Replicable and Scalable Near-Zero Net Energy Retrofits for Low-Income Housing

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ABSTRACT

LINC Housing Corporation (with support from Kango Development) has partnered with Electric Power Research Institute (EPRI) and BIRAenergy to develop, demonstrate, and document the implementation of deep, near-zero energy (near-ZNE) retrofits of low-income multifamily properties 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
- Resident education

The VERs will be implemented at The Village at Beechwood, a 100-unit low-income property owned by LINC in Lancaster, California. The team is designing and evaluating VERs for different building and unit types. An estimated 50 sensors will be installed to collect data to evaluate each VER. Energy and demand savings will be facilitated through training of residents, providing each unit with a Home Energy Meter System (HEM) that is coupled to a "smart" electrical panel and smart meter. Each retrofit will include Demand Response appliances that are controlled by the HEM and the utility.

The effort launched in October 2013. The PIER Beechwood Team ("Team") is developing a baseline and VERs with construction slated for June-November of 2014. The presentation of this paper will likely reflect activities through the construction period. One year of post-retrofit energy data will be collected. LINC's Resident Services team will work intensively with residents throughout the process to encourage energy-wise behavior. The goal is to demonstrate scalable, replicable models and provide tools for implementation to multifamily property owners.[1]

Introduction

Residents of low-income housing in California often carry the brunt of allotting a higher proportion of their income to utility costs compared to other income groups. This is primarily because owners of low-income multifamily housing lack the ability to raise rents and reinvest in a property's energy efficiency. This hurdle is raised higher by the programmatic barriers owner's face in receiving regular funding for energy improvements. The Village at Beechwood (VAB), a 100-unit, low-income multifamily property in Lancaster, California, and owned by LINC

[1] Project funders include the California Energy Commission, US Department of Housing and Urban Development (HUD), and Sempra Utilities.

Housing Corporation, is one such property. The community operates with one of the highest energy indices of all LINC properties due to extreme seasonal climates (Climate Zone 14) coupled with apartment structures and HVAC equipment in need of rehabilitation and energy efficiency retrofits. As residents pay their own electricity utility bills, high costs in the summer can be financially burdensome.

In March, 2013, a strong interdisciplinary team consisting of Electric Power Research Institute, BIRAenergy and LINC Housing Corporation (with support from Kango Development), in collaboration with Southern California Gas Company, Southern California Edison and San Diego Gas & Electric, received a $1.3 million grant from the California Energy Commission's Public Interest Energy Research (PIER) program. PIER supports energy-related research, development and demonstration for research not adequately provided by competitive and regulated markets. The PIER funding, in addition to leveraged funding through grants secured by LINC, will be applied at the Village at Beechwood (PIER Beechwood Project) to help develop, demonstrate and document the steps and components needed by low-income multifamily property owners to make whole-house energy efficiency retrofits feasible using a replicable, straightforward process.

Research Scope and Methodology

The PIER Beechwood Project seeks to incorporate a suite of new technologies in residential energy efficiency into an existing low-income multifamily property to bring the property as near-ZNE energy as possible. This project looks to establish technology packages that are cost-effective, scalable, and can be adopted into new and existing utility programs including technologies that have high potential but are in early development stages. Development of the VER packages provides the PIER Beechwood Team with the ability to demonstrate the technical and financial value of a one-stop service delivery model that can be replicated and scaled as well as presented to lenders and investors.

Thirty units comprising the various unit- and building-types at the property will be retrofitted in order to provide for testing and evaluation of measure packages for units tied to individual as well as central HVAC and/or water heating systems. This project will prioritize the production of scalable and replicable measure packages that can be applied to other LINC properties and marketed to other multifamily property owners statewide.

As of the submittal of this paper for the 2014 ACEEE Summer Study on Energy Efficiency in Buildings proceedings, the PIER Beechwood Team completed the following tasks as they pertain to the 30 subject resident units:

- Developed a baseline energy model
- Administered a detailed resident energy use survey
- Configured data loggers to determine gas consumption of various systems
- Configured a comprehensive Wi-Fi plan for measurement and verification
- Developed a suite of measures that will comprise the VERs packages

With vendor selection and procurement of equipment slated to continue through June, construction is expected to commence in early-Summer.[2] An extensive Measurement and Verification (M&V) process will continue for one year post-retrofit construction.

Leveraged Funding

The PIER Beechwood Project has relied on other sources of funding to reach the target of near-ZNE consumption in addition to the $1.3 million PIER funding, particularly through grants already awarded to LINC. LINC is a part of a national collaborative group that received an Energy Innovation Fund (EIF) grant from the US Department of Housing and Urban Development (HUD). While the PIER funding is generally allocated towards the implementation of the VERs within the 30 units, the EIF grant will cover the implementation of renewable systems such as a solar domestic hot water system and a solar photovoltaic system that will offset the property's common area load (owner-paid). Lease options to cover a solar photovoltaic system to offset resident consumption are being considered in order to provide a scalable financial model for renewable energy systems that requires little up front capital.

In addition, LINC is using a grant through the Federal Home Loan Bank of San Francisco's Access to Housing and Economic Assistance for Development (AHEAD) program to provide community-wide wireless internet access which will be critical to the success of the program's M&V component by providing a viable platform for data loggers to retrieve and transmit energy consumption data.

Utility Program Coordination

To further leverage the matching grant dollars from HUD, LINC spent considerable time evaluating the feasibility of utility incentive and rebate programs that provide direct install measures as well as dollar incentives based on overall energy savings. LINC's ideal combination of utility program offerings for the project would benefit *all* 100 units at the property in one way or another, not simply the 30 units under scrutiny as part of the PIER project. Fortunately, the use of incentives offered through partner Investor-Owned Utilities (IOUs) did not preclude the use of CEC funding nor double count the amount of funding allocated to a single measure as part of the VERs packages.

The PIER Beechwood Team was challenged with identifying which combination of available programs provided the greatest ability to leverage additional resources given the proposed scope of work for the 30 units. LINC assessed the following utility programs for their compatibility with the PIER Beechwood project:

- **Energy Savings Assistance Program (ESAP)**: This ratepayer funded program is administered by SCE and SoCal Gas and provides electricity and gas-saving direct install (DI) measures to income-qualified customers at no cost. Measures can include weatherization, appliances, low-flow fixtures, and lighting. This program can be

[2] LINC will oversee construction activities related to installation of the energy efficiency measures and provide overall construction management. Based on the chosen packages, LINC will conduct a procurement process through an open RFP, both for technology vendors and contractors. Vendor selection will be based on various criteria such as cost, technical capability and future scalability. VAB provides a unique challenge in regards to construction scheduling, as a large percentage of residents are at home throughout the day. Measure selection and construction scheduling will take into account resident living patterns in order to minimize disruptions.

extended to all 100 units at VAB including the 30 units undergoing retrofits through the CEC-funded PIER program.

- **Middle Income Direct Install (MIDI)**: This ratepayer funded program provides similar offerings to ESAP but encompasses those residents whose income levels may slightly exceed ESAP limits.
- **Energy Upgrade California (EUC) Multifamily – Southern California Regional Energy Network**[3]: This program offers a comprehensive per-unit incentive based on an ASHRAE Level 2 audit and energy model and a tiered incentive structure based on percentage savings. The audit is provided at no cost to the property owner. This program requires both pre- and post-retrofit combustion safety testing; while pretesting is included as part of the no-cost audit, post-testing of all units receiving incentives will be out of pocket and can cost up to $500 per unit.[4] This program cannot be utilized in conjunction with any other utility program, including ESAP and MIDI.
- **Energy Upgrade California (EUC) Multifamily – SCE and SoCal Gas**: This program provides similar offerings to the SoCal REN-administered EUC program including a no-cost audit, no-cost combustion pretesting, and tiered incentive structure based on percentage of energy saved. However, the IOU-run EUC program does not preclude the ability for owners to utilize other utility programs such as ESAP and MIDI as long as estimated energy savings from additional programs are calculated into the baseline from which the percentage energy savings and incentive payouts will be calculated.

Ultimately, The PIER Beechwood Team decided to pursue a combination of EUC Multifamily and ESAP/MIDI administered by SCE and SoCal Gas for the following reasons:

- Participation in both programs allows LINC to receive incentives based on energy savings for work that will already be completed in the 30 units.
- Participation in ESAP/MIDI will allow LINC to implement some element of energy efficiency in all qualifying units at VAB, not just the 30 subject units.
- While participation in ESAP/MIDI may lower the overall energy baseline from which savings will be measured, measures covered through ESAP/MIDI will be at no cost to LINC (whereas a greater incentive amount may not necessarily cover the total cost of these same measures).

Physical Property Description

The 100 units at VAB are located within 28 residential buildings comprised of four 10-plex buildings of 1- or 2-bedroom units, two 8-plex buildings of 2-bedroom units, and 22 duplexes with a mix of 2- and 3-bedroom units. All of the buildings have two stories, and each unit is located on a single floor and ranges in size from 650 sq. ft. to 1,050 sq. ft. Water heating for each duplex is provided by a shared 40 gallon, storage gas water heaters. The 8- and 10-plex buildings are supplied with hot water by central boilers at each building.

[3] The Southern California Regional Energy Network (SoCal REN) is a local government regional energy network (REN) that was created by the California Public Utilities Commission and provides technical assistance, financing resources and support for project staff at public agencies to save energy and protect resources.

[4] An unforeseen cost as part of participating in EUC is that all combustion testing failures need to be remedied immediately per EUC guidelines at full cost to the property owner. While combustion testing does place unit safety at the forefront, the unforeseen costs may potentially make the overall project financially infeasible.

The resident units have an average 12 percent glazing as function of floor area. The windows are dual pane in aluminum frames. The buildings have 2 inch batt insulation in the walls and ceiling.

The built up roofs are light-colored, and each unit has its own roof-mounted package unit providing gas-furnace heating and compressor cooling. Uninsulated metal ducts drop from the air-handler on the roof into the building to the main rooms via a dropped ceiling chase, terminating in high sidewall registers. In 2nd story units the ducts are above the ceiling insulation.

Duct leakage and air infiltration were measured in six units. The average duct leakage was 32 percent of the estimated 800CFM fan-flow from the 2-ton AC units, 87 percent of which was to the outside, indicating leaky units. The average measured return flow was 689 CFM, or 86 percent of the nominal 800 CFM fan flow. The average envelope leakage was 14.1 ACH_{50}.

Unit Selection and Energy Data

Three buildings comprising 30 units were selected based on resident tenure (one duplex, one 8-plex, and two 2-plexes). Participating apartment units were selected with guidance from Property and Asset Management. While the property includes 28 total residential buildings, true energy modeling and analysis of unit performance would require whole building analysis, particularly since the larger buildings provide space and water heating through central gas boilers. Resident tenure was another key consideration in identifying participating units due to implications for utility data availability and potential lower disturbance to equipment during the M&V process, including the HEMS.

Given the regulatory barriers to collecting aggregated utility data for properties, LINC relied on its residents to grant access to utility data by signing a utility third party authorization form. LINC was able to collect approximately 80% of resident-paid electricity data (minimum 12 months) for the 30 units in question (representing some of the highest rates of resident data collection within the entire LINC portfolio).

VAB is master metered for gas and individually metered for electric energy use. While the overall energy use impact of the measures can be obtained using the metered data, the PIER Beechwood Project calls for disaggregation of loads by end use in order to identify the impact of each measure (both individually and interactively). To this end, the goal is to obtain the energy use for gas end loads (heating, water heating, and cooking) and electricity end loads (air conditioning, lighting, appliances, and plug loads). The energy use baseline is being developed using methods such as building data analytics, non-intrusive load monitoring and submetering. For gas usage, individual components such as HVAC and water heating will be measured using gas meters.

Current In-Unit Energy Use

A detailed in-person survey was developed and administered by LINC Housing's Resident Services Studio, LINC Cares, regarding the Miscellaneous Electric Loads (MELs) equipment and their usage, as well as other pertinent information, including thermostat set-points and obtaining electric utility bill information and authorization to use the data for this project. The MELs consisted of appliances, electronics or entertainment uses, and miscellaneous items including medical equipment and portable fans or heaters. The survey data was used to help refine predictions of MELs and adjust other inputs; in particular, thermostat settings. The energy use for each unit was half that of each unit-pair.

Resident surveys that were conducted as part of the energy modeling process served two purposes. First, the surveys facilitated the necessary MEL inputs into the energy model as previously discussed. Second, the surveys helped to identify where resident services may begin to tailor programming in energy and water efficiency given what people are really using and where changes can be made accordingly. Survey results included the following:

- Many residents at VAB are not working and remain at home throughout the day
- Local climate necessitates the use of heat throughout the winter and air conditioning throughout the summer
- The most prominently used MEL aside from kitchen appliances was a television and complementary devices (e.g. cable box), with an average of two televisions per unit being used for almost seven hours per day

The simulated electricity use for each of the unit types was compared to averages of electricity use obtained from the residents of each unit type during the surveys. The models showed that the estimated average electrical energy use is within 15 percent of the actual average energy use.

Baseline Simulation

BIRAenergy developed computer models of the different units as they currently exist and simulated the models in EnergyPlus, using BEoptE+ v1.3. These simulations provided a baseline for the energy use in each unit type; the baseline served both as a basis for evaluating and developing packages to produce very efficient retrofits and to validate the models and simulation results. The energy analyses of the units was done by simulating each identical upstairs-downstairs pair as a single dwelling with the total floor area and total numbers of bedrooms and baths of the two units. Similarly, the 8- and 10-plexes were modeled by individually simulating each pair of upstairs and downstairs units as a building, all with some adiabatic walls, each set referred to here as a "unit-pair." Thus, there were end-units and central units, and each type was simulated as an upstairs and downstairs pair, and the results summed to produce whole building results.

The water heating was simulated as a small gas storage water heater for each unit-pair. Each of the 8- and 10-plexes was then built-up from the simulated unit-pairs appropriate to the units contained within each building. Where possible, the existing energy-efficiency features were determined by tests or inspections, including cutting into dropped-ceiling chases to view insulation and ducts. The average measured duct leakage and air infiltration were used in simulating each unit-pair.

Developing Very Efficient Retrofit Packages (VERs)

Packages of measures are currently being analyzed to find the best VERs for this low-income multifamily property. The final packages, in addition to energy-efficiency upgrades, will include solar domestic hot water as one of the measures as well as solar photovoltaic systems (PVs) for the common areas and possibly resident loads as well. The objectives in development of VERs packages include:

- Energy savings

- Reliability and maintenance
- Availability of the measure and of trained installers
- Cost and cost-effectiveness
- Scalability into the multifamily market
- Minimizing impact of retrofitting process on residents

To develop the VERs packages, a list of potential energy-efficiency upgrades/measures for inclusion in the VERs was developed. These measures included all energy-efficiency measures that, in the consultant's experience provided significant and cost-effective savings, as well as measures requested by the client and applicable to the building and situation. Applicable on-site energy generation options were determined and added to the list. Whole-house energy savings were determined for each measure by simulating each, one at a time, and comparing energy use to the baseline. The results of this analysis provided both the optimum cost-effective value for each measure and the relative effectiveness of each. However, the results did not show any interactions between measures, interactive effects of diminishing returns, nor effects resulting in cost savings, such as equipment downsizing. The most promising, optimized building measures were simulated in small packages of the most cost-effective measures.

Given that the occupants of the housing units pay for their own electricity and gas is master-metered for the entire facility and paid by the owner, the packages were developed in four different groups: fuel-neutral, gas, electricity, and generation. Evaluations of each measure compared to the baseline, and data collected in development of the baseline indicate that key drivers of high energy use are listed in Table 1 (not in any particular order).

Table 1. Potential measures for VERs packages

Measure		Feasibility
1	Thermostat Set Point Management: residents tend to keep their units very warm (many heated up to 75°F or higher)	Not easily enforceable
2	Increased Building Insulation: both wall and ceiling insulation were minimal and of poor quality installation	Neither practical nor cost-effective
3	Insulation of Hot Water System Underground Plumbing: system is uninsulated from the boilers to the building	Being explored to determine cost-effectiveness
4	Replacement of Laundry Equipment: runs at relatively low efficiency	Not cost-effective
Measure		Feasibility
5	Replacement of In-Unit Stoves and Ovens: old and run at low efficiencies	Will be evaluated on unit-by-unit basis
6	Lighting Retrofit: opportunities to replace all incandescent lighting with LEDs or fluorescents in both resident units and common areas of property	Feasible and leading measure candidates for VERs packages
7	Sealing of Envelope Leakage	
8	Sealing of Duct Leakage	
9	Sealing and Insulation of Building to Make Ducts in Conditioned Space, or Replacement and Heavy Insulation of Ducts	

Pilot Unit

An important component of testing the feasibility of recommended measures is the establishment of a pilot unit. This pilot unit provides a forum to test the implementation of technologies comprising the VERs before taking them to scale on all 30 units. Results from the pilot tests, including predicted and measured savings, as well as actual bids for implementing the VERs in 30 units will be evaluated before being replicated elsewhere. The pilot unit project will take place within a vacant unit and is scheduled to be completed in June, 2014.

Measurement and Verification

The PIER Beechwood Team will employ detailed end-use monitoring and large scale field deployments of monitored equipment to manage the monitoring, evaluation planning and implementation tasks of the project. Data acquisition and gathering will begin at the conclusion of construction (late-summer, 2014) and continue beyond the end of the project to summer, 2015 to provide long term performance analysis. Gathered data is stored in databases that can be accessed remotely for both performance monitoring and analysis. 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 *both* whole home energy use and to evaluate performance of individual measures.

The PIER Beechwood Team also plans to use building analytics to better understand electricity and gas usage. To this end, LINC will utilize its current online energy management contracts with both Energy Scorecards and WegoWise to provide both bill visualization tools as well as analytics for each of the 30 subject units. These tools will help establish a pre-retrofit energy use baseline and will provide for regular comparisons as data is updated on a monthly basis.

Monitoring Electricity Usage

Electric monitoring will take place through both a non-intrusive load monitoring system as well as the implementation of Home Energy Management Systems (HEMS). 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 submetered using HEMS and will be used to provide a parallel comparison of the electrical loads. The submeters 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 connect 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 uses 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 set very high (74°/75° F in many homes). This does not seem to be commensurate with the electric usage, which is paid by the residents; more M&V and analysis will hopefully shed light on this issue.

Integrated Resident Engagement

LINC Cares will be leading the charge by using PIER funds to acclimate residents to their new surroundings and how to most effectively utilize the new, efficient features found in their apartments. LINC Cares has adopted the theory of behavior change as its model for developing resident programming and individualized engagement, particularly noting that each resident may be at a different stage of understanding concepts behind sustainable living. LINC Cares foresees the creation of a culture of performance around sustainability that uses several tools and strategies with the ultimate result of reducing utility costs and creating a healthier community. Rather than focusing on general statements about the energy conservation, LINC Cares will be focusing on practical, easy-to-do steps for residents to adopt sustainable behavior for the long haul that will support the retrofits that are being implemented as part of the PIER Beechwood project.

The most critical resident engagement will take place face-to-face with the residents living in the 30 units participating in the PIER Beechwood project. The resident energy use surveys have already provided insight into the energy consumption and lifestyle patterns of residents at VAB. LINC Cares will be engaging residents in person and within their own units. LINC recently hired a Resident Services Healthy and Sustainable Home Coordinator (RSHSHC) who is focused on educating residents about the various sustainable features found at LINC properties (both present and future). For those residents living in the PIER Beechwood Project subject units, individualized communication will provide LINC with an opportunity to better educate residents on how they can reach achieve optimal comfort levels while potentially consuming less energy given the higher efficiencies of the new, retrofitted equipment.

The RSHSHC unveiled the LINC Healthy Homes Challenge at VAB in April, 2014. The Healthy Homes Challenge encourages residents to partner with LINC to make a significant impact on the overall water and electricity usage at the property while using a context of the overall impact on the environment as well as individual health and habits. The Healthy Homes Challenge includes a 20 minute fun and informational video that promotes internal discussion on items surrounding the creation of a healthier community. The program's goal is to motivate residents by providing updates on overall progress that includes activities and incentives that support the adoption of a more sustainable lifestyle. Incentives are provided based on the notion that residents meet individualized and property-wide energy reduction targets, with proof shown in utility bills themselves. As with many programs that take place at VAB, only a handful of

adults participated in the Healthy Homes Challenge event. However, continuous one-on-one outreach will hopefully convince more adults to participate in the Challenge and reap some of the tangible benefits of participating, including gift cards and other monetary incentives.

Resident engagement includes property-wide "Go Green" marketing events, campaigns and messaging in various forms (flyers, announcements, yard signs, banners, stickers). Two events that will take place in June and July center on the irrigation improvements and installation of solar photovoltaic panels affecting the property's common area. These events will play a critical role in creating social norms regarding sustainability. LINC Cares has also partnered with the Los Angeles Chapter of the US Green Building Council (USGBC) to roll out *Roots for Success*, a detailed job readiness curriculum that introduces participants to career paths in industries specifically tied to sustainability.

Technological Scalability

A key component of the project is the development of a model for both technology packages and financing that enables scalability to the greater multifamily market and its low income segment. While whole building energy efficiency upgrades have been explored for many years, the main technological challenge has been incorporating the actual costs and savings of the various efficiency measures into models that provide replication. The pilot unit project is the first step to understanding the ease of implementing a single VERs package and how scalable the technology can be with a larger scope. The PIER Beechwood Project provides a research opportunity to use extensive M&V to understand how VERs packages deliver consistent performance results when implemented within various different unit types.

On the technology side, the project aims to develop the following analytics and tools for the various phases of retrofitting existing buildings:

- Various data sources to calibrate models and shortlist opportunities for improvement
- Lower cost building auditing techniques to evaluate recommended measures
- Analysis and remote audit tools to verify the impact of the recommended energy improvement measures

There are challenges to scaling the VERs packages, however, that the PIER Beechwood Project may research but not be able to solve. Identifying and implementing technology measures is only one part of the battle; the other part includes determining out how to pay for the measures.

Financial Scalability

Development of a scalable financial model is critical to the widespread applicability of VERs and near-ZNE to the rest of LINC's portfolio as well as the entire multifamily marketplace in California. Developing business models proves challenging for low-income multifamily property owners who pay for the cost of the property upgrades but operate as a cash flow business with very limited investment capacity. Because of its combination of individually metered (electric) and master-metered (gas) utilities at VAB, The PIER Beechwood Project enabled us to investigate the advantages and disadvantages of business models that prioritize either resident billing or master metered configurations. A true understanding of financial

scalability will not be available until energy savings data is made available to identify the return on investment for particular measures (which has a bearing on several of the financing tools that exist in the market).

A significant barrier to implementing energy efficiency or on-site generation projects for owners of low-income multifamily housing is the "split incentive," which affects owners at properties such as VAB whose resident units are individually-metered for utilities.[5] In low-income housing at least partially-funded by HUD, the ability to raise rents in order to recoup the initial investments in energy efficiency is controversial given the tight restrictions in place regarding maximum rents that can be charged to low-income residents.[6] Utility allowances are based on the type or quantities of energy consuming systems or appliances. The PIER Beechwood Team analyzed how various business models consider the impact of utility allowances in low income housing, namely through attempting to develop a simple set of rules and procedures to allow a trade-off between rent-caps and reduced utility costs. In this case, a property owner would collect on cost-effective improvements to the buildings via higher rents that are more than offset by lower utility costs, due to the retrofits. Adjustments to the utility allowance, in theory, could provide flexibility in implementing VERs packages in a scalable manner where an owner would still recoup its up-front investment.

The PIER Beechwood Team made initial conclusions in regards to the project's financial scalability based on early evaluations of financial tools currently available in the energy efficiency marketplace. Conversations with limited partners and syndicators of VAB involved with the property's ownership reveal a strong hesitation towards the use of tools that bring an added level of risk to the property. This risk is related to tools that rely on energy savings to help repay energy efficiency retrofits or tools that require first lien holder rights on the property.[7] While utility incentives are generally more replicable and scalable than other financing mechanisms, the PIER Beechwood Team identified risks associated with participating in programs such as Energy Upgrade California Multifamily (particularly in regards to the costs associated with the combustion safety testing requirements and the potential for corrective actions for units that fail to exceed the overall incentive received).

As an alternative solution, the PIER Beechwood Team researched the prospect of having LINC take over electricity meters while submetering individual units. A HEMS would submeter the individual residents both for electric usage and to allocate the benefits of a solar PV system that offsets resident consumption through virtual net metering; LINC would facilitate the billing of all residents. However, there are no controls in place regulating individual resident energy consumption, and trends have shown that residential consumption increases significantly if residents are not required to pay for utilities. The risk associated with increased consumption and overall cost is too great for LINC to bear from an asset management perspective. Furthermore, resident utility billing would add another layer of risk to LINC as an owner, particularly since

[5] With a split incentive, an owner invests capital in energy efficiency measures that impact resident units. Residents, in turn, reap the benefits of more energy efficient apartments and lowered utility bills while the owner does not recoup the energy savings to help offset its up-front investment.

[6] At VAB, the maximum amount paid by a resident includes rent plus utilities and cannot exceed 30% of the household's income; the amount deemed appropriate for utilities is based on a utility allowance that is provided to residents monthly and is based on resident-paid energy uses within apartment units (as mandated by the Housing Authority of the County of Los Angeles. Microclimates within the County (e.g. Lancaster/Antelope Valley) or actual energy efficiency is not taken into account.

[7] Financing tools that will continue to be evaluated include Energy Services Companies (ESCOs), Property Assessed Clean Energy (PACE), Power Purchase Agreements (PPAs), and utility bill On-Bill Financing (OBF).

LINC would not have the ability to collect on missed utility payments similar to utility companies (i.e. LINC would not have the ability to shut off utilities or evict residents based on non-payment of utilities).

As a second alternative, the PIER Beechwood Team analyzed how a utility allowance adjustment, if a permitted option, would be financially viable. The California Utility Allowance Calculator (CUAC) is an alternative to the default utility allowance calculated by the local housing authority for new construction and some substantial rehabilitation projects.[8] In the case of VAB, current housing authority utility allowances for individually metered resident units range between $22 for a 1-bedroom unit and $30 for a 3-bedroom unit. The average resident electricity bill for any given month throughout the year is $45, which is greater than the current utility allowance; utilization of the CUAC would likely result in utility allowances being closer to the $45 per month figure. In this case, a higher utility allowance using CUAC works as a disincentive to LINC as a property owner, as an adjustment would also result in less rent collected.

Conclusion

Given space constraints, this paper does not delve into all aspects of the PIER Beechwood Project. There were several other lessons learned throughout the pre-retrofit stages of the project that had to be evaluated and overcome. The project team encountered challenges when attempting to utilize a community-wide Wi-Fi system to accommodate an advanced M&V need for monitoring gas consuming uses on the property. Also, LINC Cares had to carefully consider how resident engagement focused on how residents adapted to new technologies as well as how to deter vandalism of new equipment that would be quite visible throughout the property. As the project moves into the retrofit/implementation stage, the PIER Beechwood Team expects to gain clarity on some of these additional concerns that will help guide future endeavors that will take on these complex technological approaches and utilize the extensive M&V being completed.

Retrofitting a low-income multifamily property to be near-ZNE necessitates much more than the implementation of a package of measures. This project continues to conduct the research needed to help facilitate the seamless integration between aging buildings, new technology, and the low-income residents. At project's end in 2015, the PIER Beechwood Project will have a model for implementing whole-house energy efficiency retrofits that, at minimum, has evaluated the barriers facing low-income, multifamily owners and fully examines the efficacy of developing scalable technologies and financing models for a historically underserved market. Utilities have long struggled with making successful programs to improve the efficiency of low-income housing. Research funding has long been needed to research, develop, demonstrate and deploy the steps to successful retrofits in low-income multifamily properties. This project is designed to achieve this goal, which cannot be done 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.

[8] CUAC bases a project-specific utility allowance on the scope of work for energy efficiency or generation on-site.