013. https://healthybuilding.net/reports/14-full-disclosure-required-a-strategy-to-prevent-asthma-through-building-product-selection



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.

housing development and materials sectors standard practices around material health. Further alignment with the transparency and health requirements of Declare and the Red List will help drive additional market shifts in affordable housing and ease both soft and hard cost increases.

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 can have ripple effects that spread across the materials marketplace, transforming the U.S. economy and providing safe, healthy housing for all economic classes. Market-rate housing will also benefit from the strides being made in the affordable housing sector. However, it is the affordable housing developers who generally have the long-term investments in their buildings, residents, and communities, and the affordable housing sector that is paving a path toward toxin-free housing.

MATERIALS

CORE IMPERATIVE

12

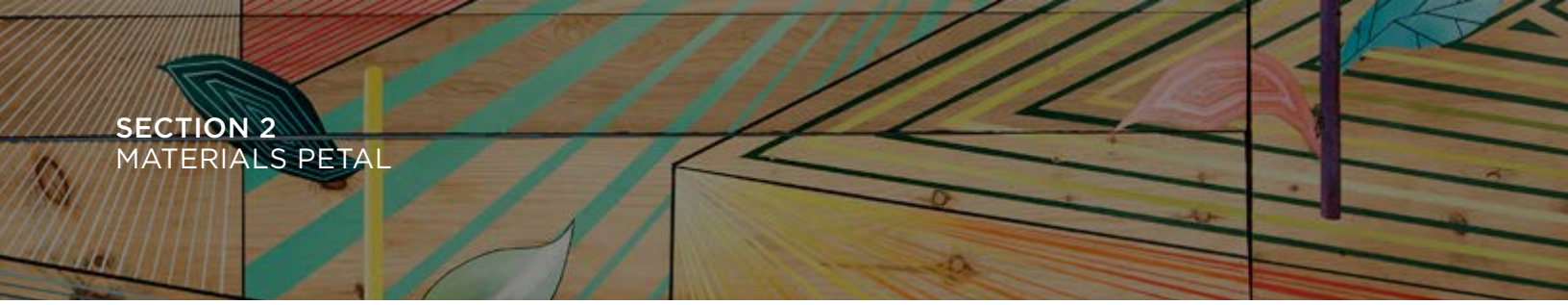
RESPONSIBLE MATERIALS

The intent of this Imperative is to set a baseline for transparency, sustainable extraction, support of local sector, and waste diversion for all projects.

All projects must positively impact the building products market by meeting the following materials selection criteria:

- The project must contain one Declare label product per 200 sq. m of gross building area, or project area, whichever is smaller, up to twenty distinct products from five manufacturers. All other product manufacturers not currently in Declare must, at a minimum, receive a letter requesting they disclose their ingredients and identify any Red List content.
- All projects (except residential) must incorporate one product certified under the Living Product Challenge.
- 50% of wood products must be FSC, salvaged, or harvested on site either for the purpose of clearing the area for construction or to restore or maintain the continued ecological function of the site. The remainder must be from low-risk sources.
- 20% or more of the materials construction budget must come from within 500 kilometers of construction site.
- The project must divert 80% of the construction waste material from the landfill and provide dedicated infrastructure for the collection of recyclables and compostable food scraps during occupancy.

When a project is targeting all Materials Imperatives, it is not necessary to document this Imperative, as all requirements are superseded by Imperatives 13-16.



Imperative I-12 Responsible Materials is a Core Imperative due to the importance of the issues presented within the Materials Petal. The Institute believes that any sustainable project should address these issues in the ways indicated above. While challenging, it is unlikely that any of these requirements will be prohibitive for affordable housing projects. Given the number of products now available in Declare and that Declare provides a shortcut for materials vetting, integrating Declare label products is likely already being done by many project teams. Utilizing local materials and diverting high levels of construction waste, while important, are similarly likely to be already performed as a best practice due to the long-standing inclusion of these requirements in the Living Building Challenge and many other green certification systems. The most challenging requirement of this Imperative is likely to be the 50% FSC (Forest Stewardship Council) certified wood requirement. However, based on feedback from current pilot project teams, while 100% FSC has proven to be a steep challenge for project teams, affordable housing teams are typically able to source at least 50% FSC wood with a moderate amount of effort. Dimensional lumber and plywood are often available with little to no cost implications, depending on the region.

MATERIALS

IMPERATIVE 13

RED LIST

The intent of this Imperative is to foster a transparent materials economy free of toxins and harmful chemicals.

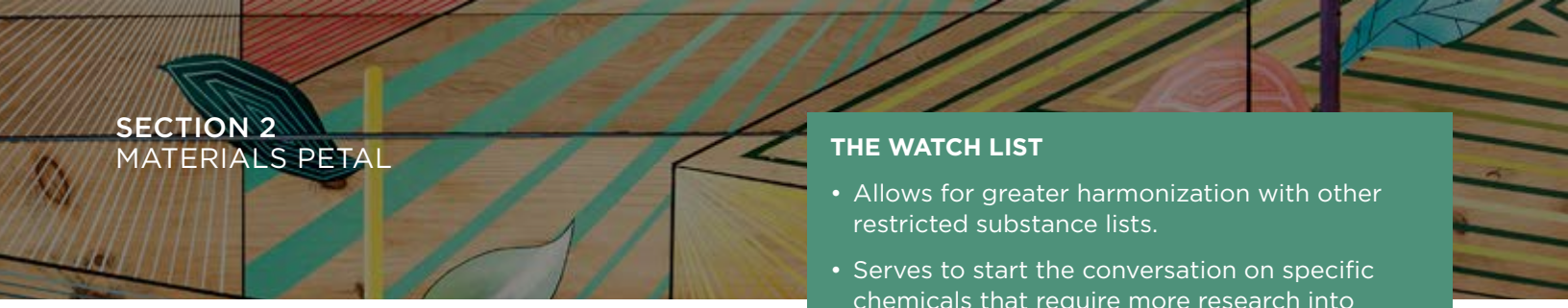
All projects must avoid the following Red List chemical classes in 90% of the project's new materials by cost. "In situ" materials do not need to be removed or vetted for Red List chemical classes.

"When the building materials do not contain lead (affects mental and physical development), chromium VI (causes cancer), any of the California banned proposition 65 materials (causes cancer and reproductive toxicity), formaldehyde (causes cancer), Bisphenol A (impacts brains, behavior, prostate glands of fetuses and small children), Phthalates (hormone disrupting agent, especially in young children) and many more Red List materials that impact people and earth wellbeing, we will feel good nodding our heads when the homeowner passes on their property from one generation to the next."

Gladys Ly-Au Young, Principal, Sundberg, Kennedy, Ly-Au Young Architects

When approaching this Imperative, project teams can take advantage of published resources and databases of healthy materials. For example, all Living Building Challenge 3.0 (or later) projects that achieved the Materials Petal (either as Petal or Living Certified projects) are required to disclose the list of materials that they used in order to reduce research time for other project teams and to increase market transparency. This list can be found on the Institute's website (see resources at the end of this chapter). Some LBC 2.1 projects have also chosen to publish their materials list. For example, the list of materials used on the Bullitt Center can be found on the Living Building Challenge Resources page of the ILFI website.[50] When using these lists, project teams should independently verify that the materials have not changed and that they still meet the requirements of this Imperative.

50 http://www.bullittcenter.org/building/red-list-compliant-products/



Other helpful resources to use as a starting point for Red List–compliant materials research include the Declare program,[51] Mindful Materials,[52] Red2Green,[53] and the HPD Repository.[54] See resources at the end of the chapter for a complete list.

New within LBC 4.0, the Institute has created the LBC Watch List to inform the continued evolution of the Red List and to create an impactful signal to the manufacturing and construction communities about which chemicals or chemical classes may be added to the Red List. As understanding of chemicals in the materials industry evolves, new chemicals or chemical classes will be added to the Watch List and further investigated by the Institute and its partner organizations, toxicologists, and industry specialists. It is structured similarly to the Red List, with chemical classes and definitive Chemical Abstract Services (CAS) Numbers.[55]

The Red List has taken an iterative approach, and evolves with stakeholder engagement involving

THE WATCH LIST

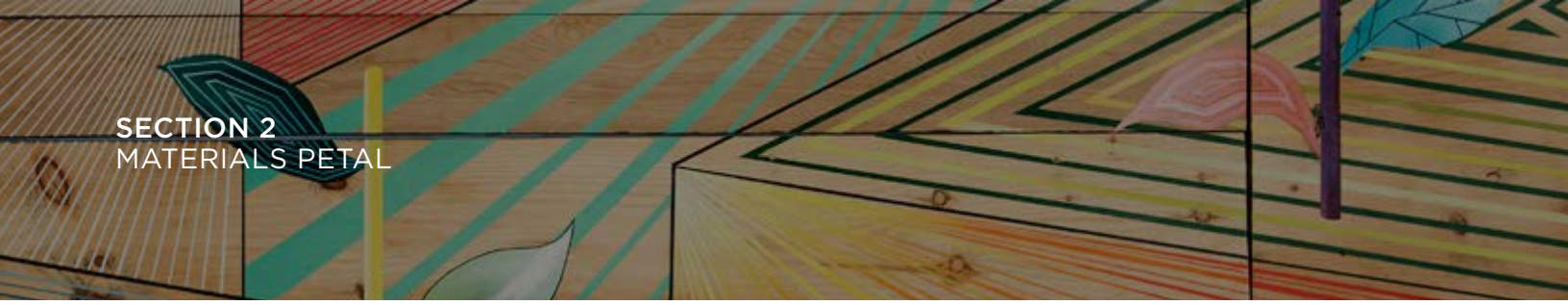
- Allows for greater harmonization with other restricted substance lists.
- Serves to start the conversation on specific chemicals that require more research into hazards and/or viable substitutions.
- Will publish CAS Numbers to the Watch List a minimum of 12 months before chemicals moved to the Red List.
- Is informative; it is not enforced in the Living Building Challenge or Declare.
- Helps avoid regrettable substitutions—the replacement of a harmful chemical with one that is also harmful.

THE RED LIST

- Antimicrobials (marketed with a health claim)
- Alkylphenols and related compounds
- Asbestos compounds
- Bisphenol A (BPA) and structural analogues
- California-banned solvents
- Chlorinated Polymers, including:
  - Chlorinated polyethylene (CPE)
  - Chloroinated polyvinyl chloride (CPVC)
  - Chloroprene (neoprene monomer)
  - Chlorosulfonated polyethylene (CSPE)
  - Polyvinylidene chloride (PVDC)
  - Polyvinyl chloride (PVC)
- Chlorobenzenes
- Chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC)
- Formaldehyde (added)
- Monomeric, polymeric and organophosphate halogenated flame retardants (HFRs)
- Organotin Compounds
- Perfluorinated compounds (PFCs)
- Phthalates (orthophthalates)
- Polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Short-chain and medium-chain chlorinated paraffins
- Toxic heavy metals
  - Arsenic
  - Cadmium
  - Chromium
  - Lead (added)
  - Mercury
- Volatile organic compounds (VOC) (wet-applied products)*
- Wood Treatments containing creosote or pentachlorophenol

**VOCs are limited, not banned. Refer to the v4.0 Materials Petal Handbook for specific reference standard + thresholds.*

51 declareproducts.com
52 http://www.mindfulmaterials.com/
53 https://materiallybetter.com/
54 https://www.hpd-collaborative.org/hpd-public-repository/
55 A Chemical Abstract Service (CAS) number is a unique numerical identifier assigned by the Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature.



toxicologists and industry specialists. The Watch List helps avoid regrettable substitutions as it is responsive to the industry and includes the same chemical classes as those on the Red List and serves to inform the market of future additions to chemical classes and individual CAS Numbers.

Once a project team registers for the Living Building Challenge, the team is held to the version of the Red List that is published at the time of registration. Should the Red List change during the project team's pursuit of the Materials Petal, the project team is not expected to abide by the updated Red List. Project teams should make themselves familiar with the many exceptions related to this Imperative, so they know the market realities and available documentation pathways for the many products they are required to vet.

MATERIALS

IMPERATIVE 14

RESPONSIBLE SOURCING

The intent of this Imperative is to support sustainable extraction of materials and transparent labeling of products.

All project must advocate for:

- The creation and adoption of third-party certified standards for sustainable resource extraction and fair labor practices for extraction of rock, metal, minerals, and timber.
- Certification under the Natural Stone Council (NSC) 373 Standard by quarries and/or manufacturers of all dimensioned stone products used with the project.

All projects must either source 80% or more of all wood, by cost or volume, as Forest Stewardship Council (FSC) certified, or as salvaged, or from the intentional harvest of on-site timber for the purposes of clearing the area for construction or restoring/maintaining the continued ecological function of the on-site bionetwork, and the remaining 20% of wood must be from low-risk sources. Alternatively, the project may achieve FSC Project Certification.

All projects must contain two Declare labeled products for every 200 sq. m of gross building area, or project area, whichever is smaller, up to forty products, and advocate to all manufacturers that are not in Declare that they register their products in the Declare Database.

All projects (except residential) must incorporate one product certified under the Living Product Challenge per 1,000 sq. m of gross building area or project area, whichever is smaller, up to three products. Residential projects must incorporate one product certified under the Living Product Challenge.

Many affordable housing projects use wood as a main structural element, which means there is a lot of wood used on the project. Thus, providing 80% 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 should identify the type of wood products required for the project early in the design process in order to ensure adequate lead time to research and identify FSC options. Choosing salvaged or reclaimed materials, which are not required to be FSC certified, is one effective strategy to limit impact of the potential upcharge for FSC.

Similar to FSC, the dimension stone industry has created a third-party certification system called ANSI/NSC 373 Sustainable Production of Natural Dimension Stone. Project teams are required to advocate to the manufacturers of dimension stone products for NSC 373 certified products to increase awareness and drive demand for certified natural stone products.

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. As the Living Building Challenge is an advocacy tool as well as a certification program, it is designed to transform the industry. As such, this Imperative requires that advocacy letters be sent to industries governing the extraction of rock, metals, and minerals.[56] Sample letter templates are available to project teams with registered LBC projects.

There is a growing list of Declare products that make meeting the requirement to specify two Declare products for every 200 square meters of project area straightforward. For example, nearly every major carpet company is participating in Declare, as well as many insulation and interior finish material companies. Affordable housing developers that intend to build multiple projects are in a strong position to encourage manufacturers to list their product(s) in the Declare database, making it easier and less time-consuming for all project teams to identify compliant materials in the future.

56 Refer to appendix E: Sample Affordable Housing Materials Transparency Letter

MATERIALS

IMPERATIVE 15

LIVING ECONOMY SOURCING

The intent of this Imperative is to foster local communities and businesses, while minimizing transportation impacts.

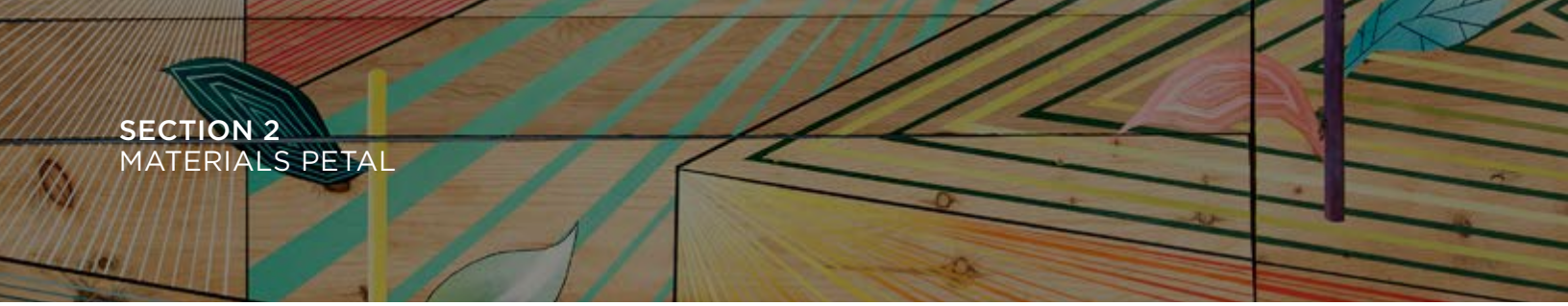
The project must incorporate place-based solutions and contribute to the expansion of a regional economy rooted in sustainable practices, products, and services. Manufacturer location for materials and services must adhere to the following restrictions:

- 20% or more of materials construction budget must come from within 500 km of construction site.
- 30% of total materials construction budget must come from within 1000 km of the construction site.
- An additional 25% of materials construction budget must come from within 5000 km of the construction site.
- The remaining 25% of materials may be sourced from any location.

One of the challenges of achieving this Imperative is being able to effectively estimate and track progress toward compliance. Because the percentages are based on cost and the actual costs of materials are not known until the construction process, project teams will need to establish a process for estimating costs during design, usually including a buffer to ensure ultimate compliance should the actual costs be different than the estimated costs. One way to do this is to the use the Materials Tracking Spreadsheet that ILFI created to estimate and track progress.[57] A project team can 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 project team is on track to meet the requirements is critical to meeting this Imperative.

57 https://living-future.org/lbc/resources/#materials-guidance

The construction site of Hopeworks Station Phase II as of May 2019. Image courtesy of Susan Puri



MATERIALS

IMPERATIVE 16

NET POSITIVE WASTE

The intent of this Imperative is to integrate waste reduction into all phases of projects and to encourage imaginative reuse of salvaged "waste" materials.

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 a natural nutrient loop.

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.

All projects must create a Materials Conservation Management Plan that explains how the project optimizes materials in each of the following phases:

- Design Phase, including the consideration of deconstruction and appropriate durability in product specifications.
- Construction Phase, including product optimization and collection of waste materials for reuse or recycling.
- Operation Phase, including a collection plan for consumables and durables.
- End of Life Phase, including a plan for adaptable reuse and deconstruction.

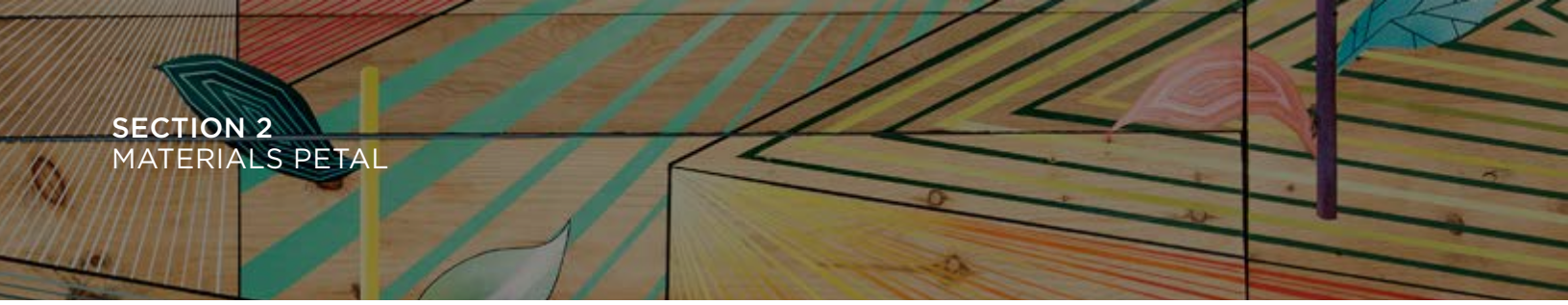
MATERIAL	MINIMUM DIVERSION RATE
Metal	**99%**
Paper and cardboard	**99%**
Soil and biomass	**100%**
Rigid foam, carpet, and insulation	**95%**
All others – combined weighted average•	**90%**
Demolition Waste	**80%**

• Hazardous materials in demolition waste, such as lead-based paint, asbestos, and polychlorinated biphenyls (PCBs), are exempt from percentage calculations.

All projects must divert waste material from the landfill to the following levels (by weight or volume) during construction.

All project types must provide dedicated infrastructure for the collection of recyclables and compostable food scraps.

Projects located on sites with existing infrastructure must complete a pre-building audit that inventories available materials and assemblies for reuse or donation.

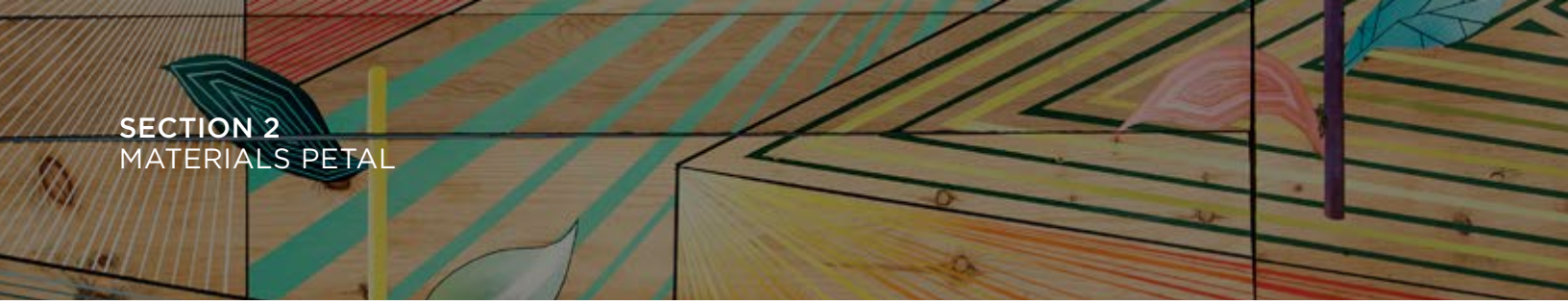


The requirement to provide a Materials Conservation Management Plan requires careful consideration of ways to reduce waste throughout all phases of a building's life. Many jurisdictions have required some level of construction waste management for years now; therefore, that aspect of the requirement 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 still critical to meaningful transformation. 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 to consider ways to design the building to optimize material use is key. For example, ways to use the structure as finish, exposing systems, and advanced framing techniques can be explored, minimizing material use from the beginning. Optimal dimensioning of spaces can also be considered to limit the cutting of materials. Project teams may also consider using prefabricated or modular assemblies to reduce on-site waste.

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 excess materials 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 project 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 need to maintain waste weight and tracking documentation themselves, or work with the waste hauler/facility in order to document compliance with the Imperative.

The requirement to use salvaged materials can 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. 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. Using salvaged materials also provides opportunities to incorporate materials that can tell a story about the history of the place—adding character and meaning to a space.

The completed interior of Lakeline Learning Center. Nearly all materials shown here are Red List Free, excluding a few minor exceptions. Photography by Casey Chapman Ross

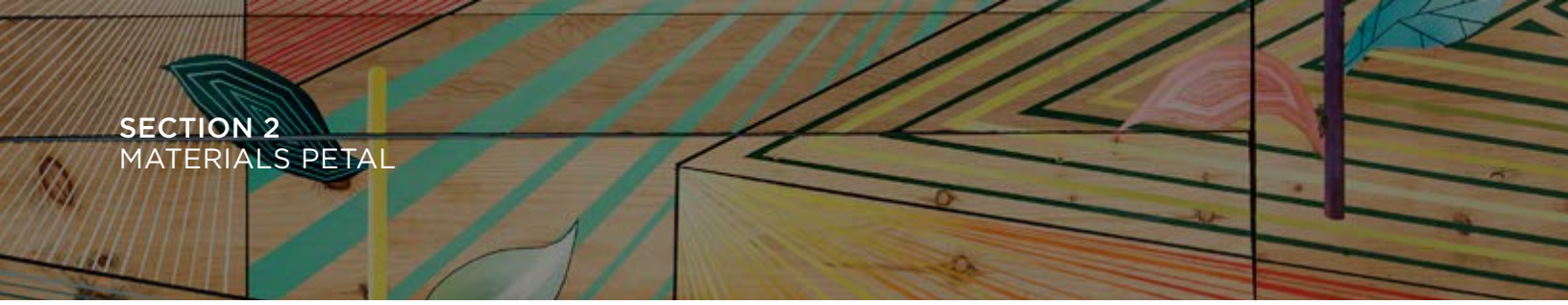


OVERALL APPROACH

Commodity building products typically do not carry a cost premium for LBC compliance, and many, if not most, can be quickly found and vetted via the Declare database. These products can represent a surprisingly large portion of the total materials used on the project. For all other materials, there are various resources that can help reduce the time needed for vetting, and the Institute is continuously developing more resources specifically for affordable housing materials. Available resources are delineated in depth below, but include the Declare database, the Red2Green Tool, and the materials list from previous LBC project teams. These resources will significantly reduce the time needed to dedicate to contacting manufacturers independently and waiting for confirmation of compliance. While the Institute recognizes these resources do not yet include all required materials for affordable housing to meet the Materials Petal, these resources are constantly updated with new research and products. The Institute is also available to help project teams, particularly affordable housing project teams, with questions and resources for vetting.

The scope of required vetting includes all building products, permanently installed finishes, hard-wired or hard-piped equipment, and appliances and equipment that plug in using a dedicated 220v outlet, office systems furniture and task seating, and site improvement and landscape products. The scope of product vetting does not include temporary construction materials (i.e., formwork); small free-standing appliances 110v or less; low-voltage equipment (i.e., security cameras); and furniture, fixtures, and equipment (FF&E) with the exception of office systems furniture. Specifically with regard to FF&E, the vetting scope does not include bed frames, mattresses, linens, side tables, night stands, occasional chairs, free standing and task lamps, rugs, and art. However, the vetting scope does include all office systems furniture, such as modular desking systems, task chairs, and mass-produced conference and meeting tables, regardless of their location within the project; it is likely these products may be included in the amenity, lobby, or common areas. The build-out materials for any tenant commercial space must also be included in the Living Building Challenge scope of work.

The Betty and Clint Josey Pavilion in Decatur, TX—a Certified Living Building and built by the Dixon Water Foundation. Image courtesy of the Josey Pavilion



MATERIALS PETAL CHECKLIST

The following tasks and activities typically associated with the Materials Petal go beyond the typical design and construction scope. Project teams should expect that these tasks will need to be completed by an outside consultant or by a project team member dedicated to this task, and may require some input from the design and construction team members:

☐ **TEMPLATES + FORMS:** Development of template emails, phone scripts, information collection forms, and/or Materials Petal summary sheets addressing all vetting-related Imperatives to assist with outreach to manufacturers.

☐ **OUTREACH + VETTING:** Outreach and vetting of selected materials. The Institute recommends vetting and documenting as many materials as possible prior to specifications and the start of the construction submittal process. Vetting will take a substantial amount of time, and this research should be front-loaded during the design phase to minimize construction delays and change orders. Simple products, such as carpet or gypsum wallboard, have multiple compliant options available on the Declare database. Simple products are not expected to require a significant vetting time commitment. Complex products, such as air handling units, water heaters, and light fixtures, will take significantly more time as these products represent more complex supply chains, and manufacturers are not as familiar with the transparency ask. Note that ILFI has and is developing many tools and resources to assist affordable housing project teams with this process.

☐ **LOCAL SOURCING:** Appropriate sourcing analysis, a review of selected products, and estimation of costs to ensure that products selected and confirmed to be Red List compliant will also meet the Living Economy Sourcing Imperative requirements. It is in the project team's best interest to collect this data during the ingredient vetting process to avoid redundant or additional conversations with manufacturers.

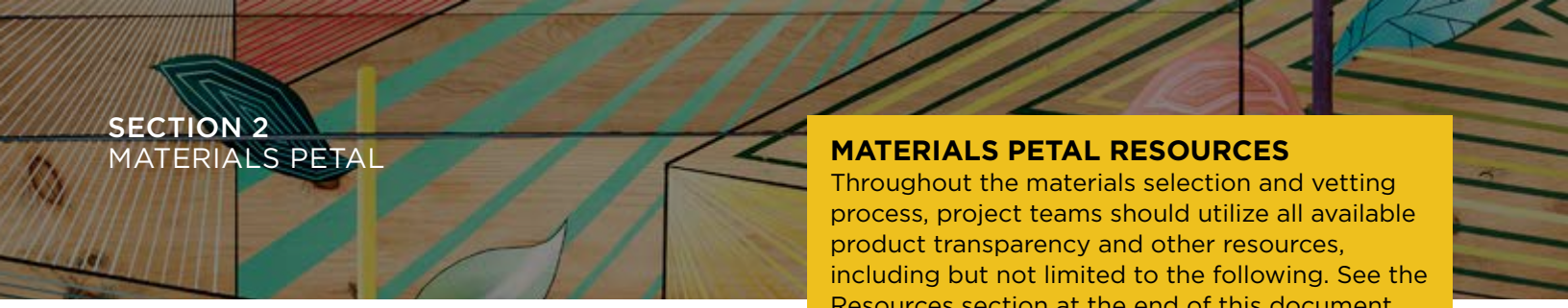
☐ **SPECIFICATIONS:** The Institute recommends including Living Building Challenge performance criteria in the project specifications. LBC sample specifications for relevant Division 01 sections have been developed and published by the Institute to offer guidance and save time.[58]

☐ **SUBMITTAL FORMS:** Development of submittal forms and installer training resources to communicate strict Materials Petal requirements to construction and install teams.

☐ **SUBMITTAL REVIEW:** Review of each construction submittal (including architectural/interiors, structural, civil, and MEP products) to confirm ingredients, sourcing location and (when applicable) FSC chain-of-custody have been collected and Imperative compliance is confirmed. Assume one added team member, or equivalent hours, throughout the construction submittal process. At this time, approved products should all be included in the Materials Tracking Spreadsheet and backup documentation organized.

☐ **DOCUMENTATION:** Final review of product documentation and narrative drafting to prepare for audit. This should include spot-checking finalized documentation, correction of any errors/omissions, drafting Imperative process narratives, and compiling any diagrams or site photos.

58 https://living-future.org/wp-content/uploads/2016/11/Sample-Spec-Sustainable-Design-Requirements.pdf



RED LIST FREE MATERIALS FOR AFFORDABLE HOUSING

Below are two lists of materials—generally accessible materials and challenging materials. These lists have been generated based on ILFI's work with the Affordable Housing Pilot Projects.

Even if a project team is not considering Materials Petal, there are several product types that can generally be found Red List Free with negligible cost increases or vetting time. All project teams should consider integrating these products as an initial first step.

The Institute also encourages all projects to choose one or two of the challenging materials to research in depth to help move the market forward. The Institute is committed to proactively reaching out to manufacturers in these categories and more to ensure that over time there are more and more Red List Free materials available to affordable housing projects in all relevant CSI divisions.

CHALLENGING MATERIALS FOR AFFORDABLE HOUSING

The products listed below require more research time to find compliant options and/or have been found by past project teams to be less cost-effective than non-compliant options. While these represent current challenges in the marketplace, industry is pushed to develop Red List Free and cost-effective options when manufacturers are contacted by multiple project teams all requesting options. This list is not intended to dissuade project teams from researching these products, but on the contrary is presented as an opportunity and challenge for project teams to push the envelope and work collaboratively, with the Institute, each other, and with manufacturers, to find solutions.

WINDOWS

Vinyl windows, like vinyl flooring, are ubiquitous throughout the built environment, particularly within affordable housing. Fiberglass and aluminum-framed windows are durable alternatives. There are fiberglass options available in Declare, but it is expected that these options will carry a price premium as compared to vinyl.

MATERIALS PETAL RESOURCES

Throughout the materials selection and vetting process, project teams should utilize all available product transparency and other resources, including but not limited to the following. See the Resources section at the end of this document for links to these resources:

The Declare Database: A database of hundreds of pre-vetted and transparent building products. Products listed in the database as Red List Free or LBC Compliant do not require any additional documentation or research for the Red List Imperative. Products with a status of "Declared" may not be used in Living Building projects without additional research showing that there is not a better product available on the market.

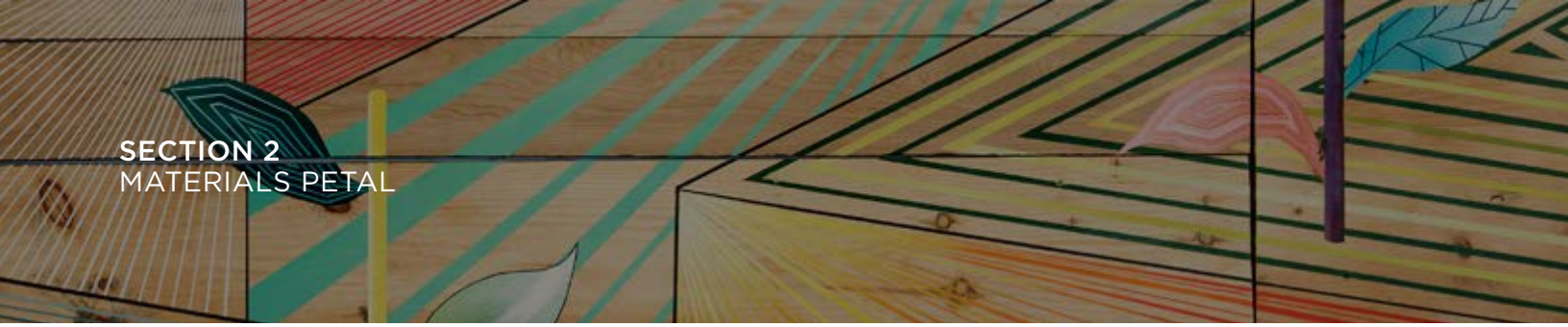
Living Product Challenge (LPC) Certified Products: are confirmed as Red List Free or LBC Compliant, and all ingredient and environmental claims have been verified by a qualified third-party assessor.

The Cradle-to-Cradle list of registered products: Products with a Cradle to Cradle Certification level of Bronze or higher are likely to meet the Red List requirements. Additional outreach to product manufacturers is required to collect a transparent ingredient list.

Health Product Declarations (HPDs): Products with a fully-disclosed HPD to 1000ppm or 100ppm meet the reporting requirements of the Red List Imperative. Additional time is required to vet the ingredients reported on the HPD against the Red List.

The mindful Materials database: The mM database is a data hub that serves as a resource to product specifiers to locate product sustainability data in one location. mM includes Declare labels, Living Product Challenge Certified products, HPDs, EPDs, and other manufacturer-submitted product data. Please note, not all Declare labels are visible on mM, and project teams should still consult the Declare Database for the most up-to-date listing of Declare Red List Free and LBC Compliant products.

Published LBC Certified Project Material Lists: All LBC 3.0 (or higher) Certified projects and voluntary LBC 2.1 Certified projects (that have achieved the Materials Petal) have published their product lists. Project teams may use these lists to identify potential manufacturers but are still required to collect an ingredients list and vet each product.



SHOWER SURROUNDS

There are few compliant, cost-effective Red List Free options available for shower surrounds. Tile is the best option as of now, but it does increase labor costs somewhat.

ELEVATORS

As of the publication date, there is just one compliant option within Declare. Elevators can be a significant cost within affordable housing projects. Until more options are developed, the most effective solution may be to minimize the number of elevators in the project (which also helps with energy use) and to ensure that an attractive, prominent stair option is provided while still maintaining easy and attractive access to all floors for persons unable to use stairs.

ELECTRICAL AND MECHANICAL EQUIPMENT

Manufacturers of complex mechanical equipment are often not as familiar with the LBC reporting requirements and may need additional time to complete the requested documentation. While many municipalities do not allow plastic piping, for those that do, cast iron will represent a cost increase. PEX or polypropylene are additional options that may or may not be allowed depending on the municipality. Note that there are several exceptions related to mechanical and electrical equipment to reflect market realities. The project team should refer to these exceptions, listed in the Materials Petal Handbook, before expending significant research time on certain components.

CABINETS AND COUNTERTOPS

The Institute has received feedback that No Added Urea Formaldehyde cabinets that were also FSC certified were not typically available on the marketplace without custom work. This is particularly an issue for multifamily and affordable housing that has a high volume of cabinets (as compared to office or other project types).

The Top Five: First Steps Toward Red List Free Materials

1. **Insulation:** While insulation commonly includes Red List chemicals, there are numerous options available in Declare that do not and should not carry a cost premium. Extruded polystyrene board, loose-fill, batt, and mineral wool are all available Red List Free, with several options listed in Declare. Spray foam insulation is likely to contain halogenated flame retardants (HFRs), a Red List chemical, and should be avoided.

2. **Resilient Flooring:** Vinyl tile flooring can be a problematic material to avoid. It is commonly used in multifamily housing due to its durability and cost-effectiveness. However, linoleum (particularly Forbo Marmoleum) is a proven product used by many affordable housing developers for years that carries a minimal cost increase and provides durability with a minimal amount of maintenance staff education. Depending on climate, project teams in the past have also found that ceramic tile or polished concrete may be viable options. In some instances, polished concrete has priced out as more cost-effective than vinyl. In the case of the 5th Avenue Apartments project, polished concrete actually represented a 35% cost savings over luxury vinyl tile.

3. **Carpet:** Red List Free carpet typically does not carry a cost premium and is widely available by multiple manufacturers in Declare. To avoid using PVC-backed carpet, nylon-backed carpet can serve as a substitution.

4. **Paint:** There are many compliant, Red List Free paint and coating products on the market and in Declare that are unlikely to carry a price increase.

5. **Gypsum Board Assemblies**: Project teams should consider specifying Red List Free drywall. There are multiple cost-efficient options available in Declare.

"Participating in the Pilot has helped us jump start our revision to our product selection process. We are establishing a standard list of Declared RED List Free products that we will incorporate in all specifications going forward."

Susan King, Principal, Studio Leader: Housing + Education, Harvey Ellis Deveraux

Therefore, the institute now allows for furniture and cabinetry substrates to contain formaldehyde up to the following limits (typically CARB PHASE II and TSCA Title VI will also comply):

- Particleboard - 0.09ppm,
- Medium Density Fiberboard - 0.11ppm,
- Thin Medium Density Fiberboard - 0.13ppm, and
- Plywood - 0.05ppm.

The healthy materials movement has made strides and become more widespread through advocacy to manufacturers and specifiers by many Living Building Challenge project teams, including affordable housing teams. Even as these improvements are made, some product types still may not exist in a Red List Free option. As of now, these non-compliant products on the marketplace may rely on the General Red List Exception. The General Red List Exception encourages research into compliant products and gives project teams a compliant pathway when a Red List Free product cannot be found. Other commonly referenced Red List Imperative Exceptions include: Proprietary Ingredients, Small Electrical Components, Small Mechanical Components, Structural Composite Wood Members, and the Composite Wood Sheet Goods Exception. All published Materials Petal exceptions can be found on the Dialogue and in the Materials Petal Handbook.

FSC WOOD

Under Imperative 14 - Responsible Sourcing, project teams are required to source a minimum of 80% of wood as FSC certified, salvaged, or intentionally harvested on site. This is decreased from the 100% requirement in place for LBC 3.1. The Core Imperative (required for all project teams regardless of certification path) requires that at least 50% of wood installed on each project be FSC certified. There is typically a cost premium associated with sourcing FSC certified wood that can range greatly depending on the region. Feedback from the Affordable Housing Pilot Projects has indicated a cost premium ranging from 2% (which can usually be absorbed in the budget) to up to 20%. In particular, composite structural wood and engineered wood, such as glulam beams, and finished-grade wood can be problematic. It is typically easier to find FSC-certified sheet goods and finish-grade veneers. Finding a millworker that can maintain FSC chain-of-custody can also be a challenging undertaking; increased customization and size of wood pieces increases difficulty. For finished wood, markups may exceed 50%, though this is certainly not the case for every project. The best way for project teams to manage these costs is to engage with a cost consultant early on in the process and research certified wood suppliers as soon as possible.

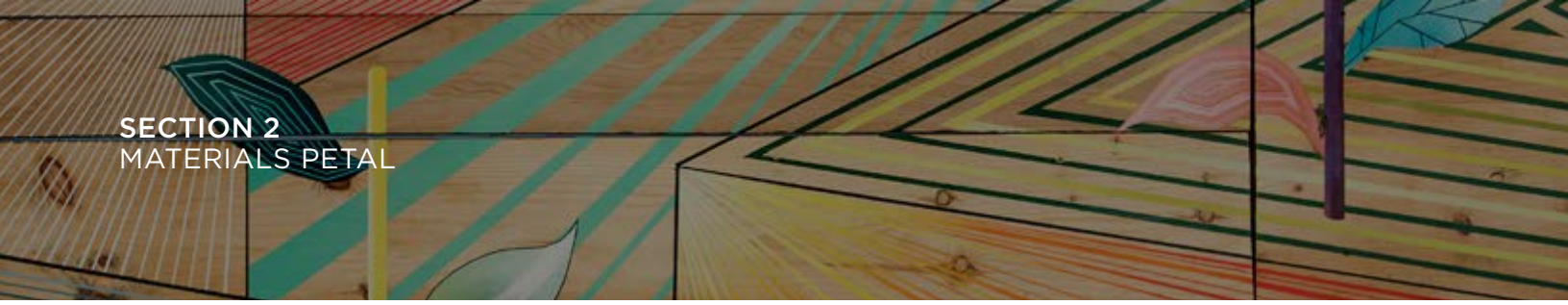
The FSC requirement in Responsible Sourcing can be especially challenging in affordable housing projects due to the prevalence of wood frame construction. Minimizing unnecessary wood through advanced framing or other strategic reductions in scope can help absorb cost increases. Prioritizing other sources of wood products that are available without markup, such as salvaged lumber, can also save on costs. As detailed in the Lakeline Learning Center case study below, this can also provide warmth and character to a building. The Lakeline project team utilized salvaged wood for wainscoting, which resulted in a beautiful tonal quality that has also proved very durable. The wood is very easy to maintain and repair with simple sanding, an important quality in this building that hosts many young children and various community activities.

BARRIERS + SOLUTIONS

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

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. Additionally, external parties can sometimes be resistant to ambitious healthy materials goals in affordable housing. If there is a



perception that these materials cost more, even when they do not, some consultants, regulators, or involved parties will pressure the developer to use the same materials that have been used for many years in affordable housing.

SOCIAL SOLUTIONS

To overcome this barrier, it is important to provide sufficient education to the project team and facilities operators to ensure that 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.[59] Utilizing available tools and databases, such as the Red2Green Tool, will also help minimize soft costs.

It is important for all members of the project team to become advocates for the Materials requirements and to fully understand the health issues associated with the Red List. While these health issues are usually focused on future residents, they also affect factory line and construction workers who deal with products while they are most actively off-gassing or have the highest leachability potential. They also affect residents in the fenceline communities surrounding manufacturing sites, which are most often low-income communities. One project team member at Aeon, the developer of the Rose in Minneapolis, noted that during the punch-out and final installation of interior products on that building, the typical smells associated with a newly finished building were nearly absent. Avoiding the effects of materials that are immediately off-gassing is undoubtedly enormously beneficial to contractors, subcontractors, developers, and others who are regularly present on site during construction. As part of an integrated design process, it would be useful to spend some time educating all parties, but especially contractors and subcontractors, on the benefits of these materials goals. Advocacy in the community is also needed to explain the clear goals of the project and to help those that may be stuck in the business-as-usual mode understand the need for transformation and that it may not be as difficult or costly as they anticipate.

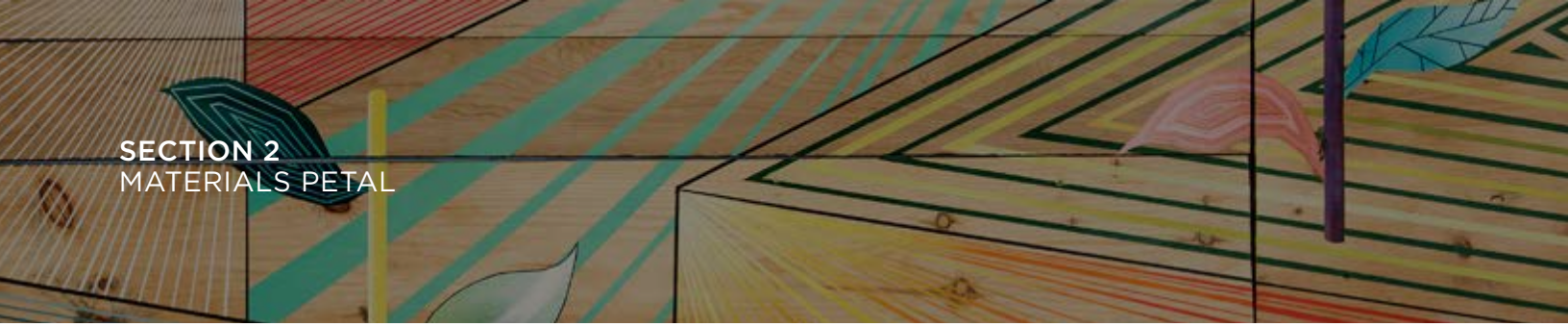
REGULATORY BARRIERS

The traditional design-bid-build process and requirements that force project teams to work with a low-bid contractor can be a significant impediment to achieving the Materials Petal. Since contractors involved in this contract type 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 increase profit. Additionally, contractors may be resistant to working with new suppliers that they have not developed a relationship with. They can tend to prefer their typical sourcing channels for predictability around pricing and availability, as well as to suit the preferences of their pool of subcontractors. This has been shown to be a particular issue for sourcing FSC wood. In some states, such as Minnesota, contractors are legally allowed to make substitutions if they can prove they are choosing a more durable selection.

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 project team of subcontractors up to speed with the goals of LBC and the project. There are many construction contracting methods that allow the contractor to participate early in the design process. Additionally, it is important to include the materials requirements language in the competitive bidding process and to ensure that specifications and contractual requirements are written to minimize substitutions. This is usually accomplished by either requiring a specific material with no substitutions or requiring that a material meet specific performance requirements (such as Living Building Challenge Materials Petal, Red List, FSC, etc.). Some project teams have also found it helpful to indicate that if substitutions are made, it will be the responsibility of the substituting subcontractor to vet the new material for compliance with Materials Petal requirements. Because many subcontractors will not want to take on this additional responsibility, this deters substitutions.

59 International Living Future Institute, https://living-future.org/lbc/resources/#technical-assistance



FINANCIAL BARRIERS

While it is often assumed that the Materials Petal will require an increase in material hard costs, it is the experience of some project teams that while the research does take more time and effort, hard costs are not increased. At least one affordable housing project, Muldoon Garden, was able to integrate healthy materials with no added cost overruns to the project, suggesting that it is possible to avoid hard cost increases. While replacing certain materials common to affordable housing (such as those listed above) do involve additional costs, many other compliant materials are not more expensive than their alternatives. The most significant expense will be to fund either a dedicated materials consultant or to account for additional research time from the project team.

FINANCIAL SOLUTIONS

The Institute now has a growing list of project-team-vetted materials gleaned from past certified projects. An updated list specific to affordable housing is also in development that will be published publicly by the end of 2019. Overall advocacy from larger developers, owners, and organizations in the affordable housing sector is helping to quickly change the marketplace because when more compliant products are available, less research is required to find them. The Institute is currently working with Enterprise on an update to their Green Communities standard. Continued alignment with groups such as this will help to push the market forward much more rapidly. Appendix E contains a template letter that any affordable housing developer or project team member 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.

New products are constantly being developed to become more cost effective and avoid price premiums. In the meantime, it is helpful to reach out to manufacturers directly to ask for discounts and donations for affordable housing projects, particularly those built by nonprofit developers. As demonstrated in the Othello Square case study below, manufacturers that are on the leading edge of sustainability and equity, such as those within Declare and the Living Product Challenge, may be more willing to assist a Living Building Challenge–certified affordable housing project than initially assumed.

Additionally, engaging with groups that are actively pushing for healthier materials can provide insights and help with pricing issues. These groups can be particularly beneficial for smaller projects that are purchasing lower volumes of materials. By combining purchasing power with additional projects, project teams can then gain leverage to push for more advantageous pricing based on a higher volume purchase. To aid in this process and to help ensure that healthy materials are available at competitive costs to all affordable housing developers, the Institute is partnering with the Housing Partnership Network in expanding materials available in their HPN Select tool.

A strategic purchasing alliance for nonprofit multifamily housing developers and an affiliate of the Housing Partnership Network (HPN), HPN Select is committed to helping create healthier, more sustainable communities. Leveraging the power of collective purchasing, HPN Select helps builders and operators of multi-unit residential housing maximize the value they get from their suppliers.

The EcoGuide is a primer to help HPN Select members understand and compare the health impacts of the materials they source and use. Offering educational content and a shopping guide, EcoGuide takes the guesswork out of members' procurement processes. By making it easier to source the healthiest products at the best possible price, HPN Select and EcoGuide help our members deliver better living environments to the residents they serve.

HPN Select is pleased to partner with ILFI as it works toward our shared vision for a greener, more accessible affordable housing market.

Richard Kingston, VP Sustainability, HPN Select

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 with benefit to a project's local community. Pioneering Living Building projects across the world have already begun to make significant inroads in the market. Public Living Building Challenge materials lists, as noted in the Materials Resource section, 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.

Furthermore, within the affordable housing industry, one key project could change the way the industry approaches materials selection and specification and dramatically lower the barriers to the adoption of the Materials Petal. While hard costs and soft costs may be increased in the short term, a pioneering project team could make a dramatic impact on this industry, ensuring healthy, safe homes for our communities' most vulnerable populations.

Owens Corning's EcoTouch™ Insulation, an Imperative Certified Living Product. Image courtesy of Owens Corning

CASE STUDIES
MATERIALS

"For this affordable equitable housing project, we have identified the most important value-add is to provide the homeowner with toxic-free materials. It is an important enough equity issue that I am willing to provide pro-bono services for the research and legwork needed to meet this important goal. Toxic-free materials, in the current market, are for people with means, resources and knowledge. How is that equitable? We need to put in extra efforts so that we can correct this problem one project at a time."

Gladys Ly-Au Young, Principal, Sundberg, Kennedy, Ly-Au Young Architects

OTHELLO SQUARE HOMEOWNERSHIP BUILDING

Homesight
Seattle, WA

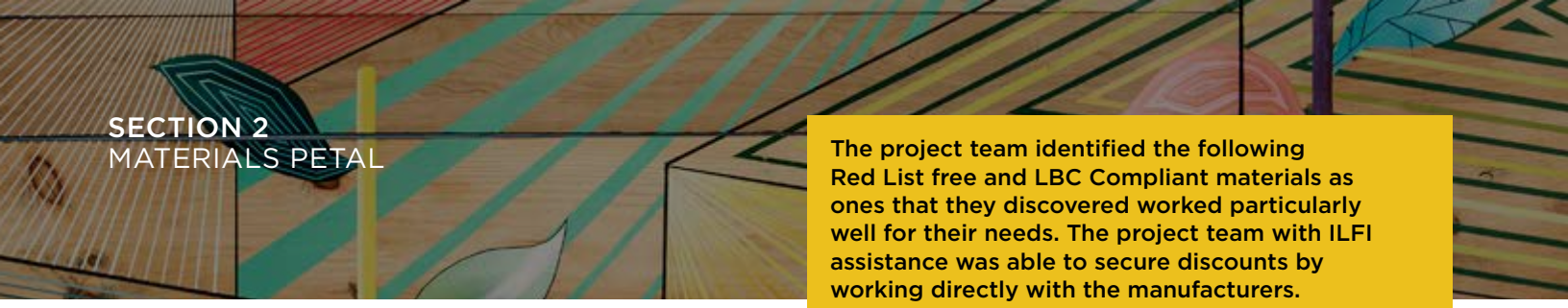
DESIGN APPROACH TO MATERIALS SELECTION

Othello Square developer, Homesight, and architect, Sundberg Kennedy Ly-Au Young Architects, see the need to integrate healthy materials into their affordable housing project as a social justice issue. Homesight is acutely sensitive to their obligations to the ethnically diverse community of Othello and views tackling Red List Free materials as part of their "unspoken contract" with the neighborhood and future residents. The low-income homeownership model of this project is intended to allow marginalized people to "control their destiny," which includes being able to stay in their own community (despite rapidly increasing housing prices), living in housing that is health-promoting, and being energy-independent through renewable energy—and thus able to spend their income on growing the economic health of their own families.

The architectural team approached the Materials Petal by first identifying the low-hanging fruit that could be easily integrated into the project with little or no additional effort or cost. The project team kept the materials palette simple to reduce the number of items to be vetted and to keep costs down. They next identified which materials would be most challenging in terms of either finding appropriate Red List Free or cost-efficient options.

The decreased or discounted cost of some products helped to offset the increased cost of others. In addition, in order to balance out cost premiums, the project architects strategically reduced scope in other areas of the project. All of these reductions in scope were in areas that have no impact on the quality of life for residents, but resulted in significant

Early conceptual rendering of Othello Square Homeownership Building identifying materials palette. Image courtesy of Sundberg Kennedy Ly-Au Young Architects



cost savings. The first move was to employ advanced framing to reduce the amount of wood needed overall. Because the project is located adjacent to a light rail station with direct access to downtown, as well as along a bustling commercial street with a plethora of shops, restaurants, and daily services within walking distance, the project team reduced the underground parking scope 20% from what was originally planned. The size of the ground floor storefront windows was also reduced, and the size of the windows in each unit was made slightly smaller. The project team opted for double-pane rather than triple-pane windows, without impacting energy goals. The team did add laminated glass to the bedroom windows to achieve a higher sound transmission class (STC) rating in these spaces. The architects predicted that the units located along Martin Luther King Jr Way S would be unlikely to utilize balconies due to the noise of traffic, light rail, and commercial activities along this street. They thus eliminated balconies on these units, but provided large communal sun decks that overlook the internal gardens and courtyard. The project team also chose to promote energy, health, and cost reduction goals at once by designing an attractive, vegetated stairwell with exterior views of the sundeck and gardens. In doing so, they chose to eliminate one of the elevators, thus saving cost, promoting active living, and saving energy use.

Because this project is one of the first affordable housing projects to seek Materials Petal Certification, it required the support of many partners. The architects provided pro bono materials research to the developer and were granted free access to the Red2Green Tool by Integrated Eco Strategies. The project team and the Institute sought out partners in the manufacturing industry that could help support the healthy materials goals of this project. The manufacturing industry responded with discounted pricing on a number of items. Most significantly, GAF agreed to donate their TPO roofing to the project. GAF has the first Declared and LBC-compliant roofing system, and this donation further reinforced the company's goals of promoting both sustainability and equity in the built environment. Sustainable Northwest Wood, Kohler, Milliken, Alpen High Performance Products, and Andersen Windows all offered discounts to the project to make their Red List goals attainable. GAF's Executive Director of Sustainability recommends that future affordable housing project teams with similar materials goals reach out to heads of sustainability within sustainability- and equity-minded product manufacturing organizations (such as members of the Institute's Living Product 50[60]) and explain the social and environmental aspirations of the project and let them translate that internally to others in the organization who are focused on brand equity.

The project team identified the following Red List free and LBC Compliant materials as ones that they discovered worked particularly well for their needs. The project team with ILFI assistance was able to secure discounts by working directly with the manufacturers.

- Galvalume metal siding (no paint)
- Sustainable NW Wood FSC cedar siding, framing lumber and plywood
- Renew Lumber FSC framing lumber and plywood
- Kohler plumbing fixtures
- PEX and cast iron pipes for waste
- Alpen fiberglass windows
- Andersen aluminum clad wood windows
- Kawneer storefront
- Sherwin Williams Fluropon metal paint
- Sherwin Williams; Promar 400 Zero VOC Interior Latex Primer
- Sanden CO2 Heat Pump Water Heater system (to keep the project fossil-fuel free)
- VP Industries FSC interior doors
- Sportworks bike rack
- Milliken carpet tiles
- Forbo Marmoleum flooring
- F-sorb acoustic tiles
- GAF TPO roofing
- FSC Wood Siding
  While the entire wood package had a premium, FSC wood siding actually presented a savings over the originally specified metal siding. This material cost between $2.90/SF and $8.90/SF, significantly cheaper than metal or fiber cement siding
  - 4" FSC-certified Douglas-fir (prefinished) = $2.90/sf (material)
  - 4" FSC-certified Western Red Cedar (prefinished) = $7.90/sf (material)
  - 6" FSC-certified Charred Cedar (prefinished) = $8.90/sf (material)

Items which carried a cost premium include:

- Fiberglass windows – 16% premium compared to vinyl
- FSC wood – up to 20% premium for certain wood items, mainly engineered wood
- Elevator
- Shower surround
- Plumbing fixtures
- Miscellaneous mechanical and electrical items

60 https://living-future.org/lp50/

BARRIERS + LESSONS LEARNED

The project team found that while grants and incentives were available for energy efficiency and renewable energy (for example, they received funding from the local utility for installing a heat pump hot water system), there are few such resources available for healthy materials. This indicates that an orchestrated advocacy effort is needed to encourage municipalities and funders to provide additional support and funding in this area.

Although cost has proven to be a barrier for specific items, many others did not actually carry a cost premium, and the project team was able to find cost-effective Red List materials with a little bit of time invested. However, the project team found that although a Red List Free or FSC product may have priced out on par with the target budget, that was not a guarantee that it would be implemented or even submitted for bid. With a very busy and tight construction market, smaller projects like this one struggle to receive competitive bids both from subcontractors and from manufacturers. In an environment where additional jobs are easily found, it was a struggle for the project team to ask subcontractors to deviate from their "business as usual" practices and vendors.

This experience reiterated that when trying to change ingrained processes, it is crucial that every single member of the project team is on board and understands their role in the outcome. Most importantly, the owner must be a leading force in pushing forward Red List Free materials and ensuring that the vision is not lost along the way. Perhaps second only to the owner and architect is the general contractor. The bidding and value engineering part of the project is a period when significant substitutions are made that can compromise the certification status and the healthy materials plan overall. The Othello Square project team recommends asking for additional pricing milestones so that decisions are made based on accurate cost information, and there is additional time to find products if the initial selections are not bid as expected. The owner included conventional materials as the baseline for bidding purposes (to ensure the project could ultimately be built no matter what), but also included a letter indicating that the owner has the intention to use the

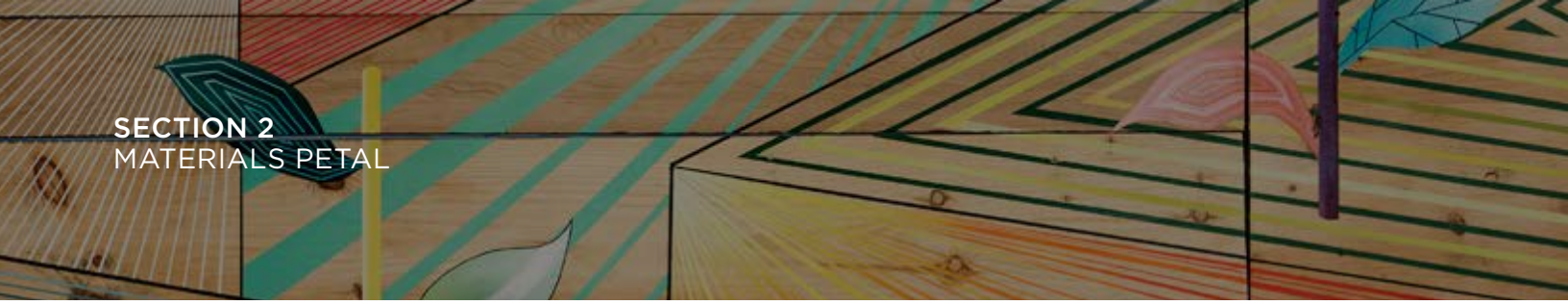
LBC-compliant alternates so that all parties receive the signal to ensure a competitive bid for both baseline and alternates. It is also imperative to involve the general contractor in any negotiated pricing or discounts promised by sustainability or equity champions from specific manufacturers so that subcontractors understand where to source materials.

Regarding overall vetting, the project team learned that tackling the highest-cost items first was the best strategy to get an idea of budget and how much scope may need to be modified in other areas to compensate, as well as to allow themselves more time to find alternatives or discounts. The project team found these resources to be most helpful in materials vetting: Declare database, ILFI's Certified Projects Materials List, Materials Petal Handbook, Red2Green Tool, Bullitt Center As-Built Product List, and Healthy Building Network's HomeFree resource.

Rendering showing the sun decks. This ingenious strategy by the architectural team avoided the extra cost of building individual balconies that would not be used because of traffic and street noise below and insteading providing larger and more pleasant communal decks overlooking the landscaped courtyard. This reduction in scope allowed them to focus on other priorities, including healthy materials. Image courtesy of Sundberg Kennedy Ly-Au Young Architects

CONCLUSION

Othello Square will receive final bidding by the beginning of August 2019. At that time, it will be more clear whether the project team will fully achieve Materials Petal Certification. Whether or not they fully achieve Materials Petal, this project has achieved much in pushing the needle forward on healthy materials in affordable housing. It is clear that even if a few materials cannot fit in the budget, there were many successes and a large portion of materials on the exterior and interior will be Red List Free, resulting in a far healthier living environment for future residents. The project will also contribute to a master list of materials that ILFI will keep continuously updated to make the vetting process simpler and quicker for other affordable housing project teams.



LAKELINE LEARNING CENTER

Foundation Communities
Austin, TX

DESIGN APPROACH TO MATERIALS SELECTION

Foundation Communities has a long history of pushing the boundary on green building in the affordable housing industry. They have a strong belief in aligning green building and affordability for health, durability, and long-term financial solvency reasons. Engaging the entire project team early on in the process, the project was started with a goal of Living Certification. The project team carefully analyzed each Petal and Imperative for compliance and costs. A summary of the overall cost estimates for several Petals can be found in the chart below. The project created a decision rubric for value engineering that included these factors: health impact, educational potential, operation risk, replicability, systemic change potential, Petal achievement impact, and fiscal impact. Using these factors, the project team reasoned that certain exterior materials and some within the building envelope (EIFS, wall/roof insulation, waterproofing in roof, rainwater cisterns, and sealants in fiberglass windows) would not have a significant impact on these factors. Not pursuing Red List Free options in these categories saved the project approximately $30,000. Similarly the project team decided not to pursue FSC framing lumber and cabinetry, with would have added $50,000 in cost. While the project did not ultimately achieve all the requirements of the Materials Petal, all interior materials are Red List Free, with the exception of windows and pipe shrouds. As with other projects, the project team strategized to reduce the overall materials palette by exposing structural materials and mechanical systems. A list of compliant materials that were used in the project, a list of materials which were not, and an example of costs can be found below.

BARRIERS AND LESSONS LEARNED

From this experience the developer, Foundation Communities has decided that they will always specify Red List Free carpet and/or linoleum (typically either Forbo Marmoleum or Armstrong Linoart). These materials are healthier, and any cost

The completed interior of Lakeline Learning Center. Nearly all materials shown here are Red List Free, excluding windows and a few minor exceptions. Photography by Casey Chapman Ross

differences for this upgrade from vinyl is negligible. Foundation Communities has also been pleased with durability and maintenance, feeling that any differences or issues do not warrant switching back to vinyl. The material itself does not cause issues, but it must be cleaned according to manufacturer's instructions, without bleach. Janitorial staff that are not educated on the needs of this product have created issues by using inappropriate cleaning products. While this does require a bit of training time, it is not an unsurmountable problem and can be solved by diligent education and training procedures. The only material that has not worked out for the project team is the porch screens, which ultimately needed to be upgraded to a higher gauge. The property manager felt that the screens being Red List Free was likely unrelated to the durability issues they faced.

CONCLUSION

Foundation Communities has been happy with the overall durability of the materials specified on the project and now begins new projects with the goal of implementing as many Red List Free products as their budget and research time will allow. While they have not yet embarked on another Living Building Challenge certification, they are open to pursuing Materials Petal or Zero Energy Certification on future projects.

The constrained development timeline that resulted from the timing of the awarding of LIHTC credits (which require projects to begin construction within a specified time frame) meant that the developer had multiple projects simultaneously in design, development, and construction. This ultimately meant that the project team had a limited capacity for materials research and needed to prioritize materials based on the likelihood of impacting resident health and the other factors mentioned in the decision rubric. The project team was also concerned about choosing materials that were likely to be replicable on future projects and did not rely on a one-time source of funding. This project, which was undertaken a few years ago, identified materials and strategies that could be easily used on future projects, such as linoleum, Red List Free carpet, and using salvaged wood for finish millwork. Each affordable housing project that provides insight like this becomes an important part of solving the puzzle of healthy materials for the affordable housing sector.

Notable LBC Compliant Materials:

- Salvaged 2x4 wood used for wainscoting
- Marmoleum flooring
- Daltile flooring
- Fiberglass windows
- Sherwin Williams Pro-Mar 200 paint
- Mohawk Carpet (donated)
- Stainless steel electrical boxes with exposed conduit
- Caesar stone lavatory surfaces
- Custom plywood cabinetry
- Metal roofing
- Cellulose fiber insulation
- NAUF millwork
- Cast iron or copper plumbing water and waste water lines (exposed)
- Concrete curb in foundation acting as baseboard

LBC Compliant Materials Not Used:

- Exterior rigid insulation - due to cost
- Exterior finishes (EIFS and Hardie Plank Siding) - due to cost and low priority
- Appliances – due to low priority and impact on human health
- Mechanical – due to low priority and impact on human health
- Miscellaneous small components – due to low priority and impact on human health
- Pipe insulation – due to oversight

The completed interior of Lakeline Learning Center. Nearly all materials shown here are Red List Free, excluding windows and a few minor exceptions. Photography by Casey Chapman Ross

MULDOON GARDENS

Rural Alaska Community Action Program (RurAL CAP)
Anchorage, AK

DESIGN APPROACH TO MATERIALS SELECTION

Architectural firm McCool Carlson Green has made a wholehearted commitment to Red List Free materials by purging their entire product library of materials that do not comply. They have taken the firm stance with vendors that they will not be welcome for informational lunch-and-learns unless their product is Declared or Red List Free. Their standard in-house specifications are now Red List Free as well. This upfront legwork and experience with the Materials Petal on other projects provided the project team with a distinct advantage and inspired them to take on the challenge of Materials Petal on an affordable housing project.

The initial plan for the project was to renovate an old Chinese restaurant, but once the site was more thoroughly investigated, it was discovered that this would not be feasible due widespread structural degradation and hazardous materials. The first materials challenge, therefore, involved demolishing the building and removing these dangerous materials. The design team was selected based on interest in pursuing this type of project. The philosophy for the project's sustainability goals was to make everything as simple and elegant as possible so that consultants would not feel they were being required to perform extra work. The architect felt that materials in particular have become overcomplicated and can be scaled back to what is essential, utilizing a natural and native palette. Vetting and materials research is a much easier task if it's only necessary to look into 100 products instead of 1,000. This reduction of the "shopping list" reduced the burden on all parties involved by streamlining the submittals, management, and budget. This pared-down aesthetic was also popular with owner RurAL Cap because of a perception throughout the local region that affordable housing projects were becoming too expensive and too fancy. Because the project team focused on including materials with a regional and familiar palette (including natural materials where possible), residents have also not minded the low-key aesthetic. The design team wrote the specifications prohibiting most substitutions allowed by contractors to avoid non-compliant products finding their way into the project.

Red List Free unit kitchen at Muldoon Garden. Image courtesy of Rural Alaska Community Action Program (RurAL CAP).

Challenging Materials to find due to either cost or availability:

- Vapor barriers (the only options were Prosoco or Vaproshield)
- Metal panel coatings
- Wood countertops

BARRIERS + LESSONS LEARNED

While the design team was selected based on interest in this type of project, the strict Living Building Challenge language during bidding and busy construction market reduced the of number of general contractors that bid on the project. However, the commitment of the chosen contractor to the project goals was an asset for the project during construction. The project was required to value engineer approximately $1 million from the budget, which resulted in the loss of several planned water reuse feature, eliminating the Water Petal from consideration. Ironically, due to the cost of the associated design and construction changes, this did not actually end up saving the project money. However, the project retained the goal of Materials Petal throughout value engineering and stayed on budget. The project team also did not face much tension with contractors trying to switch out vetted

products during pricing because it was already explicitly not allowed in the specifications and the contractors took the job with this understanding.

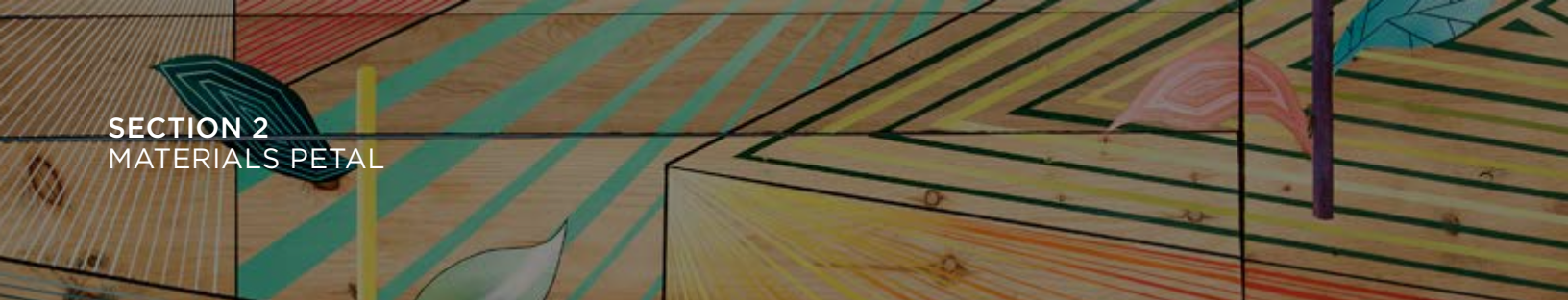
Due to value engineering, a few materials required last minute substitutions. For example, wood kitchen countertops were initially selected, but were later switched to plastic laminate, resulting in the design team needing to quickly research compliant options. They were luckily able to find an option (Phoenix) that was only slightly more expensive and able to be included. The architect found that avoiding materials that are sometimes problematic in other projects, including vinyl tile flooring and vinyl windows was not a cost problem, although the design team did need to work with the owner on adjusting to unfamiliar materials. As other teams have reported, cost premiums are not always the primary issue. Using outside-of-the-box materials can sometimes make owners nervous about performance issues. To date, there have been no reported performance or maintenance issues with any of the Red List Free products used on this project.

Red List Free unit bathroom at Muldoon Garden. Image courtesy of Rural Alaska Community Action Program (RurAL CAP).

The design team found that the subcontractors resisted bidding on FSC wood and were pushing for either removing this requirement or just bidding wood that was not FSC certified, even though the cost premium for FSC wood on this project was found to be only around 7%. The issue was not cost, but that it required subcontractors to work with new suppliers. In order to alleviate this point of tension, the architect limited the selection of wood. The exterior was an insulated structural panel system, rather than wood framing, common in many affordable housing projects.

CONCLUSION

This project is likely to become the first Materials Petal–certified Affordable Housing project, which would be a huge accomplishment that will help show a path forward for future projects. The design team strategy of being up front and strict about materials and Living Building Challenge requirements presents tradeoffs—on the one hand, it resulted in fewer contractors bidding on the project, which could become a significant budgetary issue in a tight construction market. However, the project team's success in avoiding substitutions is also attributable to this strategy. The project ended up coming in under budget (at $238/SF) and was a lower-cost project than another affordable housing project located just across the street that had none of the same sustainable and healthy achievements. The success of the project is also attributable to the architecture firm's due diligence and homework done on other projects. There can be a learning curve with vetting Red List Free materials. The second project is undoubtedly easier than the first. Having a whole product library of only compliant products makes the process that much easier. The work done by this project team and by other affordable housing projects choosing healthy materials will be aggregated and shared by the Institute (along with our current list of all other Materials certified projects and sample specifications). This will drastically reduce the learning curve on future projects. The Living Building Challenge goals on this project have brought a lot of attention to the developer and area. Muldoon Gardens was one of the first projects in the area to install PV panels—a significant statement in a place where oil is big business. Now many projects include PV panels. The project has also inspired other projects to pursue Red List Free materials.



Resources

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. **www2.buildinggreen.com**

The Declare Database
The Declare Database includes 800+ pre-vetted and transparent buildings products. Products listed in the database as Red List Free or LBC Compliant do not require any additional documentation or research for the Red List Imperative. Products with a status of "Declared" may not be used in Living Building projects without additional research showing there is not a better product available on the market. **living-future.org/declare**

Living Product Challenge
The Living Product Challenge (LPC) is a framework for manufacturers to create products that are healthy, inspirational, and give back to the environment. LPC Certified products are confirmed as Red List Free or LBC Compliant and all ingredient and environmental claims have been verified by a qualified third-party assessor. **living-future.org/lpc**

Red2Green
Red2Green is the premier healthy materials database with listings for products from 3000 manufacturers. Any project teams, including independent sustainability consultants, may access it using our online interactive software platform. R2G organizes your project's materials research and documents for auditors to get your project certified faster. **materiallybetter.com/h**

mindful MATERIALS
Mindful MATERIALS (mM) is a free platform with aggregated information on human health and environmental impacts for products from leading manufacturers, vetted by experts passionate about making it easier to make informed product choices. The mM database is a data hub that serves as a resource to product specifiers to locate product sustainability data in one location. mM includes Declare labels, Living Product Challenge Certified products, HPDs, EPDs, and other manufacturer-submitted product data. Please note, not all Declare labels are visible on mM, and project teams should still consult the Declare Database for the most up-to-date listing of Declare Red List Free and LBC Compliant products. **www.mindfulmaterials.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**

Healthy Product Declaration Public Repository
The HPD Public Repository has over 4500 published HPDs and was designed to assist project teams in product selection and specification work, as well as to compile documentation for specifications and certification submittals, streamlining the materials vetting process and reducing time and effort. Products with a fully disclosed HPD to 1000ppm or 100ppm meet the reporting requirements of the Red List Imperative. Additional time is required to vet the ingredients reported on the HPD against the Red List. **www.hpd-collaborative.org/hpd-public-repository/**

Ongoing ILFI Materials Petal Resources
Sample materials lists from project teams that have Materials Petal Certification, specifications resources, and up-to-date ongoing resources are available on the Institute's website and updated regularly. All LBC 3.0 (or higher) Certified projects and voluntary LBC 2.1 Certified projects (that have achieved the Materials Petal) have published their product lists. Project teams may use these lists to identify potential manufacturers but are still required to collect an ingredients list and vet each product. **living-future.org/lbc/resources/materials-guidanceht**

HPN Select
Housing Partnership Networks provides a platform for procuring products for affordable housing at a discounted rate. **hpnselect.com**

EQUITY

Supporting a Just, Equitable World

SECTION 2
EQUITY PETAL

PETAL INTRODUCTION

The intent of the Equity Petal is to elevate equity as a project goal, and to transform developments to foster a just and inclusive community that enables all people to participate, prosper, and reach their full potential.

The Equity Petal is synergistic with the goals of affordable housing developers to improve communities economically while ensuring that new development does not result in exclusion or gentrification. Equity is central to the mission of the Institute to lead a transformation toward a built environment that is socially just, culturally rich, and ecologically restorative. Reflecting ILFI's dedication to equity and belief that it must be focal to any sustainable project, both Imperatives within the Equity Petal are Core Imperatives, which means they are required by all projects pursuing certification under the Living Building Challenge. True sustainability can only be achieved if the movement embraces all sectors of humanity, no matter the background, income, age, class, or race.

The Equity Petal encourages inclusivity in the design and construction process and development that is universally accessible and beneficial to the larger community. Disturbing trends toward privatizing infrastructure, externalizing negative social and environmental impacts, and limiting access to nature, when combined with growing income equality, exacerbate polarizing attitudes of "us" vs. "them" and limit full participation in community life for all. Living Buildings should benefit the communities they are located in directly through the construction process and throughout the life of the building. Living Buildings should be universally accessible and beneficial. And Living Buildings should promote job creation and opportunities for groups that have been disadvantaged or excluded, as well as share the benefits of their amenities (such as public space and access to nature) with the community.

As with previous versions of the Living Building Challenge, projects are encouraged to directly support nonprofit organizations focused on equity and inclusion, including affordable housing providers, by donating 0.1% of the total project cost. Only by realizing that we are indeed all in this together can the greatest environmental and social problems be addressed.

EQUITY

CORE IMPERATIVE

17

UNIVERSAL ACCESS

The intent of this Imperative is to allow equitable access to, and protections from any negative impacts resulting from the development of, Living Building projects.

All projects must make all primary transportation, roads, and non-building infrastructure that are considered externally focused (e.g., plazas, seating, or park space) equally accessible 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.

Projects in transects L3-L6 (except single-family residences) must provide for and enhance the public realm through design measures and features that are accessible to all members of society, such as street furniture, public art, gardens, and benches.

All projects must safeguard access for those with physical disabilities through designs meeting either the principles of universal design (United States Access Board), the Americans with Disabilities Act (ADA), and the Architectural Barriers Act (ABA) Accessibility Guidelines, or international equivalent.

No project may block access to, nor diminish the quality of, fresh air, sunlight, and natural waterways for any member of society or adjacent developments. Projects must also appropriately address any noise audible to the public.

• Fresh Air: Projects must protect adjacent property from any noxious emissions that would compromise its ability to use natural ventilation. All operational emissions must be free of Red List items, persistent bioaccumulative toxicants, and known or suspect carcinogenic, mutagenic, and reprotoxic chemicals.

• Sunlight: Projects may not block sunlight to adjacent building façades and rooftops above a maximum height allotted for the transect. The project may not shade the roof of an adjacent development, unless the adjoining development was built to a lesser density than acceptable for the transect.

• Natural Waterways: Projects may not restrict access to the edge of any natural waterway, except where such access can be proven to be a hazard to public safety or would severely compromise the function of the project. No project may assume ownership of water contained in these bodies or compromise the quality of water that flows downstream. If the project's boundary is more than sixty meters long parallel to the edge of the waterway, it must incorporate and maintain an access path to the waterway from the most convenient public right-of-way.

Imperative I-17 Universal Access ensures that projects promote a public realm that is welcoming and vibrant and do not jeopardize the fresh air, sunlight, and natural resources that belong to the entire community. I-17 Universal Access requirements have not historically posed particular challenges

for affordable housing pilot projects. Occasionally, affordable housing developers wish to keep part of the site for internal use only because the areas are intended to be therapeutic or healing spaces for residents, or for safety reasons. This is an acceptable approach. In these cases, project teams should carefully design the site so that the programming needs of the project are served, while still allowing some areas of the project to serve as an amenity to the surrounding neighborhood.

EQUITY

CORE IMPERATIVE

18

INCLUSION

The intent of this Imperative is to help create stable, safe, and high-paying job opportunities for people in the local community, and to support local diverse businesses through hiring, purchasing, and workforce development practices.

All projects must have a Just label for at least two project team organizations that have an integral role in decisions during both design and construction phases, and an additional five organizations involved in the project must complete a self-assessment.

In addition, all projects must either:
Include diverse stakeholders from vulnerable or disadvantaged populations in the design, construction, and operations and maintenance phases at the following levels:

- 20% of design contract and/or construction contracts, and 10% of maintenance contracts must be with JUST organizations that meet required levels for Diversity category, or are registered Minority,[61] Woman,[62] or Disadvantaged[63] Business Enterprises (MWDBE) organizations, or international equivalent.
- Workforce development/training/community benefits agreements, registered apprentice programs, and similar programs are employed for 10% of the General Contractor's project contracts, and/or project maintenance contracts.

OR,
Donate 0.1% of total project cost to a regional, community-based nonprofit organization focused on equity and inclusion.

Imperative I-18 Inclusion is intended to help to ensure that diverse stakeholders are represented in the design and construction process and that new developments benefit communities through workforce development or community benefits agreements, or by supporting nonprofit, equity- and inclusion-focused organizations within a community.

This Imperative is aligned with the affordable housing community's desire to help form a just and equitable society and provides a framework for inclusivity in the development process to help realize this mission. While this Imperative is new within LBC 4.0, a number of affordable housing pilot project teams already incorporate the spirit of the Imperative

61 https://www.mwbe-enterprises.com/minority-business-enterprise-mbe-certification/
62 https://www.mwbe-enterprises.com/women-business-enterprise-wbe-certification/
63 https://www.mwbe-enterprises.com/disadvantaged-business-enterprise-dbe-certification/ and https://www.sba.gov/federal-contracting/contracting-assistance-programs/service-disabled-veteran-owned-small-businesses-program

into their everyday business practices, as shown in the case studies below. These organizations serve as inspiration and example for others.

JUST 2.0

The Just program was originally launched in 2014. In a short time, this program has received significant success and resulted in a meaningful impact across a number of industries. As of July 2019, there are 104 organizations with Just labels, ranging in size from three to 1,656 employees, representing industries such as architecture, engineering, construction, product manufacturing, and nonprofits. An additional 758 organizations are registered and in the process of completing the documentation process. A new version of the program, Just 2.0, was launched in May 2019 at the same time as LBC 4.0.

The Just Program is a voluntary disclosure tool for all organizations, including, but not limited to: for-profit businesses; nonprofits; government agencies; publicly traded companies; trade unions; educational institutions; cooperatives; and small businesses anywhere in the world. JUST is not a verification or certification program. JUST provides an innovative social justice transparency platform for organizations to disclose their policy statements on a number of human resource and community stewardship practices. The JUST Label is outlined by twenty-two specific social and equity indicators that are housed within the six general categories: diversity + inclusion, equity, employee health, employee benefit, stewardship, and purchasing. These categories and indicators provide a common framework and language for organizational comparison and benchmarking.

This sample Just label identifies the social justice measures met by a company and at which level (defined in the Just Manual 2.0), including those related to diversity and inclusion.

The Diversity category referenced in Imperative I-18 includes both ethnic and gender diversity and is included as a requirement to ensure that organizations reflect the diversity of the communities in which they are located. To meet the Imperative requirements, organizations need to meet fulfill level-one requirements under Gender Diversity or Ethnic Diversity in Just 1.0 or level-two requirements under Gender Diversity or Ethnic Diversity in Just 2.0.

"Sundberg Kennedy Ly-Au Young Architects serves a wide variety of community-based, mission-driven clients, helping them design projects that are engaging, dignified, and environmentally responsible. From creating affordable housing to building schools, we work to create light-filled, joyful places on limited budgets, with the ultimate goal of successfully reflecting each organization's mission. In this context, our firm's engagement with the JUST program makes perfect sense. As a transparency platform that describes how we interact with our community and employees, JUST gives us the opportunity to align our practice with our principles, and to share our progress with clients. We say we want a socially just firm; therefore, we need a way to measure how we are socially just. This is how JUST can help us keep track of where we are, so we know how to make improvements. There is no growth in complacency, and as a firm, we will benefit from a platform that is a living standard, continuously improving over time."

Gladys Ly-Au Young, Principal, Sundberg, Kennedy, Ly-Au Young Architects

CASE STUDIES
UNIVERSAL ACCESS

The goals of the JUST program are simple, yet profound:

1. To elevate the discussion around social justice in all organizations,
2. To create a common language and measurement framework for social justice issues,
3. To elevate the cause of those individuals and activists who lead on these issues,
4. To improve the Human Resources (HR) policies and practices of thousands of organizations worldwide,
5. To make life better for workers from all walks of life.

HUNTER'S VIEW PHASE III

John Stewart Company
San Francisco, CA

The Hunter's View Phase III project in San Francisco, CA, has taken on the requirements of this Imperative in a robust way. Community access to externally focused site areas can be presented at a number of scales, from simple benches and artwork for a zero-lot-line project, to more expansive areas, such as in the case of Hunter's View Phase III. Although the project owner will retain ownership of all site areas, a large portion of the site shall be dedicated to a publicly accessible park that will serve as a gathering place for the entire community. The park areas are described in detail in the Health + Happiness section of this document. Just as the greenspace promotes well-being for residents through access to nature, it extends these benefits further and benefits the entire community. A partnership with the San Francisco Public Library will result in a ground-floor library on site, with its main entrance fronting the park and its windows oriented to capture views of downtown San Francisco and the bay. These significant programming and design measures ensure that everyone in the community benefits from this development project.

The new park created as part of this development will be accessible to the community and serve as a social hub for the neighborhood. Rendering courtesy of David Baker Architects

CASE STUDIES
INCLUSION

OTHELLO SQUARE HOMEOWNERSHIP BUILDING

Homesight
Seattle, WA

Homesight, the Othello Square project developer, is committed to diversity across all areas of their work. As such, they worked to ensure that the project would provide employment opportunities for groups typically underrepresented in construction contracts. They also included an apprenticeship program in the project to provide long-lasting benefits for community members. The highlighted document outlines their vision statement, goals, and strategies for the Othello Square project. This document provides an example for how affordable housing teams can prioritize Inclusion in the design and construction process.

Category	Minimum	GOAL
Subcontractor Diversity		
Percentage of total contract dollars awarded to Women or Minority Business	15%	25%
Apprenticeship Participation		
Percentage of apprentice project hours for all project field labor	10%	15%
Hire Local		
General contractor and subcontractors will track and report the number of hours of employees from certain zip codes	15%	30%

FIGURE 23: Homesight's hiring parameters. Chart courtesy of Homesight.

OTHELLO SQUARE SOCIAL EQUITY DEVELOPMENT STATEMENT:

Minority and women businesses are significantly under-represented and have been underutilized on construction contracts. The purpose and intent of incorporating a social equity lens to Othello Square is to provide the maximum practicable opportunity for increased participation by minority and women owned and controlled businesses, as long as such businesses are underrepresented, and to ensure that Othello Square's contracting practices do not support discrimination in employment and services in the procurement of goods and services from the private sector. In line with Othello Square's mission to prevent displacement, celebrate diversity, and provide opportunities of employment and affordable housing, the social equity goals below will help us to achieve these objectives.

- Prioritize local workers living in economically disadvantaged neighborhoods, creating access to training and employment within the construction workforce.
- Support women and people of color to become part of the construction workforce, with direct access to construction contracts.
- Create a better work environment with safety protections, dispute resolution and a grievance process.
- Create an awareness of career path opportunities for residents of SE Seattle.

To support the Othello Square agreed values, the Othello Square partners commit to, in good faith, adhere to these WMBE objectives;

A. Contractors entering into agreements for the Othello Square Project shall actively solicit the employment of women and minority group members. Contractors shall actively solicit bids for subcontracts to qualified, available, and capable Women and minority businesses to perform commercially useful functions.

B. Contractors shall consider the grant of subcontracts to women and minority bidders on the basis of substantially equal proposals in the light most favorable to Women and Minority Businesses.

Social Equity Goals:

Each building's General Contractor must be able to exercise affirmative efforts to assure equality of employment and contracting opportunity, that may include, but are not limited to, employment goals for women and minorities and goals for subcontracting to Women and Minority Businesses. Any goals established under this agreement shall be reasonably achievable.

The local hire parameters are limited to King, Pierce, and Snohomish County with a strong emphasis to the following targeted zip codes 98118, 98108, 98178, 98106, 98126, and 98168.

Job Fair:

To facilitate the ability of women, minority and local hire employees and businesses to participate in job opportunities at Othello Square, the building Owners and Contractors shall host job fairs at a location in the Othello neighborhood prior to commencement of hiring.

Documentation:

Contractors shall furnish evidence of the Contractor's compliance with these requirements of women and minority employment and solicitation and will submit evidence of compliance consistent with the SHA Section 3 reporting requirements to the Othello Square Integration Manager.

Contractors shall provide records necessary to document: 1) Affirmative Efforts to employ women and minority group members; 2) Affirmative Efforts to subcontract with Women and Minority Businesses on Contracts; and 3) the Contractor's non-discrimination in the provision of goods and services consistent with the SHA Section 3 reporting requirements. Documentation will be created and distributed by HomeSight and should be submitted to the Othello Square Integration Manager.

*** "Affirmative Efforts" means documented reasonable attempts in good faith to contact and employ women and minorities and to contact and contract with Women and Minority Businesses.

*** "Women or Minority Business" means a business that is at least 51 percent owned by women and/or minority (including, but not limited to, African Americans, Native Americans, Asians, and Hispanics) group members.

TEXT COURTESY OF HOMESIGHT

THE PROJECTS AT MILL CREEK

Community Rebuilds
Moab, UT

Community Rebuilds, the developer of the Projects at Mill Creek, also operates on a business model that incorporates apprenticeship as a key element throughout all phases of their business. For example, they routinely employ AmeriCorps Vista program participants in their office, providing them with opportunities to run projects, learn about the design and development process, etc. As the program description document shows, Community Rebuilds also has a robust internship and apprenticeship program. The apprenticeship program thereby is holistic and allows for learning within all stages of development, from construction training to project management.

"Community Rebuilds utilizes low tech sustainable building methods to reduce the short term and long-term costs of our homes. We use simple architectural designs that reduce design costs and encourage replicability, incorporate healthy natural materials that are "dirt cheap"—materials such as mud and straw, and utilize recycled, salvaged and donated building materials wherever possible. Most importantly, affordability comes through our homeowners and volunteer building interns who compete the bulk of the construction labor and offset the construction costs."

Rikki Epperson, Acting Executive Director, Community Rebuilds

Community Rebuilds workers on a project. Image courtesy of Community Rebuilds

WE BUILD HOUSES... BUT WE BUILD BUILDERS, TOO!

Community Rebuilds
Internship & Apprenticeship
www.communityrebuilds.org
www.communityrebuilds.wordpress.com
150 S 200 E * Moab, Utah 84532
(435) 260-0501

Our mission is to build energy efficient housing, provide education on sustainability, and improve the housing conditions of the workforce through an affordable program.

Community Rebuilds operates in 5-month semesters in the areas we serve. We lead volunteers (that we refer to as student interns) through free workforce training in the construction of straw bale homes from foundation to finish. Our internship program is inclusive and open to anyone, and most of our volunteer student interns come with little to no building experience. We reserve a minimum of 50% of our intern slots for those who identify as female that are interested in breaking into the construction industry. Our interns are mentored and supervised by lead instructors/construction supervisors. Our training is free, and our program provides housing and a food stipend in exchange for the student interns labor and participation.

This training/labor exchange program offsets the construction costs for our affordable housing program.

Community Rebuilds hires serval graduates of our internship program each year as building apprentices. This apprenticeship provides an advanced educational opportunity for our alumni interested in becoming construction managers and/or supervisors in the larger field of construction. Apprentices are paired with a homeowner and lead instructor/supervisor for two semesters. The apprentice receives deeper mentoring on building, as well as focusing on leadership skills, teaching interns, ordering materials, coordinating sub-contractors, and overseeing construction budgets.

Many of our apprentices are hired back as assistant builders who ultimately become lead instructors.

Resources

JUST Manual 2.0
The JUST User Manual offers a comprehensive overview of the program and describes the application process. Organizations are encouraged to review the manual prior to registering for the program. Please note that the JUST User Manual is currently available in Version 1.0 and Version 2.0. JUST 1.0 will be phased out as of December 2019, and applications/renewals to this standard will no longer be accepted in 2020. Organizations that are new to JUST are highly encouraged to download JUST 2.0 and begin documenting or developing policies that address indicators in this standard.
http://go.pardot.com/l/464132/2019-03-25/ghpndr

National Minority Supplier Development Council
The National Minority Supplier Development Council advances business opportunities for certified minority business enterprises and connects them to corporate members. Membership through a local affiliate provides access to a list of 12,000 certified minority-owned businesses.
https://www.nmsdc.org/our-network/

Agencies, WBENC-Women's Business Enterprise National Council, NWBOC-National Women Business Owners Corporation, Regional Minority Supplier Development Councils of the NMSDC, California Public Utilities Commission (M/WBE Clearinghouse), and Small Business Administration's Small Disadvantaged Business & 8(a).
http://www.diversityinforesources.com/Products/ProductDetail/89

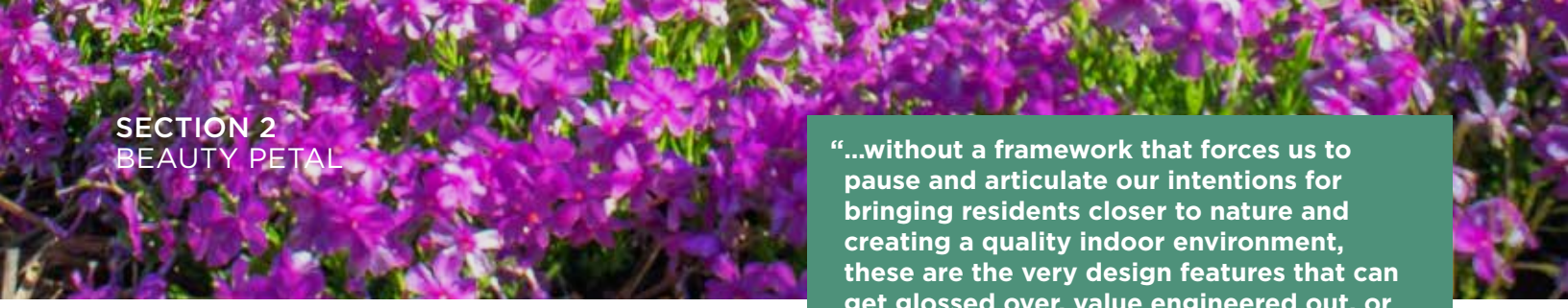
Americans with Disabilities Act
ADA.gov provides information, technical assistance, and design standards to comply with the Americans with Disabilities Act.
https://www.ada.gov/

The Kendeda Building for Innovative Sustainable Design, being completed at Georgia Tech, is utilizing salvaged 2x4s from local movie sets to fulfill the requirements of the Materials Petal. General contractor Skanska teamed up with GeorgiaWorks!, which trains chronically homeless men for jobs in the construction industry, to mill this wood, exceeding the requirements of the Equity Petal. One individual that worked on this project went on to be hired by Skanska and then recruited by a competitor, demonstrating the value of the skills learned on the project. Image courtesy of Skanksa USA.

BEAUTY

Celebrating Design that Uplifts the Human Spirit

Phipps Center for Sustainable Landscapes in Pittsburgh, PA—a Certified Living Building. Image: Paul G. Wiegman



"...without a framework that forces us to pause and articulate our intentions for bringing residents closer to nature and creating a quality indoor environment, these are the very design features that can get glossed over, value engineered out, or simply not receive an equivalent level of design thinking."

Katie Ackerly + Chelsea Johnson, David Baker Architects

PETAL INTRODUCTION

The intent of the Beauty Petal is to recognize the need for beauty and the connection to nature as a precursor to caring enough to preserve, conserve, and serve the greater good. As a society, we are often surrounded by inhumane physical environments. Embracing a biophilic design process emphasizes that people and nature are connected and the connection to place, climate, culture, and community are crucial to creating a beautiful building.

Mandating and assessing beauty is an impossible task—that's why beauty under the LBC is assessed by the efforts made by the project team to create a space that is culturally rich and that connects occupants to the historical and natural environment of their space. The intent of the Beauty Petal is closely aligned with the work that many affordable housing developers do every day to create welcoming and safe spaces for residents; this Petal simply provides a framework and set of strategies by which to measure and elevate this work. When done early and thoughtfully, the Beauty Petal is easily accomplished at no added cost.

BEAUTY

CORE IMPERATIVE

19

BEAUTY + BIOPHILIA

The intent of this Imperative is to connect project teams and occupants with the benefits of biophilia and incorporate meaningful biophilic design elements into the project.

Projects 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. The exploration must result in a biophilic framework and plan for the project that outlines strategy and implementation ideas for the following:

- How the project will be transformed by deliberately incorporating nature through Environmental Features, Light and Space, and Natural Shapes and Forms.
- How the project will be transformed by deliberately incorporating nature's patterns through Natural Patterns and Processes and Evolved Human–Nature Relationships.
- How the project will be uniquely connected to the place, climate, and culture through Place-Based Relationships. The project must meaningfully integrate public art and contain design features intended solely for human delight and the celebration of culture, spirit, and place appropriate to the project's function.

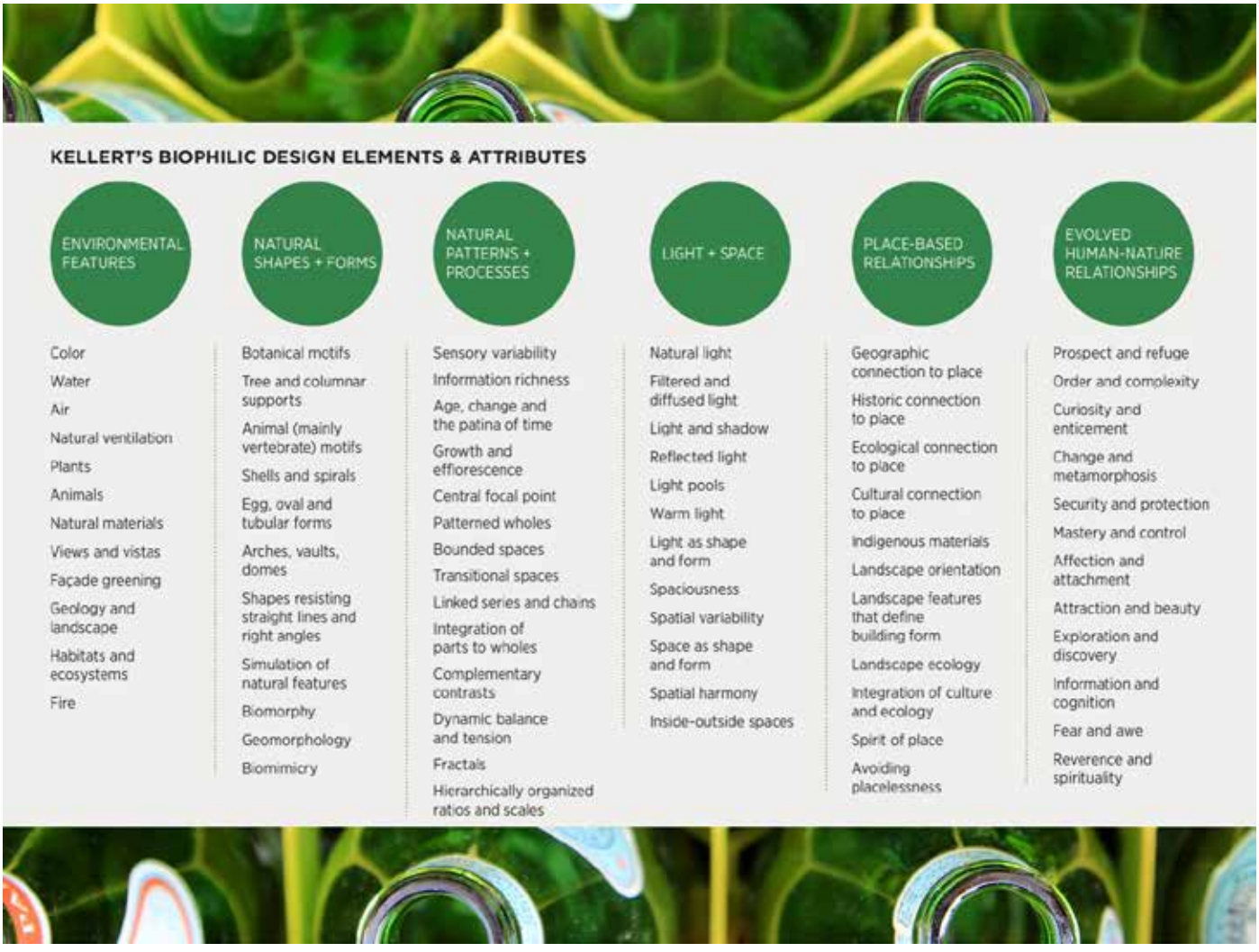
The framework should include a record of the exploration day and goals for the project, as well as historical, cultural, ecological, and climatic studies that thoroughly examine the site and context for the project. The plan must contain methods for tracking biophilia at each design phase to ensure sufficient implementation of the framework.

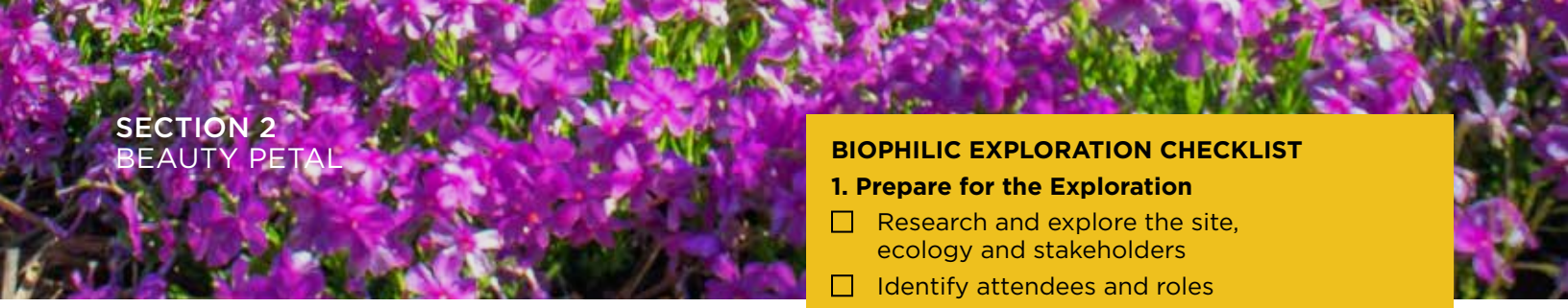
Imperative I-19 Beauty + Biophilia ensures that project teams embark on an intentional and thorough effort to integrate culturally, historically, and naturally significant elements into the design of their buildings. The main requirement of this Imperative directs project teams to host an eight-hour Biophilic Design charrette, which brings designers, engineers, occupants, naturalists and/or biologists, local community groups, and other stakeholders together to explore the ways biophilic design can influence the design and construction process and the design of the building.

"Biophilia" is a term coined by E.O. Wilson that means "love of life." It refers to the innate, genetically determined affiliation of human beings to nature and other living organisms. The concept originates out of the understanding that more than 99% of human evolution has occurred in nature and in direct response to natural, not human-created, forces. A healthy connection to nature is critical to our physical, and mental health and well-being.

The design of the built environment in modern times has resulted in an increasing disconnection of people and nature. Biophilic design, as conceived by the late Dr. Stephen R. Kellert, is the practice of connecting people and nature within our built environments and communities. Dr. Kellert developed a framework of elements and attributes in an effort to articulate and

FIGURE 24: Stephen Kellert's biophilic design elements + attributes.





apply biophilic design principles for the design of the built environment. There are six broad categories, known as elements or experiences. Within each is a list of attributes that could be applied to the design. It is not necessary to apply all of the attributes to a project, but rather through a study of the ecology, culture, and history of the site and the community to understand which elements and attributes are most important and applicable to the particular project. With this understanding, the diverse group of project team members can explore ways both big and small for these attributes to inform the design and construction process.

The requirement is to hold a one-day, eight-hour biophilic design charrette. The Institute has issued an exception that allows project teams to hold two four-hour charrettes if needed. Either way, the charrette needs to include diverse stakeholders, be focused on biophilic design, and result in the creation of a framework and plan for the project to follow throughout the design and construction process. As such, it is critical this charrette happens early so that it can truly inform the siting and design of the building. The idea is the use the framework and plan as a way to record the project's biophilic design goals and track the progress toward implementing appropriate strategies. These documents can also track necessary changes to the strategies and incorporation of new ideas and approaches. The goal is to ensure that biophilic design is thoughtfully considered throughout the process to maximize the health, wellness, and ecology benefits.

The Institute has seen a demonstrated need among the Living Building Challenge community for biophilic design resources that can take the practice from theory to reality. While progress has been made to communicate what biophilic design is and to demonstrate why it is crucial to a Living Future, less progress has been made around the process of how to achieve it. Thus, the Institute has brought together leading experts in the field to form an Advisory Task Force to lead a Biophilic Design initiative through collaboration and inclusion of existing resources. This Initiative aims to achieve the goal of broad adoption of biophilic design among the design community, building owners, and cities. A key first resource created by the Institute with the help of the Advisory Task Force is the Biophilic Design Guidebook (http://go.pardot.com/l/464132/2019-03-25/ghpnlf). It includes guidance for running an effective biophilic design charrette and creating the resultant framework and plan. The steps listed below represent a recommended approach to planning and executing a biophilic design exploration/charrette for a project, including information that is specific to Imperative 19. Detailed descriptions and recommendations for each step are provided within the Guidebook.

BIOPHILIC EXPLORATION CHECKLIST

1. Prepare for the Exploration

- ☐ Research and explore the site, ecology and stakeholders
- ☐ Identify attendees and roles
- ☐ Design exercises
- ☐ Determine homework
- ☐ Create agenda

2. Hold Exploration

- ☐ Facilitate introductions
- ☐ Agree on goals
- ☐ Complete initial exercise
- ☐ Explore context
- ☐ Investigate biophilic design
- ☐ Incorporate exercises
- ☐ Brainstorming ideas
- ☐ Integrate biophilic design
- ☐ Outline next steps

3. Develop Key Documents

- ☐ Document the exploration
- ☐ Write up framework
- ☐ Write up plan

Incorporated into the requirements for biophilic design is also the requirement to "meaningfully integrate public art and contain design features intended solely for human delight and the celebration of culture, spirit, and place appropriate to the project's function." While these art and design features may be inspired by the biophilic elements and attributes, they also may explore other directions relevant to the residents and communities. There are many different ways to fulfill this requirement, and part of the challenge and the fun is finding the ways that are most meaningful and "delightful" to the residents and users of the buildings. The age, family composition, background, and culture of the group may provide inspiration. Some projects have

developed community art projects that residents and their families can participate in, like a mural or mosaic, that adds color and beauty and also a sense of ownership and belonging. Some projects work with local artists to develop and incorporate art that reflects the broader community and its culture and history into the landscape and building design. Some projects consider smaller elements like handcrafted drawer pulls or stair railings that turn a functional item into a work of art that makes people stop and smile when they use it.

These requirements are not typically challenging to meet on affordable housing projects due to mission alignment and typical project goals. Regardless, project teams are encouraged to think outside the box and to deeply explore the possibilities for elevating any efforts in a way that truly lifts the human spirit and creates engagement, delight, pride, connection, and community.

Etsy employees working at the company headquarters, a Petal certified Living Building. Image: Emily Andrews

BEAUTY

CORE IMPERATIVE

20

EDUCATION + INSPIRATION

The intent of this Imperative is to provide educational materials about the operation and performance of the project to the occupants and the public in order to share successful solutions and catalyze broader change.

All projects must provide:

- A Living Building Challenge Case Study.
- An annual open day for the public.
- A copy of the Operations and Maintenance Manual.

All projects (except single-family residential) must:

- Provide a simple brochure describing the design and environmental features of the project.
- Install interpretive signage that teaches visitors and occupants about the project.
- Develop and share an educational website about the project.
- Include one Living Future Accredited Professional on the project team.

Imperative 20 recognizes the power of each new Living Building to be the pebble sending ripples through a pond. More often than not, the reason a Living Building comes into existence is because a member of the project team visited another Living Building and was inspired by what is possible. Within affordable housing, this is even more significant, as each building will help pave the way for the whole sector. With this in mind, Imperative 20 sets out a series of informational and educational requirements. These requirements are designed to inform and inspire the next round of Living Buildings by allowing visitors to learn from an in-person or virtual visit to the project.

Though most of the requirements are public-facing (an annual open house, a Living Building Challenge Case Study for display on the ILFI website), others such as the operations and maintenance manual and interpretive signage within the building can be used for staff education as well as tenant education and behavior change. Some projects have opted to "gamify" efficiency and conservation, so that tenants can see their energy and water use and compare it to other residents. Additionally, for projects that collect rainwater and/or produce solar energy on site, displays in common areas can be used to show occupants the amount of resources they have available, which may result in adjusted resource use. Some projects also see genuine comfort and pride arise in residents who know that their home is contributing positively to their family's and community's health and well-being.

While the list of requirements above may seem prescriptive, project teams are encouraged to consider what methods will work best to educate and inspire the residents and others. This Imperative should not require any additional cost, and should be seen as an opportunity to tell the story of the project team's accomplishments.

CASE STUDIES
BIOPHILIC DESIGN

THE PROJECTS AT MILL CREEK

Community Rebuilds
Moab, UT

The mission of Community Rebuilds is to build energy-efficient housing, provide education on sustainability, and improve the workforce housing conditions through an affordable program. For the Projects at Mill Creek—their first affordable housing project to pursue Living Certification—they partnered with Architectural Nexus, Inc. to integrate regenerative design concepts and increase their social enterprise in Moab and surrounding areas.

The project team researched the context of the site over the course of 2018, producing a monthly wind rose chart, massing insolation studies, shade studies, analysis of community composition and needs, and native and indigenous building traditions in preparation for their October 2018 biophilic design charrette.

The charrette brought together members of the core project team (including members of Community Rebuilds' apprenticeship program), along with water and solar consultants, plumbers, electricians, academics, and members of local government. Together, they reviewed the history and natural patterns of the site, and defined the lens of biophilic design as it relates to the project vision and

Community Rebuilds board members, interns, and the lead builder, Mark Buehrer of 2020 Engineering, discuss biophilic design elements for the Projects at Mill Creek during the Biophilic Design Exploration that took place at Utah State University's Moab campus. Image courtesy of Community Rebuilds

A truth window beautifully crafted by Community Rebuilds workers to reveal the inner component of the building, particularly the straw bale construction. Image courtesy of Community Rebuilds.

background. After reviewing the basics of the Living Building Challenge, attendees visited the site, and then broke out into smaller groups to generate biophilic design approaches to achieving the requirements of the various Petals.

As a result of their preparation and diverse participant list, the project team ended the charrette with pages of design strategies to explore. These included earthen floors, wildlife patterns on and around the site, using sun spaces to create warmth, emulating canyons to direct and mitigate sound, using metal roofs to magnify the biophilic sound of rain, truth windows to showcase the straw bale construction, utilizing naturally colored plaster and other moldable materials evocative of the surrounding bluffs, and embedding communal activity into the homes. Now that the exploration is complete, the project team plans to track and compile achievements, progress, and changes during all the following phases: schematic design review, design development review, construction documentation review, the first half of construction, following construction but prior to occupancy, and post-occupancy.

Through this exploration, the project team was able to create early collaboration and buy-in from stakeholders, address some of the barriers they faced (noise from bordering roads, excess heat penetration, collecting seasonal rainfall), design a space that connects their occupants to nature, and meets the requirements of Imperative 19. They found it an incredibly worthwhile and fruitful experience at minimal extra cost.

BLOCK PROJECT

Facing Homelessness
Seattle, WA

Given their focus on occupant dignity and community building, participating in a Biophilic Design Exploration was an obvious choice for BLOCK Architects. Their charrette, facilitated by the Institute in January of 2019, brought together representatives from all aspects of the project team, along with local government, volunteers, BLOCK Home residents, and community members. The charrette started with a deep exploration of the region, including discussion of some of the big problems, such as stormwater runoff, combined sewer overflows, urban heat island effects, wildfires, and massive population increases. There was also an introduction to the history of Seattle, highlighting the various ways that historic and modern institutionalized racism have impacted the local homelessness crisis.

As with the Projects at Mill Creek, attendees at the BLOCK Project charrette generated a wide array of potential strategies for the integration of biophilic design. These ranged from using BLOCK homes as garden nurseries for native plants, weather stations, or community hubs in case of natural disaster, to including guest books for those that have visited or participated in the building process. There were some simple ideas about design elements to elicit joy and connection, including tiled walkways in which each tile was made by a different community member, a sculpture which doubles as a bird feeder, fragrant plants, and a "catio" for residents to keep a treasured pet.

In addition to a deep commitment to incorporating meaningful biophilic design elements into the homes, the project team is also committed to education and community engagement. In order to meet the requirements of Imperative 20, the project team is committed to hosting move-in celebrations for the whole community to commemorate each BLOCK Project's opening. Additionally, they aspire for these buildings to act as learning centers for the community to experience off-grid systems and Living Buildings. They are in the process of developing a plan to fully leverage the learning opportunities presented by these buildings while balancing the rights of the occupants to privacy and security.

Members of the community and design team discuss how biophilic design will be incorporated into the tiny houses of the BLOCK Project. Images courtesy of BLOCK Architects and Facing Homelessness.

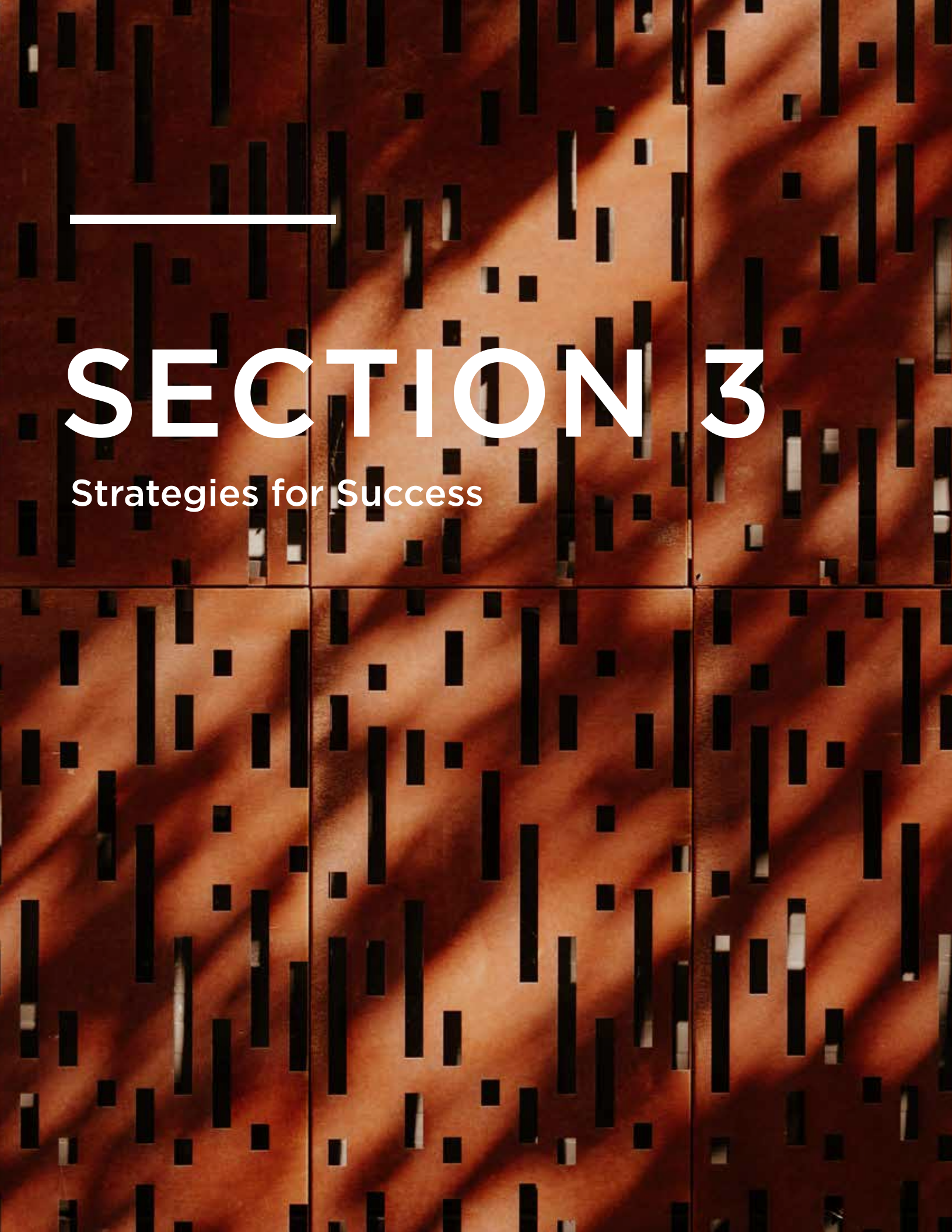
A key aspect of the education plan under development is engaging the resident as the expert. The idea is to empower the resident by having something to offer the surrounding neighbors and community. In nearly every location, the BLOCK Home is the most sustainable home in the area, offering a living lab for learning about regenerative design in the built environment. The resident, someone who was previously homeless, is the person most knowledgeable about the home because they live there and know how it works and how to operate it overtime. This process builds real pride and dignity from which a better life is built.

Resources

Biophilic Design Initiative
The International Living Future Institute has brought together leading experts in the field to form an Advisory Task Force that will lead the initiative through collaboration and inclusion of existing resources. This initiative aims to achieve the goal of broad adoption of biophilic design among the design community, building owners, and cities. Case studies and other biophilic design resources can be found on the Biophilic Design Initiative website.
living-future.org/biophilic-design

Biophilic Design Guidebook
This guidebook was developed to help Living Building Challenge project teams develop more biophilic projects and comply with the requirements and intent of this Imperative. The guidebook includes a general overview, as well as recommended topics, content, and tips.
go.pardot.com/l/464132/2019-03-25/ghpnlf

Creating Biophilic Buildings
Creating Biophilic Buildings, by Amanda Sturgeon, calls for an intentional biophilic design renaissance and provides a fresh, insightful place to begin exploring how to create places where people and nature can thrive together. Sturgeon shines contextual light on brilliant historical examples of biophilic design and goes on to present a carefully chosen selection of fourteen international buildings that illuminate both the process and the results. The clear examples, imagery, methodologies, and lessons from these case studies, combined with Sturgeon's practical tools and resources, are the reader's compelling starting point on the pathway to creating truly biophilic buildings.
living-future.org/product/creating-biophilic-buildings



SECTION 3

Strategies for Success

There are many steps in the process of planning, financing, designing and constructing an affordable housing project, especially one pursuing the Living Building Challenge. This section looks at four key steps – the integrated design process, education and support, financing, and materials selection - and identifies a few key strategies and/or programs that affordable housing pilot project teams have found helpful in their pursuit of Living Building Challenge certification.

INTEGRATED DESIGN PROCESS

Vital to the success of a Living Building Challenge project, integrated design demands that key project team members engage from early visioning on the project onward. This process is unlike the traditional design-bid-build scenario where the architect and consultants design the building and then hand off that design to the contractor to build.

A traditional design and build process postpones the contractor's involvement until it is time to bid and build. At this late stage—and with project timeline demands—healthy building materials, biophilic design attributes, and other key Living Building Challenge requirements can be sidelined by contractors that have little to no investment in the original Living Building Challenge goals.

An integrated design and build process sees key project team members—including the contractor and trades—learning about and committing to achieving the chosen Living Building Challenge certification pathway. This shared commitment to pursue the world's most impactful green building certification program then carries the team forward, together, and informs all future design, bid, and build decisions. An integrated design and build process allows for early materials research, the required biophilic design exploration, and a thoughtful, holistic approach to site analysis, architectural design, materials sourcing and engineering solutions. This approach honors, and capitalizes on, each team member's expertise. For example, while trade contractors may not have a deep knowledge of materials science, they will have specialized information about the availability of trade-specific building materials. And when Red List requirements demand substitutions for traditional building materials, the trade contractors will be the most knowledgeable team members to ensure these substitutions meet all performance criteria. An integrated design process plays to the strengths of each team member and provides team members ownership over the ultimate success of the project.

An integrated design process begins with project team education. This education includes background information on the "why" of sustainable design and how the Living Building Challenge provides the best pathways for the built environment to protect and nurture earth's biosphere and human communities. This introductory education should take place during site analysis and/or conceptual design and should be rapidly followed by both a Living Building Challenge workshop and the biophilic design exploration (for projects pursuing Petal or Living Certifications). Core project team members should participate in all workshops, explorations, and charrettes throughout the design, bid, and build process. The focus of the initial workshop will be to develop goals and workplans around each Petal and/or Imperative the project team intends to pursue. It is an opportunity for project team members to discuss the feasibility of achieving the Living Building Challenge within the inherent constraints of the project budget and timeline. Shared aspirational, yet realistic, goals prepare the project team for success.

During Conceptual and Schematic Design—and into Design Development and Construction Document phases—core project team members should work closely with consultants to identify and document compliant strategies for meeting all Imperative requirements. Living Building Challenge requirements should be included in the construction contract documents to ensure that the contractor is legally obligated to bid and install only compliant materials and to operate on site according to Living Building Challenge Imperatives. The most effective way to ensure success is to provide proprietary specifications where specific materials and equipment are identified by the integrated design and build team. Performance specifications should also be included in the construction documentation so that inevitable construction-phase substitutions and/or material additions meet Living Building Challenge requirements.

FIGURE 25: Traditional Design-Bid-Build process.

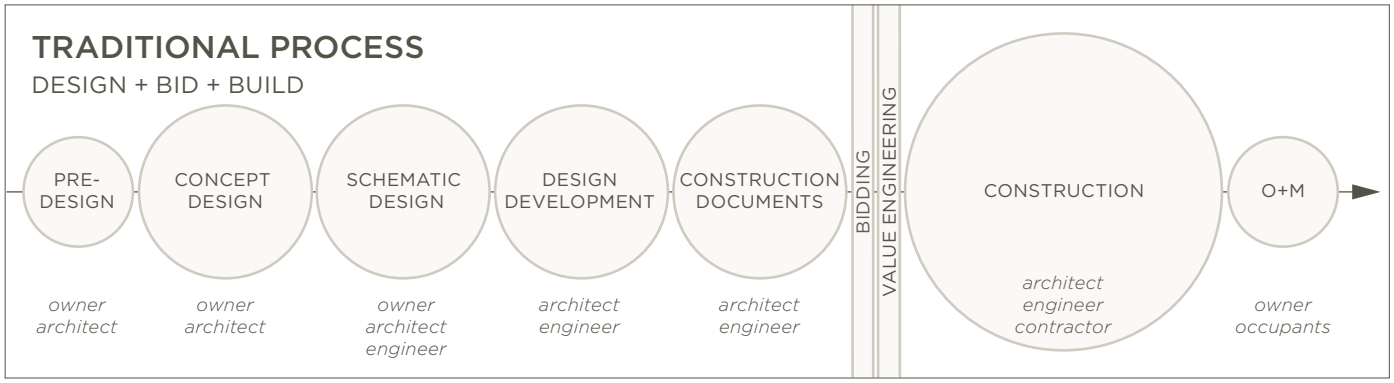
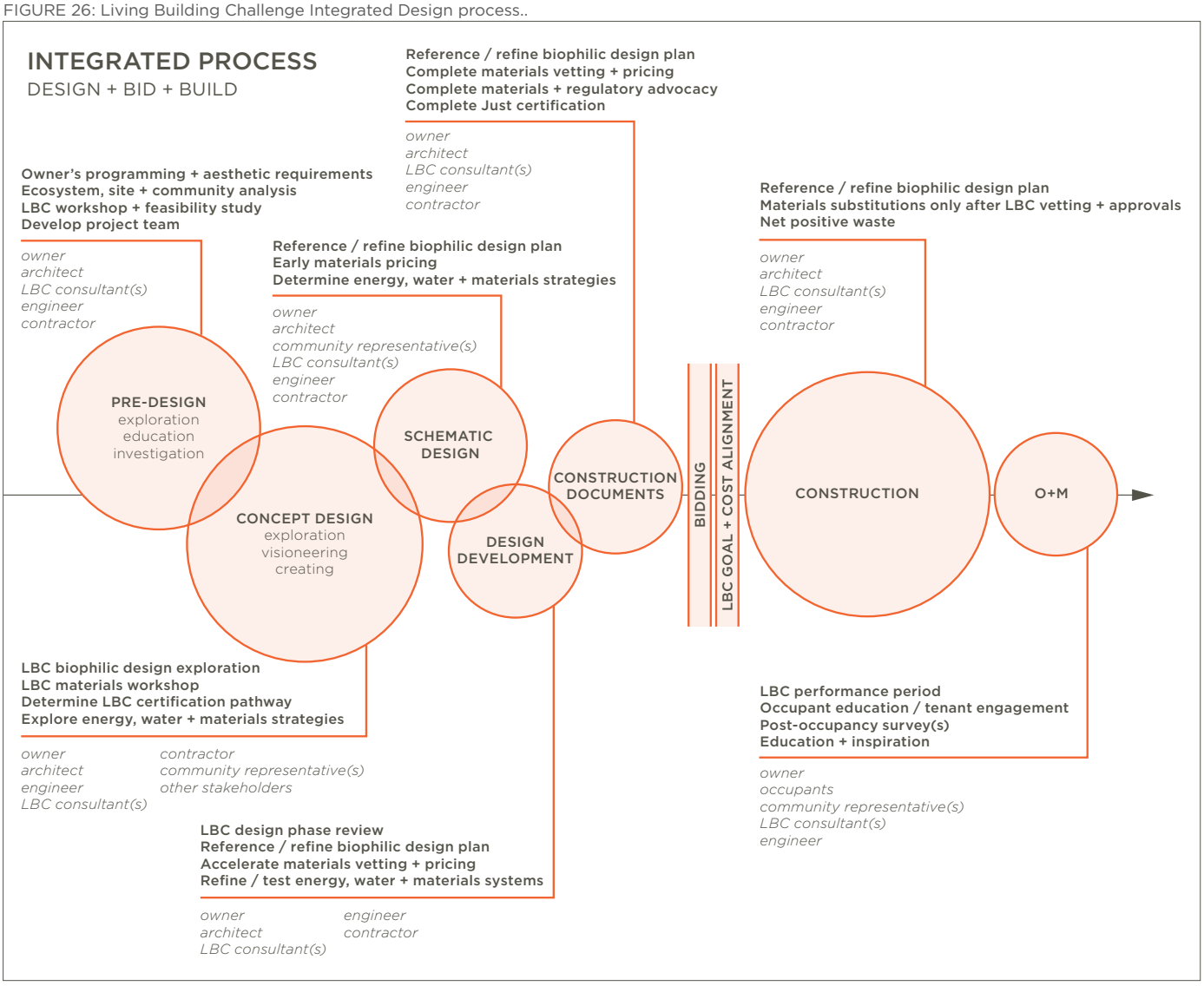


FIGURE 26: Living Building Challenge Integrated Design process..



"Having the LBC as a framework for setting the tone of team coordination was really refreshing and I think has contributed to a more collaborative workflow among team members. Very little of our discussions directly address LBC imperatives (the heavy lifting is really confined to a few relationships), but there is a sense that this project is different, or special in some way, and I think consultants generally feel invited to volunteer ideas they may not have on a conventional project, or get into a problem, like hot water system design, in a way they wouldn't on a typical project. It has fostered more openness with the client as well. We have devoted time during our weekly calls to do a deep-dive into each petal, and this has really made the LBC tangible and less scary to the client."

Katie Ackerly, Associate + Sustainability Lead, David Baker Architects

Living Building Challenge requirements should be included in the construction contract documents to ensure that the contractor is legally obligated to bid and install only compliant materials and to operate on site according to Living Building Challenge Imperatives. The most effective way to ensure success is to provide proprietary specifications where specific materials and equipment are identified by the integrated design and build team. Performance specifications should also be included in the construction documentation so that inevitable construction-phase substitutions and/or material additions meet Living Building Challenge requirements.

Prior to construction—and ideally a construction contract requirement—the general contractor should hold a workshop to educate trade contractors about the intent and requirements of the Living Building Challenge. Any change orders and/or substitution requests should be vetted for Living Building Challenge compliance by the general and/or trade contractors before they are sent to the design team and materials consultant for final approval. To realize Living Building Challenge success, it is recommended that the Construction Administration (CA) team include the architect, sustainability consultant, and project engineers.

Working together from the start of the project, building a shared vision and goals, following a collaborative process, making use of everyone's expertise and experience, integrated design ultimately saves time and money and helps ensure the best possible outcomes for the project and the participants. Some of the key differences between the integrated design process and a conventional design-bid-build process are illustrated in the accompanying diagrams. While design-bid-build is highlighted, it should be noted that Integrated Design can be applied to any contract/procurement model. The key is getting all core stakeholders involved early and ensuring engagement and collaboration throughout.

The Lakeline Learning Center project in Austin, Texas, provides an example of lessons learned when it comes to integrated design. While the project team employed an integrated design process, no input was sought from the on-site Learning Center Coordinator, who manages building operations. Although the building functions well in terms of programming, materials, and design, the Learning Center Coordinator has struggled to manage the on-site urban agriculture. Native plants on site have thrived, and residents often pick and eat blackberries and figs from the garden. However, the Coordinator does not have the expertise to manage other on-site crops that require more intense cultivation. Therefore, portions of the garden have thus far been unused. The project owner, Foundation Communities, will need to strategize going forward on how to optimize the potential of the urban agriculture, whether by replacing all species with low-maintenance native plantings or designing a program for residents and/or others to manage the garden. Foundation Communities shared with ILFI that this experience underlined for them the importance of engaging end-users early in an integrated design process.

EDUCATION AND SUPPORT

As mentioned above, integrated design begins with project team education. It is critical to success that project team members share a common understanding and language around the what, the why, and the how of the Living Building Challenge and how it aligns with the owner's mission and project's goals. While the process begins with education, learning does not end there. Learning opportunities are present throughout the process, as are opportunities to share information and educate others. Some of the learning will be formal, online, or in person, to ensure that everyone has the necessary information to proceed successfully. Much of the learning will be informal, with project team members sharing expertise and experience with each other throughout the project as they collaborate on the design and construction.

Many practitioners that have worked on Living Building Challenge projects speak to the joy of the process and the satisfaction of learning and being challenged to grow in their profession. One architect shared that it

"made design fun again." He shared that he knew how to design affordable housing, but the opportunity to design "Living" affordable housing reengaged him in the design process in fresh new ways and brought the spark back for why he became an architect to begin with. This type of engagement and passion brings life to the people, to the process, and the design – ultimately making for better projects and better homes for residents.

Education, specifically sharing information, is core to the Living Building Challenge with Imperative 20 – Education + Inspiration being required for all projects seeking Petal or Living Certification. The goal is to share solutions and lessons learned in order to catalyze broader change in the market. We are on this path toward a Living Future together. We can get further faster by working together and learning from each other. In all cases, and especially within the affordable housing sector, the Institute is committed to help with this collaboration and information sharing. Below are brief descriptions of some of the tools and support available to help affordable housing projects pursuing the Living Building Challenge.

RESOURCES

The Institute creates and maintains a robust library of resources to assist project teams pursuing the Living Building Challenge. In addition to this Framework itself, there are numerous guidance documents, design and tracking tools, research reports, materials lists, sample specifications, and case studies. Many of these resources have been referenced throughout this Framework in the appropriate sections. All of these resources are available on the Institute's website free of charge to all project teams. The only exceptions to this are the Living Building Challenge Petal Handbooks, which are free to Institute members and available for a modest fee to non-members.

EDUCATION

The Institute has a large and growing suite of educational offerings to assist project teams pursuing the Living Building Challenge or for people just interested in learning more. Education is available online and in person with several courses specially customized to affordable housing. The Institute is committed to education and information sharing and to providing venues to others to share this information.

Affordable Housing Courses Available:

- Introduction to Living Affordable Housing: Strategies and Benefits to Applying the Living Building Challenge
- The Living Building Challenge Framework for Affordable Housing
- Energy Equity and Resiliency in Affordable Housing
- Water, Health, and Independence in Affordable Housing
- Innovating the Materials Petal in Affordable Housing
- Engaging Residents In Affordable Housing
- Introduction for the Materials Petal for Affordable Housing
- Materials Vetting for Affordable Housing

Coming Soon:

- Introduction to the Energy Petal for Affordable Housing
- Green Financing

WORKSHOPS

In-person education can run from one-hour presentations to half-day, full-day, or multi-day workshops. These workshops provide overviews and insights into the Living Building Challenge, other ILFI programs, and/or in-depth explorations of key topic areas such as net positive water, healthy materials, or designing for zero energy. The Institute hosts workshops regularly across the country as stand-alone events and in conjunction with ILFI's conferences and other affordable housing and green building conferences.

WEBINARS

The Institute also hosts frequent webinars with Institute staff and outside experts on relevant topics such as financing options and tenant engagement. These are typically offered live so that attendees can ask questions in real time and then recorded so others can listen and learn at any time.

ON-LINE EDUCATION

The Institute hosts an online learning management library for on-demand education. This library includes courses on all of ILFI's programs, green building strategies, and numerous courses specifically

created for affordable housing teams. The Institute is continually adding new courses.

AFFORDABLE HOUSING SUMMITS

The Institute hosts Affordable Housing Summits at each of our main conferences each year - the Living Future unConference[64] and the Living Product Expo.[65] These summits are key opportunities for affordable housing practitioners to come together to dialogue, share, and work together to solve shared issues and celebrate successes.

CONFERENCE SESSIONS

The Institute also curates several affordable-housing themed presentations and provides Living Building Challenge office hours during these conferences—opportunities for project teams to have specific questions answered by Institute subject-area experts.

LIVING FUTURE ACCREDITATION

The Institute provides an opportunity for project team members to distinguish themselves as leaders in the regenerative design and build community by becoming Living Future Accredited (LFA). Those who have achieved LFA are recognized for their Living Building Challenge expertise worldwide. Under LBC 4.0 and Core Green Building Certification, it is required that project teams include at least one Living Future Accredited professional.

AFFORDABLE HOUSING COHORT

Since 2013, the Institute has been convening regular cohorts of affordable housing projects. The third cohort is currently underway through the summer of 2020. The purpose of these cohorts is to provide a forum for direct engagement between project teams working on the Living Building Challenge. Regular calls and meetings provide opportunities for cohort members to share successes, lessons learned, and resources and to ask questions of each other to help overcome barriers. These calls are also opportunities for the Institute to share new ideas and resources. Cohort members commit to helping each other be successful and to also allowing the Institute to share their stories and use their experiences to create valuable resources to help the larger affordable housing sector. While the cohorts have defined start and stop dates, the Institute continues to work with all cohort members past and present to help ensure the highest level of success on their project.

TECHNICAL SERVICES

The Institute also provides project-specific consulting services to affordable housing teams. These services include, but are not limited to, feasibility studies, customized workshops, materials reviews/sourcing assistance, design phase reviews, and biophilic design explorations. Thanks to generous foundation support, these services are provided at no cost to those affordable housing projects that are part of the Institute Affordable Housing Pilot Program. For others, they are available at modest fees. The Institute's technical services are not designed to replace sustainable building consultants. Instead, they are designed to build capacity and instill confidence in a project team as it pursues the Living Building Challenge certification. They help ensure a project team remains on the path to success during the design and construction process. Institute technical services are customized for each project team, and any modest cost is, typically, far outweighed by the value these services bring to the project. Affordable housing pilot project teams have regularly cited the Institute's technical support as critical to providing their team the best chance to realize Living Building Challenge certification.

GREEN FINANCING FOR AFFORDABLE HOUSING

Most affordable housing projects are financed through several sources. The process to pull together the funding is often long and complex with many sources of funding coming with specific requirements and constraints for how and when it is spent – putting additional pressure on the schedule for affordable housing projects. While Living Building Challenge projects often have lower operating and utility expenses, there can be additional first costs that need to be managed. For example, pursuing Net Positive Energy means installing a renewable energy system such as photovoltaics on the project. This will be an added line item and cost compared to a project not

64 https://unconference.living-future.org
65 https://productexpo.living-future.org

"The development of the Fifth Avenue Apartments via the Pilot Program was a series of small victories and is a demonstration of how the 'unbuilt version' can become an advocacy tool. We are using it as an exemplar to start a dialogue with the state housing authority and some of the incentive providers who are currently not recognizing the Living Building Challenge program in a meaningful way."

Susan King, Principal + Studio Leader: Housing + Education, Harvey Ellis Deveraux

pursuing the LBC or Zero Energy. While such systems typically pay for themselves in a few years, they still have to be funded with upfront dollars which may have constraints attached that might not allow those dollars to be spent on renewable energy. So how does an affordable housing developer build the maximum number of homes and achieve the Living Building Challenge on budget? This section describes some of the funding options successful projects have used.

STATE QUALIFIED ALLOCATION PLAN (QAP)

Many affordable housing projects receive a significant portion of their funding through individual state's qualified allocation process. Once or twice a year, state's housing finance agencies accept project applications for funding. Typically, the monies available are not sufficient to fund all the project's applying. To aid in the selection process, state agencies create lists of criteria with assigned point values. These lists have a significant influence on the kind of housing that gets built and the attributes that housing includes. They can be used to incentivize certain kinds of building. Many state agencies have added sustainability criteria to these lists in order to incentivize certain green attributes.

The Institute has partnered with several state housing finance agencies in order to integrate programs like LBC, Zero Energy, and Declare into their Qualified Allocation Plans (QAP). Project teams that pursue these programs receive additional points in their application for low income housing tax credits, increasing their chances of receiving critical funding.

The Institute recently advocated to eight states and one district for inclusion of ILFI's programs in state QAP programs, including Washington, California, Illinois, the District of Columbia, Alaska, Texas, Colorado, and Missouri. ILFI programs have been accepted into three QAPs as of the date of publication of this Framework: Washington, California, and the District of Columbia.

WASHINGTON

Project teams that achieve Zero Energy certification are awarded five points within Washington State's tax credit at the 4% level. Project teams are required to achieve a minimum of forty points to be eligible for the tax credit, so projects that pursue Zero Energy certification can check off almost 13% of their points.

CALIFORNIA

New Construction and Adaptive Reuse Projects receive five points if they commit to develop the project in accordance with the Living Building Challenge.

DISTRICT OF COLUMBIA

Five preference points will be awarded to projects that go beyond the minimum threshold Green Building Act requirements and commit to achieving Zero Energy or Living Building Challenge Certification. Any project claiming this preference must demonstrate the capacity and experience to achieve certification. Also, the architectural plans and project budgets (development and operating) submitted in the application must reflect the commitment to certification.

The Institute is continuing to work with state housing finance agencies around the country in order to reward project teams that pursue the Living Building Challenge and other ILFI programs with low income housing tax credits. If you would like us to do this work in your state, reach out to advocacy@living-future.org.

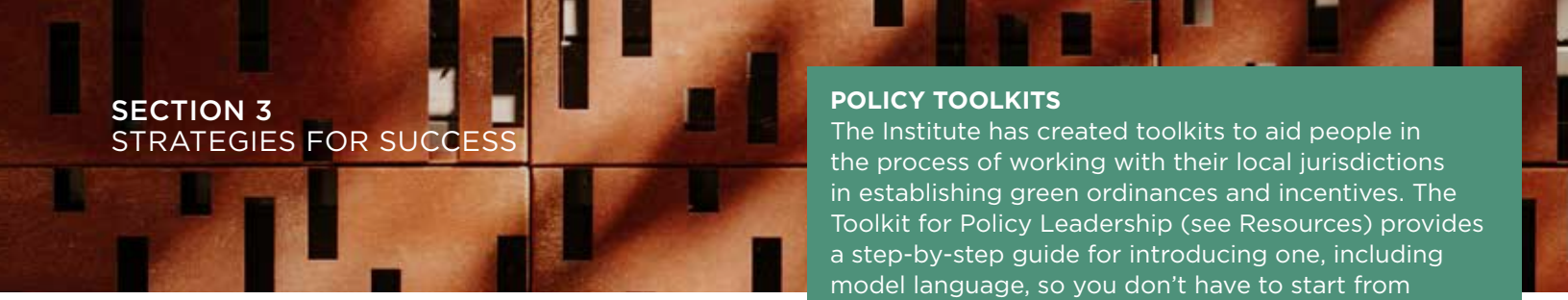
INDIANA – MOVING FORWARD PROGRAM

Since 2015, the Indiana Housing and Community Development Authority (IHCDA) has run an innovative program called Moving Forward,[66] utilizing tax credit allocation points to encourage net-zero affordable housing that aims to increase quality of life while also decreasing costs related to utility bills and transportation costs. The authority chooses several development teams with whom to work closely

"As part of the Moving Forward program, Broadway Lofts truly represents a step forward for affordable housing in Northwest Indiana. By incentivizing the design and construction of high-efficiency, net-zero energy affordable housing through a set-aside in the state tax credit allocation, Indiana is proving to themselves and neighboring states that this type of design is both possible and beneficial in our region."

Matthew McGrane, Farr Associates

66 https://www.in.gov/ihcda/movingforward.htm



toward these goals, and through a two-day-long charrette, identifies minimum and stretch goals for the project. Stretch goals for this year's process included Living Building Challenge Certification and/or replacement of all interior materials with Red List Free products.

LOCAL INCENTIVES

Many state and local governments as well as utilities have incentives available to encourage and fund sustainability features in buildings in new and existing buildings. These often include features like: weatherization of existing homes, energy efficiency and water efficiency upgrades, LED lighting, and photovoltaic arrays. Some incentives are cover hard costs and some cover soft costs. For example, Seattle City Light offers discounts on low-flow showerheads and high-efficiency lighting. Other incentives give developers departures from certain planning and land use codes which all them to increase their building height and square footage and ultimate revenue. Other incentives other reduced permitting fees, expedited permitting and/or marketing opportunities. No matter the form, all of these kinds of incentives help offset the first cost of designing and constructing Living Buildings. Project teams should contact their local planning departments, sustainability departments, and utilities to see if any such incentives already exist in your area.

The Institute is working with state and local agencies around the country to provide financial incentives for project teams taking on the Living Building Challenge. Most jurisdictions have set ambitious goals to combat climate change and public health concerns in their communities, and the Institute's suite of programs provides them with an existing framework for reaching these targets.

POLICY TOOLKITS

The Institute has created toolkits to aid people in the process of working with their local jurisdictions in establishing green ordinances and incentives. The Toolkit for Policy Leadership (see Resources) provides a step-by-step guide for introducing one, including model language, so you don't have to start from scratch.

WATER POLICY GUIDE

The Water Policy Guide is an advocacy resource focused on net positive water. We know from Living Building Challenge teams that water regulations make it difficult for projects to utilize resilient, integrated systems. Thanks to the generous support of The Kresge Foundation, this document includes our assessment of existing regulations in the United States, highlights current policy precedents and calls for three critical policy changes. We hope to continue this research across our global network to ensure that all water is used and re-used as a precious resource in all of our buildings and communities. See Resources at the end of this section.

A CLOSER LOOK: LIVING BUILDING PILOT PROGRAM: SEATTLE, WA

Seattle became the first city in the United States to incentivize the Living Building Challenge when it initiated the Living Building Pilot Program (LBPP). This program applies to existing and new construction projects that pursue the Living Building Challenge. The City provided this path in the Land Use Code to:

- Stimulate innovation
- Encourage models of high performance
- Identify barriers in codes and processes

In 2018, the City incorporated updates from the LBPP Technical Advisory Group (TAG) that met for over a year to recommend adjustments that maintain the rigor of the program while incentivizing Living Buildings. Incentives include: permitting assistance; design departures; a 15% increase in floor area ratio (FAR); and a height increase incorporating 10' in zones with height limits of 85' or less and 20' in zones with height limits greater than 85'.

Additional changes include updates to the two City requirements for projects that decide to pursue the Petal Certification pathway: energy use must be 75% or less of targets established in the energy code, and potable water cannot be used for non-potable uses. With the 2016 legislation, these incentives are now granted outright for developers participating in the LBPP which provides more certainty for project teams, in lieu of the previous system that allowed similar departures achieved through the design review process.

The 2018 adjustments to the LBPP are important to Seattle as a leader in green building and are critical in meeting the City's climate action goals. As construction skyrockets in Seattle, it is crucial that new and existing buildings adopt regenerative building practices, and the Living Building Pilot Program intends to further that.

The Bullitt Center was the first project to participate in Seattle's LBPP; building height departure was used, and the extra 10 feet of height was divided among each of the floors to increase structure height for better daylight penetration. Several projects being permitted (of varying size, both residential and commercial office) are participating in the LBPP. The City of Seattle is considering additional updates to the LBPP as the program continues to be refined.

FEDERAL RENEWABLE ENERGY TAX CREDIT

The federal government's Renewable Energy Tax Credit (RETC) program includes a variety of incentives to subsidize renewable energy technologies. The Investment Tax Credit (ITC) portions of this program provide a mechanism to help finance solar energy systems used to provide electricity or solar hot water. Depending on location, it's estimated that utilizing the ITC can help bring the payback for a photovoltaic array (PV) down from 12–15 years to 7–8 years.

The ITC was originally implemented under the Energy Policy Act of 2005. The program was renewed for one year in 2006 under the Tax Relief and Healthcare Act, and again in 2008 for eight years under the Emergency Economic Stabilization Act. In 2015, Congress renewed the credit under the Omnibus Appropriations Act, but included a ramping down of the provision, meaning that the tax credit will be 30% of the full cost until 2019, decrease to 26% in 2020, 22% in 2021, and 10% in 2022, at which point only commercial construction will qualify.

Unlike the Low-Income Housing Tax Credit (LIHTC), the ITC is not competitively awarded. ITC also includes no maximum basis and no requirements regarding amountof energy production. Therefore, the ITC can effectively be applied to any project including solar energy, as long as the affordable housing developer retains ownership of the equipment. The developer cannot receive the credit if engaged in a PPA or solar lease.

As with LIHTC, nonprofit housing developers cannot directly benefit from the ITC due to their lack of a tax burden. Therefore, it is necessary to find a third-party investor to purchase the credits. In order to receive the full monetary benefit of the subsidy, affordable housing developers can require the purchase of the ITC in the RFP soliciting LIHTC investors. Leveraging the desirability of LIHTC should allow developers to require a 100% pass-through of the solar investment tax credit. Two examples of pilot projects taking advantage of this tax credit to assist in funding photovoltaic panels are Hopeworks Station Phase II and Lakeline Learning Center.

The developer of Hopeworks Station Phase II is purchasing solar panels that are manufactured in-state in order to receive $58,000 in operational benefits through a Washington State program. They are applying the 30% ITC to the cost of the panels, wiring, meters, depreciation, and canopy. The tax credit amount from the panels alone will be approximately $100,000. This will enable the project to install a 200-kilowatt photovoltaic array that will fully offset the energy use of the residential portion of the project.

To help Lakeline Learning Center in their pursuit of Zero Energy, the developer required their LIHTC investor to also purchase solar investment tax credits and pass them to the housing developer. The affordable housing developer was able to receive a total value of $67,848 in tax credits (30% of eligible costs related to the photovoltaic system). The project achieved Zero Energy Certification in October 2018.

ITC PERCENTAGE BASED ON YEAR OF CONSTRUCTION

2017 - 2019
30 percent

2020
26 percent

2021
22 percent

2022 ONWARDS
10 percent - commercial only

ESTIMATED PAYBACK WITH ITC
7-8 years

ESTIMATED PAYBACK W/O ITC
12-15 years

ELIGIBLE ENERGY EXPENSES

- Photovoltaic array
- Solar curtain wall
- Equipment sales tax
- Installation costs
- Step-up transformers
- Circuit breakers
- Surge arresters
- Structural roofing (for PV only)

FANNIE MAE GREEN LENDING PROGRAM

Fannie Mae provides green financing options that enable high-performing and sustainable projects to save on long-term financing costs. When developers convert construction loans to a permanent mortgage, a Fannie Mae lender partner can originate the loan, which is then purchased by Fannie Mae. Fannie Mae purchases mortgage loans originated by 25 Delegated Underwriting and Servicing (DUS®) lender partners and then securitizes them as Mortgage Backed Securities (MBS).[1] When an MBS is backed by a loan that has met the standards of Fannie Mae's green financing program, it is disclosed as a Green MBS. Fannie Mae's green financing program began in 2012, and has grown exponentially in recent years, issuing over $20 billion a year in Green MBS in 2017 and 2018.[2]

One of Fannie Mae's Green financing products provides preferential pricing for properties with a Fannie Mae–recognized Green Building Certification. All buildings certified as Zero Energy through ILFI can receive a lower interest rate—ultimately saving the property owner money in permanent financing costs. Fannie Mae's Green Building Certification program recognizes various certifications, with ILFI's Zero Energy Certification classified under Level 1 and receiving the most preferential pricing.[3] While this financial benefit can be very important for owners of affordable properties, it is not limited to affordable housing owners and can be pursued by any multifamily property that receives a Fannie Mae–recognized certification. However, given that nonprofit affordable housing owners are also typically the developer and thus are responsible for both the permanent financing costs and the initial design/construction plan, such affordable properties are uniquely situated to benefit from the savings. The owner/developer can plan up front for a building to achieve Zero Energy and simultaneously plan for this certification to save on permanent financing costs. An owner/developer should contact a Fannie Mae DUS lender for financing and let them know that the project will be achieving this certification to obtain preferential pricing from Fannie Mae.

How does the process work?

- Borrower contacts a Fannie Mae DUS Lender when planning to acquire or refinance a newly constructed or existing building;
- Lender does a preliminary assessment to determine if the property's green building certification qualifies for Fannie Mae's Green Building Certification program and determines the pricing benefit based on the certification level;
- Lender registers the loan with Fannie Mae and completes a formal underwriting process;
- Lender closes the loan with the borrower and Fannie Mae buys the loan from the DUS Lender; and
- Fannie Mae securitizes the green mortgage loan, disclosing it to the MBS investor as a Green MBS.

TEXT COURTESY OF FANNIE MAE

1 https://www.fanniemae.com/multifamily/dus-lenders
2 https://www.fanniemae.com/content/tool/mf-green-bond-impact-report.pdf
3 https://www.fanniemae.com/multifamily/green-initiative-green-building-certifications

PROPERTY ASSESSED CLEAN ENERGY (PACE)

Property Assessed Clean Energy, or PACE, is a financing mechanism that provides 100% funding (soft and hard costs) for energy-efficiency, renewable energy, or water conservation capital projects. Using the framework of PACE allows project owners to realize a positive cash flow from their investments immediately and pay the capital costs back over 15–20 years through a special assessment placed on the property. PACE is not conventional debt and can help extend the capital budget of the project, allowing room for energy and water investments that save on operational costs.

The PACE program is available in 32 states and the District of Columbia, and most commercial multifamily properties are eligible (both for-profit and nonprofit development). Utilities and municipalities across the nation have also begun to offer incentives for energy and water conservation measures. For example, Seattle City Light offers discounts on low-flow showerheads and high-efficiency lighting. Many other jurisdictions offer financial incentives for other energy and water-saving measures—it is always wise to check in with your local city, county, and utility company about which programs are available in your area.

FUNDING PROFILE EXAMPLES

Financing options for green building varies significantly by region, depending on local incentives or available grants. Listed below are examples of funding profiles from a few past and current affordable housing pilot project teams.

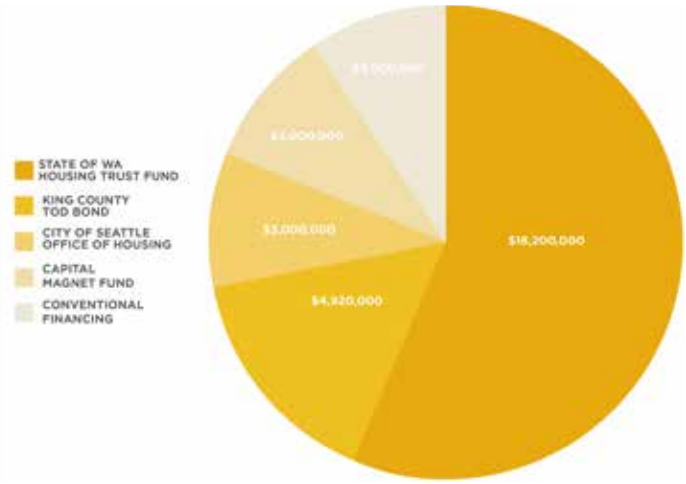
HOPEWORKS STATION PHASE II

Housing Hope and Hopeworks Social Enterprises
Everett, WA

SOURCES	TOTAL	RESIDENTIAL	COMMERCIAL	STATUS
State Housing Trust Fund	1,000,000	1,000,000		approved
State Housing Trust Fund - UHEE	750,000	750,000		approved
Federal Home Loan Bank - AHP	500,000	500,000		approved
Snohomish County - Home	600,000	600,000		approved
Deferred Developer Fee	942,341	731,351	210,990	approved
Low Income Housing Tax Credits	12,927,362	12,927,362		approved
City of Everett - CDBG	358,400		358,400	approved
Snohomish County - CDBG	201,000		201,000	approved
Additional County/City Funds	1,100,000	600,000	500,000	approved $500,000, pending $600,000
New Market Tax Credits	2,946,015		2,946,015	approved reservation letters
WA Building Communities Fund	2,750,000		2,750,000	Included in Governor's and State Senate capital budgets
Commercial Loan/ Social Investor	2,625,000		2,625,000	pending ($740,000 as of May 5)
Hopeworks Capital Campaign	2,600,557		2,600,557	$795,000 raised
TOTAL SOURCES	29,300,675	17,108,713	12,191,962	

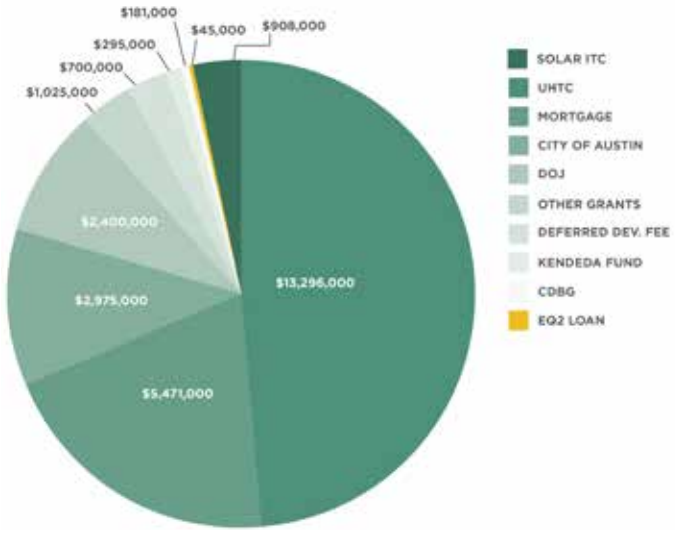
OTHELLO SQUARE HOMEOWNERSHIP BUILDING

Homesight
Seattle, WA



LAKELINE LEARNING CENTER

Foundation Communities
Austin, TX



CEDAR SPRINGS

A Community of Friends
La Verne, CA

CONSTRUCTION FINANCING		PERMANENT FINANCING	
SOURCE	**AMOUNT**	**SOURCE**	**AMOUNT**
UNION BANK	$9,774,287	HCD MHP-HOMELESS YOUTH	$3,157,376
LACDC - HOME	$2,452,322	LACDC - HOME	$2,452,322
MHSA (LA COUNTY DMH)	$1,000,000	MHSA (LA COUNTY DMH)	$1,000,000
MHSA (TRI-CITY)	$800,000	MHSA (TRI-CITY)	$800,000
GP EQUITY	$100	GP EQUITY	$100
DEFERRED COSTS	$4,233,342	DEFERRED DEVELOPER FEE	$1,248,739
TAX CREDIT EQUITY	$1,710,196	TAX CREDIT EQUITY	$11,311,710
		TOTAL	**$19,970,247**

MATERIALS SELECTION: ENGAGING WITH MANUFACTURERS

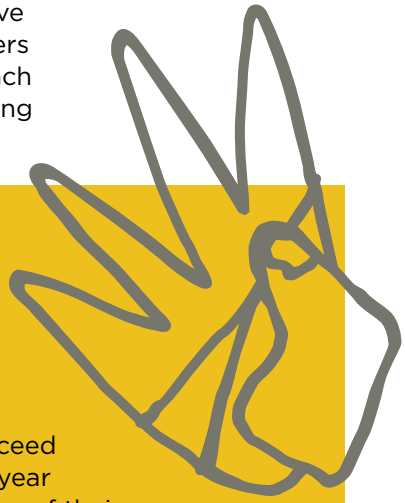
More and more affordable housing developers are focusing on healthier materials. With growing awareness of the adverse impacts of chemicals on human and environmental health and with more burden borne by lower income communities, selection of healthy materials for affordable housing becomes a critical equity and social justice issue. However, there are fewer funding incentives available to support the inclusion of heathy materials than for energy-efficiency and water efficiency measures. In addition, healthier materials do not necessarily coincide with long-term reduced operating costs and can thus be more difficult to justify from a bottom line standpoint. There are real costs associated with poor air quality caused by off-gassing building materials and exposure to chemicals, yet these costs are primarily healthcare and loss of work related costs borne at the individual household and societal levels, not costs that will show up on the project pro forma. Costs and availability of Red List Free materials across all sectors have improved greatly over the last few years, and the soft costs associated with materials research continues to decline as more projects become certified and new tools and resources become available. However, there are a few materials commonly used in affordable housing that do typically represent real hard cost increases, particularly from the baseline specifications of many affordable housing developments. As mentioned in the Materials Section above there are numerous strategies to avoid cost premiums associated with the Materials Petal. Here we focus on two additional strategies related to manufacturer engagement, especially with manufacturers engaged with the Living Product Challenge.

The Living Product Challenge (LPC) provides opportunities for the Institute to encourage manufacturers to price products accessibly and to support affordable housing developers that are seeking to create healthier environments. Product manufacturers pursuing LPC Certification are seeking to ensure there are no deleterious effects from their products on the production workers, end-users, or the overall environment. There is a parallel relationship between LPC manufacturers and LBC project teams, particularly those working on affordable housing, in that they are both seeking to leave a positive imprint on communities. Two requirements of the LPC provide opportunities for affordable housing projects and manufacturers to work together directly. These are handprinting and equitable investment.

LIVING PRODUCT CHALLENGE℠

HANDPRINTING

Manufacturers within the Living Product Challenge utilize handprinting to offset the water, carbon, and energy (and human health under LPC 2.0) impacts of their production process. Using a life cycle analysis tool, manufacturers determine the impact of manufacturing the certified product and, after incorporating strategies to reduce these impacts internally, determine an appropriate offset. Some strategies for handprinting in the past have included providing customers with LED lightbulbs with each product purchase or donating low-flow showerheads



For the Water Petal of the Living Product Challenge, Mohawk sought to create a positive impact by developing a strategy for water savings that will exceed the 1.1 million gallons per year used for the manufacturing of their Lichen carpet. To achieve that goal, Mohawk partnered with Morehouse College in Atlanta to retrofit the showerheads in its dorms. Although only 15 showerheads would be necessary to meet the water-saving needs for Lichen's handprint, Mohawk is helping to install more than 100 low-flow showerheads, enough for every shower in every Morehouse dorm.

The Institute is working with manufacturers to connect them with affordable housing developers for handprinting opportunities.

to upgrade the fixtures in a dormitory of a local college. Handprinting within the latest version of the Living Product Challenge, LPC 2.0, is also required to provide a social co-benefit. Given this requirement, the donation of products such as photovoltaic panels or low-flow water fixtures to affordable housing projects is one clear pathway for manufacturers to achieve this requirement. In the case of registered LBC projects, the Institute can quickly provide manufacturers with the information needed to calculate the life cycle impacts of such a donation as well as the specific financial needs of each project, resulting in a streamlined process. The Institute is working with several manufacturers interested in piloting handprinting for affordable housing projects with the intent to develop a scalable process and platform to broaden the scope to many more project teams and manufacturers.

EQUITABLE INVESTMENT

Under LPC Imperative 16 - Equitable Investment, manufacturers of Living Products commit to making products accessible to the affordable housing sector. The specific requirement is:

"When relevant, manufacturers must offer building products to Affordable Housing projects at price parity with similar products in its category."

Some manufacturers that have achieved this Petal have also committed to offering a discount or donation to affordable housing project teams when asked. The early case study of the Othello Square project highlights several examples of this. As more manufacturers certify under the Living Product Challenge, more products will become available at reduced costs to affordable housing.

Manufacturers that have committed to the Equitable Investment requirement of the Living Product Challenge as of the date of the publication include the following. Project teams are encouraged to check the Institute's Affordable Housing website for a continuously updated list.
living-future.org/affordable-housing/

MossWallArt™, a certified Living Product. Plant Solutions, the manufacturerer of MossWallArt™, achieved 4/4 in Equity on their Living Product label. Image courtesy of Plant Solutions

Resources

ILFI Website
Find information about all ILFI programs, resources, and initiatives on ILFI's website.
living-future.org/

Renewable Energy Tax Credit ENERGY STAR.gov
This website explains the federal requirements for receiving renewable energy tax credits.
www.energystar.gov/about/federal_tax_credits

PACE Nation
PACE Nation promotes adoption of PACE financing in local jurisdictions and provides informational resources.
pacenation.us/

Fannie Mae Green Building Certifications
Fannie Mae's website walks through the various green building certifications that they recognize for preferential pricing, including the Living Building Challenge.
www.fanniemae.com/multifamily/green-initiative-green-building-certifications

Living Product Challenge
Download the Living Product Challenge to read about the Equitable Investment and Social Co-Benefits Imperatives that relate to affordable housing.
go.pardot.com/l/464132/2019-03-25/ghpnd9

ILFI Online Learning
View and watch all 55 ILFI courses here (including 8 affordable housing courses) and learn how to become Living Future Accredited.
living-future.org/online-learning/

The Toolkit for Policy Leadership
The Toolkit for Policy Leadership provides a step-by-step guide for introducing green ordinances and incentives, so you don't have to start from scratch.
https://living-future.org/wp-content/uploads/2018/04/Policy-Leadership-Toolkit-v-1.0.pdf

Water Policy Guide
The Water Policy Guide is an advocacy resource focused on net positive water. This document includes our assessment of existing regulations in the United States, highlights current policy precendents and calls for three critical policy changes.
https://living-future.org/wp-content/uploads/2016/10/Advocating_A_Living_Future.pdf

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SUMMARY OF MAJOR FINDINGS

Since the publication of the first edition of this report in 2014, the Institute has worked with a total of 27 registered affordable housing projects. These projects, in various stages of site acquisition, design, construction, and operation, are providing more in-depth information on the successes that are possible for Living Affordable Housing, as well as the remaining challenging areas. This report reflects on the many successes that have been undertaken by dedicated affordable housing project teams throughout the nation, as well as barriers that still need to be addressed on a broader scale. While some cost barriers still remain, particularly related to the Water Petal and certain product categories, enormous progress has been made since the first report. This update is in many ways an in-progress report because the Institute is still actively working with the majority of pilot projects that are still in design or earlier phases. As each project progresses further, new lessons will continue to be learned that will undoubtedly provide a wealth of information for the affordable housing sector.

PLACE

The Place Petal provides a framework for project teams to consider the uniqueness of their own particular place, culturally and in terms of environmental resources. The Place Petal addresses two critical issues for low-income communities—access to healthy food and cost/ease of transportation. Urban Agriculture and Human-Scaled Living align well with the goals of affordable housing and can likely be integrated into projects with minimal costs and significant improvements to quality of life. Urban agriculture is a growing area of interest within affordable housing due to food access issues prevalent in low-income communities. There are a number of case studies within our pilot projects and affordable housing projects throughout the nation showing that urban agriculture integrated within affordable housing can become an important and popular amenity for residents.

WATER

The Net Positive Water Modeling presented in this report shows that Responsible Water Use is nearly achievable through high-efficiency fixtures alone. A small amount of handprinting (allowable for affordable housing projects under both Responsible Water Use and Net Positive Water) or other strategies will likely be needed to meet this Imperative. The modeling also shows that it is feasible for multifamily affordable housing projects using the Municipal Potable Water and/or Blackwater Treatment for Multifamily Affordable Housing Exception to meet Net Positive Water using a reasonably sized cistern. Since tenant water consumption varies only slightly by climate zone, meeting this water reduction target should be possible in all climate zones. Multifamily projects typically have more than sufficient greywater to meet non-potable needs, but may struggle to supply sufficient potable water without using existing exceptions.

As regulatory as well as financial barriers continue to impede progress on achieving the treatment

requirements of the Net Positive Water Imperative, the temporary alternative compliance pathway for affordable housing projects to connect to a municipal sewer for blackwater treatments is still available. This compliance path acknowledges that on-site blackwater treatment is challenging for affordable multifamily housing. It offers a pathway to certification for projects that rewards project teams who push significantly beyond best practice and incorporate rainwater collection and reuse, as well as

Certified Affordable Housing projects:
Lakeline Learning Center, Austin, TX
Lopez Community Land Trust, Lopez Island, WA
Rocky Road Straw Bale, Moab, UT

greywater recycling and treatment. Additionally, the Institute allows affordable housing projects to handprint for both Responsible Water Use and Net Positive Water. Handprinting allows affordable housing project teams the opportunity to reduce water elsewhere, potentially within other projects in their portfolio, thus reducing long-term utility costs for both the LBC project and others. Many water efficiency upgrades, such as low-flow showerheads and aerators, have low up-front costs and can provide great savings for both energy and water in the long term. Incentive programs for water upgrades in affordable housing also exist in numerous jurisdictions that may help fund the limited cost. Regulatory barriers that prevent rainwater collection and on-site greywater 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 to implement larger systemic regulatory reform.

ENERGY

Net Positive Energy in affordable housing has tremendous momentum due to rapidly accelerating solar technology, as well as committed practitioners developing highly effective envelope-sealing and energy-efficiency technologies that are becoming known and adopted much more broadly.

Net Positive Energy is the area that has attracted the most interest thus far from affordable housing developers in the pilot program, with the majority of registered pilot projects planning on Energy Petal certification. There are many case studies in the sector now showing that with proper energy-efficiency measures and a feasible method to fund photovoltaic panels, Net Positive Energy is achievable for multifamily projects that are moderately dense—approximately three to four stories tall, though this varies somewhat by climate. Given more robust energy-efficiency measures and/or additional on-site photovoltaic placement options, on-site Net Positive Energy is within reach for multifamily projects that are five to seven stories. Three pilot projects are now working through the feasibility of net-positive energy for projects between six and seven stories. Depending on the region, regulatory barriers regarding net zero energy, such as caps on system sizes or limits around net metering, remain a barrier. Federal incentives for renewable energy remain an important incentive. Local incentives, such as PACE financing, are growing around high-efficiency and renewable energy, particularly for affordable housing, but vary largely by region.

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 are also effective solutions if utility regulations restrict an on-site PV array's size. Distributed solar generation costs are decreasing rapidly, so projects that do not have the ability to incorporate on-site PV now should be designed to be Net Positive Ready to take advantage of on-site PV as the economics improve.

Net Positive Energy has begun to see large ripples throughout the affordable housing sector. The many projects pursuing Energy Petal currently in the pipeline will provide even more information on energy conservation, tenant engagement, and incentives and funding for renewable energy that will continue to build the momentum.

"The BLOCK Project sees homelessness as a community crisis: healthy communities do not allow their members to be homeless. This means a community solution and community healing are needed if we want to end homelessness and the trauma it creates. This holistic approach also makes BLOCK Homes a perfect match for the Living Building Challenge (LBC); they epitomize the ILFI principle of "giving more than they take, creating a positive impact on the human and natural systems that interact with them."

Kim Sherman, BLOCK Home Host

HEALTH + HAPPINESS

There is a growing recognition of the importance of housing on human health. The idea that housing is healthcare means that affordable housing projects must do more than simply provide shelter. The Health Happiness Imperatives can significantly improve physical health through improvement of indoor air quality and mental health through access to nature. Though vetting for CDPH for interior materials may add a minor amount of hard and soft cost to the project, it is not likely to be significant within the overall project budget. Air quality testing is also an added cost, but the requirement is now more flexible to allow for creative, budget-friendly options that meet the intent of this Imperative. Overall, these Imperatives are an important alignment area with affordable housing due to the increased focus on occupant health and well-being.

MATERIALS

Healthy materials have become more widely available and affordable since the last report. Though approaching the entire Materials Petal has still had limited uptake among projects compared to the Energy Petal, there are at least two projects anticipated to achieve or come very close to achieving it. Among the other pilot projects and the affordable housing sector broadly, there is momentum to begin integrating Red List Free products on at least a gradual basis, particularly with product categories that have the most impact on human health. As there are several product categories with robust Declare options, the soft and hard costs of including many materials is minimal. The research produced by the projects attempting all or parts of the Materials Petal will be enormously beneficial to the sector and will be aggregated by ILFI and shared publicly. Alignment and integration with other rating systems, including LEED and Enterprise Green Communities, will create more market demand for healthy products at a cost-efficient price. Coordinated healthy material purchasing across the sector, led by groups such as Housing Partners Network, will also help to bring down the cost with the potential to transform the materials market overall.

An integrated design process for the Materials Petal is critical to reduce impact on a project's construction schedule and budget. It is important to ensure that all project team members, particularly contractors and subcontractors, are in agreement with the Materials goals of the project to avoid non-compliant substitutions during bidding. Project specifications should include provisions requiring either a specific compliant product or performance requirements dictating compliance with the Red List or FSC. Contractual requirements requiring any substitutions to be vetted by the substituting party may also help mitigate the issue, though they may deter bidding on the project up front if the construction market is very competitive.

Though the Materials Petal still likely requires some soft cost increases unless a project team is already very well-versed in the Red List, the Institute is actively developing resources and partnerships to decrease those costs and to work to decrease the cost of certain product types that have so far proven cost prohibitive.

Hunters View Housing Phase 2, San Francisco, David Baker Architects. Image: Bruce Damonte

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A more fully developed Master Materials List for Affordable Housing is being developed, informed by projects that are attempting 100% Red List Free and FSC certified materials throughout the building, as well as by project teams that incorporated a smaller percentage of compliant materials. Active partnerships with Enterprise Green Communities and Housing Partnership Network provide opportunities to further push the market and show demand for Red List Free and FSC certified products within affordable housing. New alignments between the Living Product Challenge and the affordable housing sector, in addition to Living Product and Declare manufacturers that are eager to step forward and be a part of the solution by providing discounted or donated healthy products, are another exciting path forward for healthier and more affordable materials.

Image: Chad Podoski, Flickr

The Materials Petal seems on the precipice of a sea change. At least two projects are aggressively pursuing the Materials Petal, with two more pursuing Living Certification, including the Materials Petal. Their list of products, and those used by other project teams exploring materials in a more limited scope will help to make incorporating Red List Free materials much easier for future project teams and ease fears among owners and other project team members regarding new materials and unknown costs.

EQUITY

The case studies within this section of the report show that an Equity lens and a commitment to improve the local community is already integral to affordable housing. This Petal represents an area where affordable housing may lead the way and provide important precedents for other types of projects to be as thoughtful and deliberate in including all key stakeholders in the design and construction process and ensure that the resulting project ultimately benefits those already living in a community, economically and otherwise.

BEAUTY

Biophilic design further grounds a project to its place and culture, an important if sometimes overlooked aspect of development. Biophilic design is a significant area of interest for many affordable housing developers as it can help create a unique housing experience that feels both beautiful and contextual. The power of healing trauma through biophilic design and natural elements has begun to be documented and provides an interesting area of future exploration that could be greatly beneficial to affordable housing residents. When incorporated early in the design process, biophilic design can be incorporated for minimal cost. Affordable housing projects pursuing the Living Building Challenge typically do so with the plan to become both a leader and an inspiration for future projects in the sector. The Inspiration and Education Imperative formalizes these goals and provides a means for each project to tell their story most effectively.

A LIVING FUTURE FOR AFFORDABLE HOUSING

The affordable housing sector is rife with innovation. For years, developers and practitioners in the sector have had to adapt to a worsening housing crisis, escalating construction costs, decreased funding, and shifting regulatory requirements. The sector has continuously responded with better ways to serve their residents and provide more units of desperately needed housing. Affordable housing is now not simply a roof over one's head, The Housing First philosophy adopted by most developers means that affordable housing is intentionally designed to improve quality of life, help residents access services, promote economic and community development, and in many cases, heal and recover from trauma. The deliberate and careful planning that goes into these structures is synergistic with the goals of the Living Building Challenge to make buildings that work in a fundamental and equitable way for people and the environment.

This update shows the significant progress made over the last five years toward Living Affordable Housing. The number of projects attempting the Living Building Challenge, now 27, shows an enthusiasm and willingness within the affordable housing sector to approach the ambitious goals of the Living Building Challenge and find a viable path forward. There are now three certified Zero Energy affordable housing projects (ILFI's pilot project Lakeline Learning Center, Lopez Community Land Trust, and Rocky Road Straw Bale), with several more Zero Energy, Energy Petal, and Materials Petal projects likely to follow in the next year. There are two projects now beginning construction that have a realistic plan for Living Certification (BLOCK Project and the The Projects at Mill Creek). Two organizations—Community Rebuilds and the BLOCK Project—have committed to volume certification, representing a critical future opportunity to scale up the impact of the Living Building Challenge by working across a development portfolio rather than just project by project. This will drastically bring down the cost, effort, and time needed to achieve the Challenge.

There are still persistent regulatory and financial barriers. For example, the structure of the Low-Income Housing Tax Credit system caps spending for projects and can result in rapid development schedules that can sometimes hinder the time needed to fund money for renewable energy and other strategies (that will save money in the long term) or research cost-efficient Red List Free materials that are critical to resident health. However, each new project builds momentum and breaks down these barriers through a new case study and replicable model, while also decreasing the information gap around energy-efficiency strategies, healthy materials, and other sustainable design and construction strategies. These case study projects joined with a concerted effort by key partners to push for widespread innovation and adoption will help overcome these barriers.

The progress highlighted in this Living Building Challenge Framework for Affordable Housing represents rapid and meaningful change. The impact of each groundbreaking project team extends well beyond the boundaries of any one project and has begun to impact the entire affordable housing community. Yet, there is still significant work ahead to ensure the Institute's ambitious vision that all people – regardless of economic status – have the opportunity to live in the world's healthiest, most sustainable homes. Our next task is to demonstrate Living Affordable Housing is scalable. The Institute invites key strategic partners from innovative developers, designers and contractors to policy makers and forward-thinking philanthropic organizations, to join the Institute in making this vision a reality.

The challenges for affordable housing development are great due to low budgets, compressed timelines, and shifting regulatory requirements. However, in many ways, the affordable housing sector has the opportunity to lead the way on many of these important challenges due to the social and environmental mission of many developers. Affordable housing is a sector that constantly innovates based on current conditions and centers the holistic needs of occupants at the core of all decisions.

The affordable housing sector can solve the challenge to create healthy, regenerative housing that is net positive for residents, the environment, the community, and society as a whole.

ILFI GLOSSARY

Living Building Challenge (LBC): Made up of 7 Petals (performance categories) and 20 Imperatives, LBC is the Institute's oldest and most well-known certification. It outlines the measures of a building that defines 'what good looks like' by ensuring Net Positive energy and water, healthy materials, a connection to nature, and other elements that ensure the built environment is socially just, culturally rich, and ecologically restorative. LBC 4.0 was launched in May 2019 and is currently the latest version of the Standard.

Living Certified: Achievement of all 20 Imperatives and 7 Petals, either within the Living Building Challenge or Living Product Challenge, after a one-year performance period.

Petal Certified: Within the LBC, achievement of all ten Core Imperatives plus the remaining Imperatives to complete either the Water, Energy, or Materials Petal after a one-year performance period.

Petal Handbooks: Guidebooks that outline in more detail the requirements and documentation needed for each Imperative.

Living Product Challenge: The Living Product Challenge is a framework for manufacturers to create products that are healthy, inspirational, and give back to the environment.

Handprinting: The opposite of a "footprint," a handprint is defined as the good that a project team (building or manufacturer) can cause to happen in the world. In the case of the Living Product Challenge, a handprint offsets the resources needed to produce a particular product. Handprinting is also used in a similar manner under the LBC Water Petal (see the Water Petal Section for an explanation and graphic).

Declare: A transparency platform and product database that shows where a product is assembled, what it is made of, and where it goes at the end of its life.

Red List/Red List Free: The Red List identifies the worst-in-class chemicals ubiquitous in the built environment, including carcinogens, reproductive toxins, and bioaccumulative substances. The status of Red List Free indicates that a manufacturer has provided evidence that a product has reported that all ingredients down to 10,000 parts per million are free of Red List chemicals. A Declare label showing a status of Red List Free means that a product must be reported as free of Red List chemicals down to 100 parts per million.

LBC-Compliant: A product defined as LBC-compliant means that the product contains Red List chemicals, but falls under one or more existing exceptions outlined in the Living Building Challenge program.

Zero Energy Certification: An ILFI certification confirming that the project produces at least 105% of its annualized energy load through PV panels or other renewable sources, primarily on site or through a published off-site exception.

Zero Carbon Certification: An ILFI certification confirming 100% of the annual operational energy use associated with the project is offset by new on- or off-site renewable energy. 100% percent of the carbon emissions impacts associated with the construction and materials of the project must be disclosed and offset.

Core Certification: Core Certification outlines the ten best practice achievements that a building must obtain to be considered a sustainable building.

Affordable Housing Pilot Program: Cohorts of affordable housing projects that, with technical assistance from ILFI, are striving for Living, Petal, or Zero Energy Certification. These projects serve as innovators that, through identification of replicable strategies and pathways result in tools and resources beneficial to the affordable housing sector.

Just: A voluntary disclosure tool for organizations to highlight the social justice and equity practices within their operations.

APPENDICES

APPENDIX A
Introduction to the Low-Income Housing Tax Credit

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 multifamily 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 incentive 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 nonprofits, 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 to help 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 project 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, reprioritize, 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 project 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
Water Calculations

I-05 RESPONSIBLE WATER USE CALCULATIONS

Scenarios 3-4

Responsible Water Use: Indoor Water Use

End Use	Gallons per person per day	% of Total
Toilets	6.46	26%
Kitchen Faucet	7.50	30%
Lav Faucet	2.50	10%
Showers+Bath	7.69	31%
Dishwasher	0.30	1%
Laundry (Common)	0.62	2%
Total indoor use (daily per capita)	25.07	100%

Fixture Flow Rates

Proposed Flow Rate (gpm, gpf or gpc)	Uses (or cycles) per day (x) duration if applicable
1.28	5.05
1.5	5.00
0.5	5.00
1.25	6.15
3	0.10

Scenarios 1-2

Responsible Water Use: Indoor Water Use

End Use	Gallons per person per day	% of Total
Vacuum Flush Toilets	1.31	6.6%
Kitchen Faucet	7.50	37.6%
Lav Faucet	2.50	12.5%
Showers+Bath	7.69	38.6%
Dishwasher	0.30	1.5%
Laundry (Common)	0.62	3.1%
Total indoor use (daily per capita)	19.92	100.0%

Fixture Flow Rates

Proposed Flow Rate (gpm, gpf or gpc)	Uses (or cycles) per day (x) duration if applicable
0.26	5.05
1.5	5.00
0.5	5.00
1.25	6.15
3	0.10

APPENDIX C
Water Calculations

I-06 NET POSITIVE WATER USE CALCULATIONS

Multifamily Affordable Housing Stakeholder Location Water Calculations

Location	Climate	Total Consumption (g/c/d)	Rainwater use (g/c/d)	Size of cistern to support Net Postive Water	Size of cistern in feet	Size of roof area (sf)
Scenario 1: Closed Loop - 100% of use supplied by rainwater, other than irrigation, vacuum flush toilets		20 g/c/d	100%			
Minneapolis, MN	Cold-hot	2673	2673	150,000 gal	45' X 45' X 10'	100,000
Christiansburg, Virginia	Mixed-humid	2673	2673	15,000 gal	14' X 14' X 10'	60,000
Chicago, IL	Cool-humid	2673	2673	60,000 gal	28' X 28' X 10'	60,000
San Jose, CA	Hot-dry	2673	2673	350,000 gal	68' X 68' X 10'	200,000
Austin, TX	Warm-humid	2673	2673	30,000 gal	20' X 20' X 10'	75,000
Vancouver, WA	Mixed-marine	2673	2673	115,000 gal	39' X 39' X 10'	70,000

Scenario 2: Municipal Potable Supply with vacuum flush toilets*		20 g/c/d	N-P uses only			
Minneapolis, MN	Cold-hot	2673	270	5,000 gal	8' X 8' X 10'	10,000
Christiansburg, Virginia	Mixed-humid	2673	270	4,000 gal	7' X 7' X 10'	2,100
Chicago, IL	Cool-humid	2673	270	1,500 gal	4' X 4' X 10'	3,000
San Jose, CA	Hot-dry	2673	270	14,000 gal	14' X 14' X 10'	12,000
Austin, TX	Warm-humid	2673	270	1,500 gal	4' X 4' X 10'	3,000
Vancouver, WA	Mixed-marine	2673	270	2,000 gal	5' X 5' X 10'	5,000

*Non-potable use has been drastically reduced by converting to vacuum or foam flush toilets, so a much smaller roof area and cistern is required

Scenario 3: Municipal Potable Supply with Low Flow Toilets		25 g/c/d	N-P uses only			
Minneapolis, MN	Cold-hot	3385	956	13,000 gal	13' X 13' X 10'	12,000
Christiansburg, Virginia	Mixed-humid	3385	956	2,000 gal	5' X 5' X 10'	12,000
Chicago, IL	Cool-humid	3385	956	2,000 gal	5' X 5' X 10'	7,500
San Jose, CA	Hot-dry	3385	956	30,000 gal	20' X 20' X 10'	40,000
Austin, TX	Warm-humid	3385	956	4,500 gal	8' X 8' X 10'	7,000
Vancouver, WA	Mixed-marine	3385	956	30,000 gal	20' X 20' X 10'	12,000

Scenario 4: Rainwater for potable, greywater for non-potable		25 g/c/d	P uses only				Non-potable demand	Greywater supply (from showers, bathroom sinks, and laundry)
Minneapolis, MN	Cold-hot	3385	2428	5,000 gal	8' X 8' X 10'	100,000	956	1460.0
Christiansburg, Virginia	Mixed-humid	3385	2428	4,000 gal	7' X 7' X 10'	50,000	956	1460.0
Chicago, IL	Cool-humid	3385	2428	1,500 gal	4' X 4' X 10'	60,000	956	1460.0
San Jose, CA	Hot-dry	3385	2428	14,000 gal	14' X 14' X 10'	175,000	956	1460.0
Austin, TX	Warm-humid	3385	2428	1,500 gal	4' X 4' X 10'	60,000	956	1460.0
Vancouver, WA	Mixed-marine	3385	2428	2,000 gal	5' X 5' X 10'	60,000	956	1460.0

APPENDIX D
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 the Energy Petal.

Example Net Positive Calculation

1. Select Location: Seattle, WA
2. Calculate potential size of the PV array for a 25,000 sf roof. Assume PV efficiency factor of 17 and 80% roof coverage.
   (25,000sf X 17 X 80% ÷ 1,000) = 340 kW
4. Assume default efficiency.
5. Assume fixed tilt of 20 degrees.
6. Select Commercial Installation.
7. PV Watts Result = 373,070 kwh/yr
8. Convert Units from kwh/yr to kbtu/sf/yr
   (373,070 kwh/yr ÷ 100,000 sf X 3.41 kbtu) = 12.72 kbtu/sf/yr
9. Reduce EUI target to meet Energy Petal requirement for 105% of consumption (12.72/sf/yr ÷ 105%)
10. Project EUI target = 12.72 kbtu/sf/yr

APPENDIX E
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 multifamily 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 of products are also now just as critical components to help make our decision.

Rather than use products that contain substances harmful to humans, animals, 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. We seek to make informed decisions about product selection and are asking you to share information about your product contents and their associated environmental and health hazards. As the need for transparency in the products we select and specify continues to grow, we will give preference to manufacturers that provide this information and will begin to phase out products that do not include reporting on content.

Some of the tools that [Your Organization] and our consultant teams use to gather knowledge about the chemical content of building materials are the Living Building Challenge's Declare program, Cradle2Cradle certification, The Green Wizard, and the Pharos Project. Your company already may participate in these. If not, we encourage you to engage in these initiatives so that, as partners in the building industry, together we can deliver healthier buildings to owners and end users. Manufacturers that provide full, transparent disclosure of their product content are the most helpful to our designers.

We request that your company provide [Your Organization] with an HPD for your primary products. 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,