REPLICABLE AND SCALABLE NEAR-ZERO NET ENERGY RETROFITS FOR LOW-INCOME HOUSING

SOLUTION OVERVIEW
LINC Housing has over 30 years of experience creating communities for limited income families, seniors, and persons with special needs throughout California. LINC is committed to building housing that is affordable, environmentally sustainable, and a catalyst for community improvement. LINC communities are known for excellent design, outstanding management, and life-enhancing resident services.

To strengthen its commitment to sustainability, in 2012 LINC Housing formed SEED Partners, a mission-driven energy and water services company. SEED is focused on sustainable retrofits of LINC’s expanding portfolio, development of renewable energy projects, and enhancing the features of LINC’s properties under development. SEED also offers consulting services to help other owners with retrofitting their portfolio. Project goals focus on improving efficiency and supporting a “quadruple bottom line” that reduces residents’ utility costs and creates healthier living conditions, saves building owners money on operations, benefits the environment by reducing each building’s carbon footprint, and helps California meet its goal of reducing greenhouse gases to 1990 levels.

Residents of low-income multifamily housing generally spend a higher proportion of their income on utility costs compared to higher income groups. This is a challenge for building owners, who do not have access to regular funding for energy efficiency and are unable to raise rent to fund these improvements. The Village at Beechwood (VAB), a low-income multifamily property owned by LINC Housing in Lancaster, California, operates with one of the highest energy indices of all LINC properties because of extreme seasonal climates, the age of its buildings, and inefficient HVAC equipment.

The California Energy Commission (CEC) awarded a Public Interest Energy Research (PIER) grant to Electric Power Research Institute (EPRI) in 2013 to work with LINC to design and implement an energy efficiency retrofit program at this property. LINC was chosen because of the organization’s demonstrated leadership in incorporating sustainability into affordable housing. The $1.3 million grant was awarded so that EPRI and LINC, along with Southern California Gas Company, Southern California Edison, and BIRAenergy could develop a scalable and replicable energy efficiency project for VAB. Under this grant, LINC worked with several partners to develop, demonstrate, and document the implementation of deep, near-zero energy (near-ZNE) retrofits of a low-income multifamily property in California, through a comprehensive turnkey approach including:

- Cost-effective Very Efficient Retrofit (VERs) packages
- Rigorous monitoring to validate actual savings
- Financial tools
- One-stop delivery models

For more information, visit https://betterbuildingssolutioncenter.energy.gov
• Resident education

The VERs measures were piloted in approximately one-third of its units at VAB and extensive data has been collected since their implementation in 2015. The preliminary results demonstrate that VERs measures can be used alongside solar technologies to reduce annual electricity use in a low-income multifamily housing property. By the project’s end in 2016, it will be a model for implementing whole-building energy efficiency retrofits that, at a minimum, has evaluated the barriers facing low-income multifamily owners and has examined the efficacy of developing scalable technologies and financial models for a historically underserved population.

ORGANIZATION TYPE
Affordable housing developer

BARRIER
Obtaining financing for near-zero net energy retrofits in low-income housing

SOLUTION
Developed the replicable and scalable near-zero net energy retrofit model

OUTCOME
Creation of a model that documents the steps low-income multifamily property owners can take to make whole-building energy efficiency retrofits

POLICIES
LINC Housing followed these internal guidelines to implement its replicable and scalable near-zero net energy retrofit model:

1. Obtained leveraged funding with matching grant dollars from various sources.
2. Established dedicated team members to manage the design, financing, and maintenance of the project.
3. Followed internal LINC Housing goals to achieve maximum efficiency for tenants while reducing property operational costs.
4. Meet the CEC’s goals to investigate innovative technologies, tools, and approaches that will lower costs and enhance environmental sustainability.

As with any investment, there are risks to developing and implementing the model. For this reason, LINC Housing compared project benefits against the risks and determined it was worth pursuing.
PROCESS
After receiving a $1.3 million grant from the California Energy Commission in 2013 to complete a PIER project, LINC Housing partnered with Electric Power Research Institute, BIRAenergy, Southern California Gas Company, and Southern California Edison property in Lancaster, California. The PIER funds were supplemented by an Energy Innovation Fund grant from the U.S Department of Housing and Urban Development (HUD) and a grant through the Federal Home Loan Bank of San Francisco.

LINC began collecting baseline utility data in 2013 and laid out its primary objectives for the project before identifying specific energy efficiency upgrades. The objectives included:

- Energy savings
- Improved reliability and maintenance of systems
- Cost savings and return on investment
- Scalability into the multifamily housing market
- Minimal disturbance of residents during construction

LINC used utility data and resident energy use surveys to better understand the nature of energy use at VAB and hired a consultant to help design an efficiency program. The team created a list of potential energy efficiency upgrades that would work for VAB, but also for similar low-rise wood frame garden apartments that are typical in California. LINC also considered that the renovations would occur in occupied space, the accessibility limitations of the buildings, the potential for hazardous materials, and the cost effectiveness of each measure. In addition to the VERs measures, the team included on-site energy generation options in its analysis of options.
The team calculated potential whole-building energy savings by simulating the impact of each proposed energy efficiency measure on energy use compared to the baseline. The results of this analysis provided the optimum cost-effective value for each measure and its impact on energy use. The team created small packages of VERs and simulated their impact on energy use to determine which set of efficiency measures would be most effective for VAB. The final package of VERs also included solar domestic hot water and solar photovoltaic systems (PVs) for resident loads.

LINC implemented the VERs in 30 of the 100 units at VAB and installed approximately 50 sensors to collect data and evaluate the effectiveness of each measure. For one year after completing the retrofit, LINC will collect utility data from the 30 units and compare it to the remaining 70 units that were not retrofitted. The results of the post retrofit analysis will provide insight into effective approaches to energy efficiency in low-income multifamily housing.

OUTREACH
LINC Cares, the resident services division of LINC, led the resident outreach efforts throughout the retrofit project.

The division began by distributing resident energy use surveys, which helped the retrofit team choose the most effective measures to implement. The surveys revealed lifestyle patterns specific to VAB residents, such as spending a lot of time at home, which affected LINC’s energy modeling and the expected outcomes of the retrofit program.

LINC Cares was also responsible for educating residents about energy efficiency. The team played
an important role in explaining the purpose of the retrofits, telling them what to expect throughout the process, and answering any questions or concerns. In addition, the team unveiled the LINC Healthy Homes Challenge in April 2014, which encourages residents to partner with LINC by significantly reducing energy and water consumption. The challenge rewards tenants with gift cards and other incentives for meeting individualized and property-wide energy reduction targets, as tracked by utility bills. The challenge engages residents in a variety of ways, including having them watch a 20-minute informational video, “Go Green” marketing events, and distribution of flyers throughout the property. In June and July 2016, the LINC team will showcase its irrigation improvements and solar PV installations at two tenant events.

LINC Cares continues to recruit new tenants to participate in the Healthy Homes Challenge and plans to create specific trainings on using the programmable thermostats in each unit, which some residents have not used because of their unfamiliarity with these thermostats. By providing education, incentives, and a social norm of sustainability, LINC hopes that its tenants are learning how to live comfortably while reducing their energy consumption.

TOOLS AND RESOURCES
Resources:
- California Energy Commission PIER program
- Southern California Edison Energy Savings Assistance Programs for Low Income Multifamily Homes
- LINC Cares Health Homes Challenge video

OUTCOMES
Retrofitting a low-income multifamily property to be near-ZNE requires much more than the implementation of a package of measures. This project continues to research the best ways to integrate its aging buildings, new technology, and the low-income residents.

At the project’s conclusion, the PIER Beechwood Project will be a model for implementing whole-house energy efficiency retrofits that, at minimum, has evaluated the barriers facing low-income multifamily owners and fully examined the efficacy of developing scalable technologies and financing models for a historically underserved market. Utilities have struggled to create successful programs that improve the efficiency of low-income housing. For this reason, there has been a need to research, develop, demonstrate and deploy the steps to successfully retrofit low-income multifamily properties. This project was designed to fill this gap in the research, but it could not have been completed without research funding. Without the aid of funding from programs such as PIER, energy efficiency retrofits of the existing low-income housing market will continue to languish.

The preliminary results have demonstrated that implementation of the VERs has significantly decreased energy usage at VAB compared to the control units that were not retrofitted. Retrofits in these units focused on weather sealing the units, insulating ceiling spaces, and sealing and insulating ducts that distribute air from the roof-mounted HVAC to the occupied spaces within the units. All of these measures increased the effectiveness and efficiency of the cooling system.
without replacing the units, and allowed the units to perform better during the hottest months. Not only is this represented in the data of Figures 3 and 4, which shows a reduction on power usage during the hottest months between control units and retrofitted units, but is also reflected in anecdotal data collected in interviews with residents. Residents in retrofitted units shared that their apartments felt cooler, and were staying cooler when the air conditioning was turned on, and that they did not need to run the systems as long or at as low a temperature in order to achieve a comfortable condition. Previously, many had run their units day and night without feeling they were ever truly cool.

Figure 1. Control data showing the relationship between outdoor temperature and electric-power draw (left), and monthly energy consumption (right). Note that for this control residence, which is typical for the complex, the power draw tracks the outdoor temperature. Notice also for the columnar data that the summer months of July – August, the residence used about 500 – 550 kWh.

Figure 2. Electric power vs outdoor temperature and summer monthly energy use for a retrofitted “test” home. The retrofits were performed during the months of June and July. Note the drop in power draw from the test unit in the left graph. Also note the lower monthly electricity use for the months of July, August (about 300 kWh) compared to the control home in Figure 3 (about 550 kWh).

Having successfully implemented its retrofit program at VAB, LINC is already planning to expand these efforts to other units. The organization has recently received a grant to retrofit two more properties and hopes to eventually reach the rest of its building portfolio.
MEASURING SUCCESS
The PIER Beechwood Team will employ detailed end-use monitoring and large-scale field deployments of monitored equipment to manage the planning, implementation, monitoring, and evaluation stages of the project. The team will collect data through 2016, storing it in databases that can be accessed remotely for performance monitoring and analysis.

The data analysis will be automated using algorithms programmed through the relational database using existing EPRI expertise. EPRI will utilize this basic infrastructure and methodology to monitor each building for whole-building energy use and to evaluate performance of individual measures.

The PIER Beechwood Team also plans to use its current online energy management contract with WegoWise to better understand electricity and gas usage. WegoWise will provide bill visualization tools and analytics for each of the 30 retrofitted units, using the performance of the non-retrofit units as a control. LINC will use these results to establish a pre-retrofit energy use baseline that can be compared against monthly data from the retrofitted units.

Monitoring Electricity Usage

Electric monitoring will take place through both a non-intrusive load monitoring system. The non-intrusive load monitoring technology uses analysis of electrical current and voltage signals to identify the end use devices as they operate. Some of these technologies can measure down to the level of identifying individual appliances which is important in understanding plug load usage.

The buildings will be sub-metered using Home Energy Modeling System (HEMS) and will be used to provide a parallel comparison of the electrical loads. The sub-meters will be installed at the main distribution panels for each residence and will track energy usage by circuit. The energy management system can control loads and provide feedback on energy usage by select loads. Each home will be outfitted with up to 50 individual sensors connected remotely through a gateway to a central server monitored by EPRI. The sensors will be placed strategically to provide enough data to validate performance of each significant measure. It is also expected that each home will be equipped with a “smart” circuit panel to provide sub-metering of loads. The HEMS system in each home will be connected to either the circuit panel or to the utility meter to provide real time energy use to the occupants. The HEMS system will also be designed to collect data on occupant interaction (such as thermostat temperature adjustment) with the permission of the occupant, which will assist in separating the technological and behavioral components of energy use.

Monitoring of Gas Usage

Under the guidance of Southern California Gas Company’s Emerging Technologies Division, gas usage will be monitored at the individual appliance level as well as the common services such as water heating and laundry. This will allow determination of gas use for all end users and comparison to the Energy Plus simulations.

Standard residential gas meters will be used for measuring the rooftop units, residential cooking loads, and duplex water heaters. The laundry facilities and the common water heater closets will be measured using commercial gas meters. In addition, the gas usage will also be calibrated with
modeled usage. One of the key drivers of gas usage is the set point in individual residences. Initial audits have shown that the set points are very high (74°/75° F in many homes). This does not seem to be commensurate with the electric usage, which is paid for by the residents; more M&V and analysis will hopefully shed light on this issue.
Replicable and Scalable Near-Zero Net Energy Retrofits for Low-Income Housing - Better Buildings Solution Center


For more information, visit https://betterbuildingssolutioncenter.energy.gov