Mosaic Gardens New Construction, Low-Income Multifamily ZNE

DR15.21 Final Report

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ABBREVIATIONS AND ACRONYMS

ACH	Air Changes per Hour
CAT5	Category 5 cable is a twisted pair cable for computer networks
CCSF	Closed Cell Spray Foam
CEC	California Energy Commission
EPRI	Electric Power Research Institute
FCU	Fan Coil Unit
HVAC	Heating, Ventilating and Air Conditioning
IR	Infrared, or Infrared image
ISP	Internet Service Provider
LEED	Leader in Environmental Design
LINC	LINC Housing
LIMF	Low-Income Multi-Family
Ducted Mini-Split HP	Small, single unit Heat Pumps, known as Ducted Mini-Split Heat Pumps, usually with very minimal duct runs
OCSF	Open Cell Spray Foam
PV	Photovoltaic (modules): Silicon based panels used to generate electricity from the sun
R (value)	Insultation R value measures how well building insulation can resist heat
"Smart"	A device that communicates with other devices
T-Stat	Thermostat
ZNE	Zero Net Energy: A building that produces as much energy as it consumes in a year.
SCE	Southern California Edison
M&V	Monitoring and Verification

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EXECUTIVE SUMMARY

This project is an in-situ demonstration of how selected emerging technologies are installed and how they perform in a low-income multi-family building setting. It is a collaboration between SCE, California Energy Commission, EPRI and LINC Housing, which is the building developer with a long history in California.

SCE became interested in this project because of the opportunity it presented to guide future program planning and construction practices in the multi-family new construction market, with a particular interest in underserved low-income customers. This was a necessary project since there was still only minimal guidance on the particular emerging technologies installed through this project, and none that focused on the low-income housing market.

The SCE team's approach to this project was shaped by circumstances before Edison became involved. The building owner designed this building to comply with Leader in Environmental Design (LEED) Platinum construction. The owner contacted SCE about participating in modeling and construction, as well as supplying rebates, to help this project stretch even further and achieve ZNE status. Because construction drawings were complete when SCE became involved, certain earlier work had to be redesigned to include the energy efficiency measures proposed by SCE's SME. Nonetheless, SCE saw an opportunity to test the possibilities for achieving ZNE in this sector and to additionally field test certain emerging technologies and best practices in the building envelope.

The project has been a success on many fronts, and problems that were encountered have been documented and offered as lessons learned for moving forward. Findings from this project will be used to inform future SCE program design and information dissemination with building trades. The project has yielded information that CEC will evaluate in developing new Title 24 standards. EPRI is collecting and analyzing indispensable plug load energy usage information it will share, which will help analyze building performance and occupant behavior which could reveal opportunities for demand response at this site.

INTRODUCTION

The Mosaic Gardens project demonstrates how innovative Zero Net Energy (ZNE) measures can be effectively adopted in new construction. This in-situ analysis focuses on the underserved low income multifamily (LIMF) market. When this project got underway in 2015 California's statewide Big, Bold Goal of cost-effectively achieving ZNE in the residential sector by 2020 looked very difficult.

This project reports one set of measures that shows how a California multi-family residential construction project achieved this status for a portion of its facility. At the outset, the building owner was focused on achieving Leadership in Energy and Environmental Design (LEED) with Platinum level certified construction. The owner requested that SCE help undertake and incentivize additional building design modifications and measures to reach ZNE stats.

The project is a collaboration between SCE, California Energy Commission, EPRI and LINC Housing which is the building developer. LINC has a 36-year history of building homes for families and seniors, specializing in the low-income segment throughout California. LINC Housing is a participant in the U.S. Department of Energy's Better Buildings Challenge and has continued constructing new apartment complexes to very high efficiency standards. LINC asked SCE to test new whole building technologies and materials with the goal of improving the building's energy use performance. LINC also took advantage of SCE's available rebates and incentives as part of this project.

SCE stakeholders include the Emerging Technologies Program, Emerging Markets and Technology, the Savings by Design group, and the Codes and Standards group. Together, these groups support projects that investigate opportunities for greater grid flexibility and resiliency through advancement of demand response, distributed energy resources and market transformation.

The CEC has been working with SCE and the state's other utilities over consecutive three-year building code cycles to incrementally tighten Title 24 energy standards. The end goal is residential and commercial energy codes consistent with ZNE performance standards. The CEC provided grants for EPRI to install monitoring equipment on all circuits in the building, tracking individual plug loads throughout the complex.

Together, these stakeholders leveraged multiple resources to investigate energy efficiency and demand response opportunities, helping the owner identify and choose measures that qualify for incentive payments and reach energy goals in a cost-effective manner. The SCE team has remained active in supporting the project throughout the design, construction and M&V process.

BACKGROUND

The largest percentage of new residential construction in California is now multi-family buildings. Much of this new housing stock is targeting a long-overlooked segment: low income tenants. State and Federal programs are offering incentives to developers to encourage high efficiency building construction in this sector.

This project provided SCE with a real-time in-situ opportunity to demonstrate how innovative ZNE measures can be effectively adopted in this segment. The knowledge acquired provides information on implementation challenges that can be a barrier to ZNE construction. An additional goal of the project was to conduct post-occupancy field testing to evaluate opportunities for provide demand response at a later date.

MOSAIC GARDENS FACILITY

Mosaic Gardens, located in Pomona, California, is a new three-story low-income multi-family residential development consisting of forty-six apartment units constructed on an infill lot. The apartment units vary in size from one to three bedrooms. This community serves tenants that are low-income, with half the units designated for displaced residents. Below the building is a 22,245 square feet subterranean parking garage for 51 vehicles. This is an all-electric building except for natural gas used for clothes dryers in a common laundry room and a roof-mounted domestic hot water system that utilizes two natural gas boilers and an insulated storage tank.

ZNE CONSTRUCTION

The central purpose of this project, from the perspective of the owner, was to bring the Mosaic Gardens up to ZNE status. SCE had an additional objective of field testing certain emerging technologies. ZNE buildings meet their overall net energy consumption through smart building technologies and practices with the balance of the energy needed coming from on-site renewable energy. Total annual energy use in a ZNE building should not exceed the amount generated on-site by a renewable resource.

SCE became involved in this project after the initial construction design had been completed. Although the building was on track to meet LEED Platinum standards, early decisions were made that complicated prospects for achieving ZNE without making design changes. SCE was not part of the project team early enough to the first design decisions.

LINC had been mostly unaware of how advanced framing possibilities could have resulted in a building that is more energy efficient. The owner opted for an envelope framing design with standard framing details in their construction. This included six-inch exterior walls. They did, however, utilize some of the advanced framing on the partition walls with 2x4 staggered studs and 2x6 exterior walls with 16" on center spacing. The 16-inch spacing could have been moved to 24-inch had they opted for more advanced framing. Framing details around the windows created a large area with minimal insulation and significant thermal short circuiting.

EMERGING TECHNOLOGIES

The central purpose of this collaboration was to bring this LEED Platinum building up to ZNE performance before it was completed. SCE's additional interest was in testing emerging technologies that could improve energy performance. An integrated approach was adopted to serve both purposes by incorporating efficient materials and technologies that are not yet widely utilized.

BUILDING ENVELOPE MEASURES

Multi-family developers typically construct buildings that meet minimum standards for Title 24 code. Numerous emerging technologies were considered before the chosen energy measures were installed.

Project plans were submitted to the City of Pomona in 2015, prior to adoption of the 2016 Title 24 code. This project still fell under the jurisdiction of the 2013 code which specified 2x4 wood framed walls with R-13 fiberglass batt insulation.

Low-income new apartment buildings constructed today must meet or exceed 2019 standards. This project specified high-performance building envelope measures to maximize building efficiency and minimize installed cost to help garner the highest return on investment possible while still achieving ZNE.

A particular challenge at this site was the building's architectural features that were difficult to insulate and seal properly. These construction details added multiple layers of subcontractor effort that had to be carefully coordinated by the site Superintendent. They pose a potentially high risk as energy loss areas from thermal shorts and excessive air leakage in the form of infiltration and exfiltration depending on the stack effect cycle.

Closed Cell Spray Foam Insulation

Closed cell spray foam insulation is a high-performance building envelope measure that was used on the exterior building walls, partition walls between apartments and the top floor attic. CCSF insulation was selected for this project because of its excellent thermal properties, its structural shear value and clear superiority to fiberglass batts, blow-in fiberglass, open cell spray foam and others forms of insultation still in common use.

CCSF is one of the few insulations that can be used in 2x4 wall framing in conjunction with the proper exterior rigid insulation to meet the CEC's applicable Title 24 energy code requirement. CCSF gets its high R-value from the billions of tiny bubbles ensconced in the material. These are filled with gas produced from a chemical reaction that occurs when the two chemicals are mixed to activate the foam.

The R-value of CCSF is 6.5 to 6.9 per inch depending on project conditions. Conventional open cell spray foam (OCSF) has a much lower R-value of 3.9 per inch. Additionally, it is not waterproof and does not provide any structural strength, though if installed thick enough can aid in reducing air infiltration. Both OCSF and fiberglass insulation require thicker applications to meet R-value building envelope requirements. Due to its inability to air seal the building envelope and the thermal convection it allows within the framing cavity, fiberglass insulation needs to be de-rated 10-20% when considering its actual performance in the field.

Prior to this study, fiberglass batt was the dominant choice in building construction. Even today, CCSF is not yet widely adopted by home builders, most likely due to its higher initial cost, although on a lifecycle cost basis it is clearly superior. CCSF had not previously been tested in low-income multi-family buildings that are several stories tall, and this project offered SCE a good opportunity for an in-situ analysis of its application and performance.

Cool Roof

A CCSF-base cool roof was installed for solar reflectance of infrared and ultraviolet wavelengths to minimize heat transfer to the building. Cool roofing is superior to standard roofs that bear the heat of full sun and temperatures that can exceed 100°F over ambient temperatures. When a roof gets this hot, it conducts heat much more readily into the attic, increasing the air conditioning load. A cool roof is only 5°F – 10°F higher than ambient temperatures, helping to reduce the load on the HVAC equipment, thus also increasing its life expectancy and decreasing life-cycle costs. Additionally, cool roofing provides improved thermal emittance, which is the ability to radiate absorbed non-reflected solar energy.

The reflective finish used on cool roofs has minimal insulation value of its own, but the several inch thick CCSF base adds additional R-value and shear strength to the roof. The use of CCSF increased the R-value of the roofing assembly overall and made the roof much stronger than conventional roof installations. CCSF has been successfully used in sealed attics in hurricane prone areas to reduce building damage during storm events.

Ducted Mini-Split Heat Pumps

Individual ducted mini-split heat pumps had been planned to be installed in all 46 apartments and in two zones within the Community Center prior to the stage at which SCE became involved. SCE proposed to install the highest possible SEER rated units available at the time, which they did. The technology has been generally shown to possess high heating and cooling capacity. It incorporates inverter-driven compressors and variable-speed fans, with minimal ductwork required. The distributed nature of these heat pumps offer several advantages, including eliminating the need to shut an entire HVAC system down for HVAC repair or maintenance.

Smart Communicating Thermostats

The SCE project team chose smart, communicating thermostats to replace the base design of the existing thermostats specified by the building owner before SCE became involved. The new wireless thermostats are collecting data for current and future research purposes, including energy use measurement and performance verification. At a later date these thermostats could be programmed to test demand response capabilities by controlling heat pump electrical draw following ADR signals. For now, these thermostats are collecting valuable data to inform future design.

The new thermostats communicate with each other in a mesh-network style configuration and can be programmed to perform load shifting. They record run time and temperature histories for accurate real time identification of issues and can notify the management and/or the HVAC maintenance contractor which means immediate notification and quick resolution of any problems.

Smart communicating thermostats are a fast-growing market, both in terms of the number of units sold and the number of firms offering competing products. Today's smart thermostat market is less than ten years old and is part of a larger consumer-driven Internet-of-Things trend of ever greater connectivity and automation. The industry continues to innovate, providing an increasing number of features that include advanced heat pump controls and energy management that are an element of achieving ZNE building status.

RENEWABLE GENERATION

The renewable generation on this project is a 34-kW rooftop PV array to serve the Community Center. This array was not sized large enough to allow the 46 apartments in the building to reach ZNE. It would have required a PV array nearly double in size to fully meet ZNE for the entire project. For now, the Community Center has achieved ZNE status and the remainder of the building is ZNE ready.

ASSESSMENT OBJECTIVES

The focus of the field assessment at Mosaic Gardens is the construction and performance of selected emerging technologies. The assessment was intended to explore issues surrounding identifying challenges and lessons specific to each. These include everything from HVAC sizing to tenant behavior to equipment connectivity issues. This report documents the field experience and reports lessons that are helpful in accelerating measure adoption.

This assessment will help SCE and other stakeholders gain confidence that the selected emerging measures and equipment are worth adopting, and to anticipate the kinds of problems encountered in this study. The assessment yields recommendations contained in the final chapter for future dissemination to trade allies, research and education. These findings will additionally inform the CEC as it develops new multi-family building codes.

TECHNICAL APPROACH

This was essentially a construction project that involved the installation of several emerging technologies. The technical approach was shaped by circumstances before SCE became involved. The building had been designed with important features that would have helped it achieve LEED Platinum status. The new challenge was to identify and incorporate additional measures and equipment that could elevate the building to ZNE status. The project offered SCE an opportunity to learn from the design and construction of these new elements. Key elements of the technical approach are described below.

DUCTED MINI-SPLIT HEAT PUMPS AND SMART THERMOSTATS

Energy efficient ducted mini-split heat pumps were specified in each of the apartments and the Community Center as an element of the owner's original construction project consistent with LEED building practices. These are an efficient heat pump models, and a decision was made to keep the units in place. The thermostats, however, were all replaced with wireless state-of-the-art smart communicating thermostats as part of SCE's recommendation to achieve ZNE and demand response capabilities.

The heat pump condensing units are located on the roof of the building and fan coils are located above the ceilings in each apartment and the Community Center. The fan coils and condensing units are connected by refrigerant piping and low voltage control wiring.

Figure 1 at right illustrates a typical configuration installed at the site. The condensing unit is shown on the lower left, which is installed on the roof. The ducted fan coil unit (FCU) is shown on the upper left of the diagram.

These are installed in a central location in the hallways in a soffit above the ceiling in each apartment, with ducts that extend to the rooms of each apartment.

Figure 1: Heat Pump System

Some rooms are conditioned without the need for a duct because of the location of the ceiling unit. The FCU's are accessible through a return grille/hatch located in the hallway of each apartment, directly below the FCU.

The installed rooftop HVAC condensing units are shown in Figure 2. This installation includes a raised curb with sheet metal caps supporting the condensing units.

Refrigerant lines and electrical service and control cabling is extended through the roof through a sealed sheet metal roof jack.

Figure 2: Ducted Mini-Split Heat

The smart communicating thermostats were installed to replace the original factory thermostats. They have advanced capabilities that include the ability to respond to OpenADR signals that can later enable demand response program participation.

The HVAC contractors had no experience installing and connecting these thermostats to the heat pumps because this is such a new technology. One purpose of this project was to learn about the kinds of problems that could be encountered and how they were overcome.

As it turned out, several difficulties were encountered, described in the next section. In addition to technical problems, tenant behavior created complications that impinged on optimal performance of the HVAC systems.

A wireless gateway was installed to help the thermostats communicate. It was initialized into a portal that provides additional control and monitoring of individual heat pumps.

The wireless communication between the gateway and each of the thermostats is part of a secure self-healing wireless net. Tenants do not need to have their own internet because the thermostat portal is served by a common internet connection in the building.

Figure 3: Wireless Gateway

This can be extended for some distance provided that thermostats are within range and there is no interference to inhibit communications. The portal was constructed in the communications closet located in the Community Center.

The thermostats utilize mesh network communication, represented in Figure 4. This reduces the amount of hardware required for successful data collection and transmission to the dashboard website.

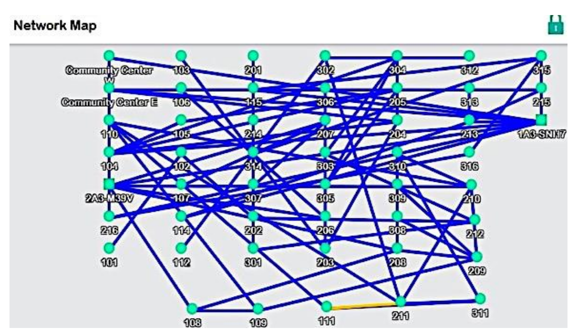

Figure 4: Mesh Network Map

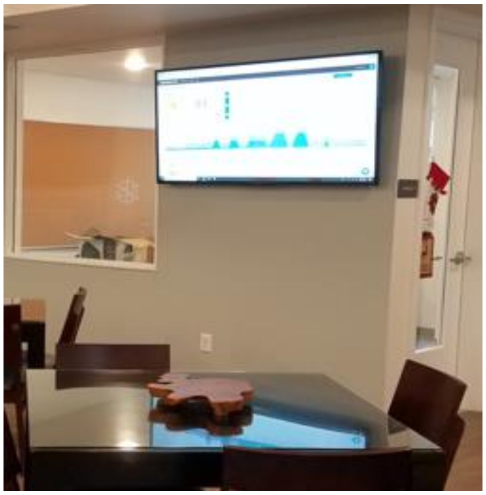

Figure 5: Dashboard Display in Community Center

Dashboards for the thermostats allow a quick overview of individual apartments and all the units in the multi-family building complex.

The dashboard is prominently displayed in the Community Center, shown in Figure 5, to keep tenants interested in the subject of energy use and mindful of actions they can take to keep their electric bills low.

Building management can utilize the dashboard to keep track of the status of each unit in the building. It indicates whether each unit is running heat or air conditioning, and whether there is any malfunction.

Figure 6 shows temperature and energy use over a six-day period. The dashboard also allows users to view this information on an hourly basis.

Individual dashboards for building tenants have advanced features and allow customization to reduce energy use. The dashboard has a menu that can be personalized by individual tenants. They can select setting such as vacation mode, shown in Figure 7 below.

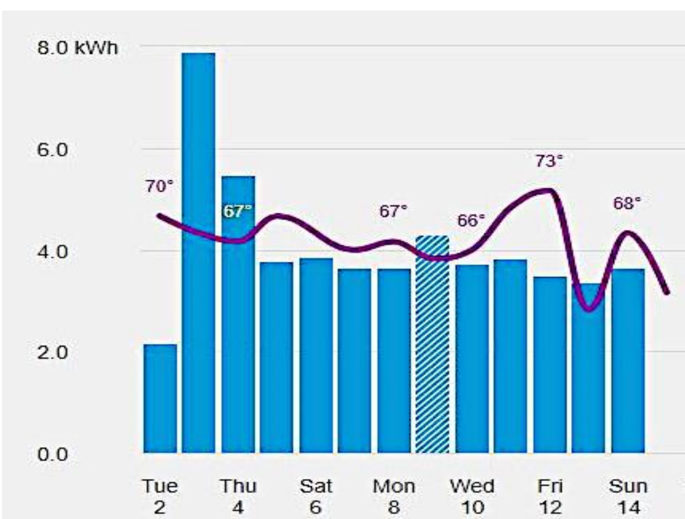

Figure 6: Temperature versus Energy

Figure 7: Vacation Mode on Thermostat

BUILDING ENVELOPE MEASURES

The design features of the building envelope were consistent with LEED practices and beyond. It was determined that additional insulation and air sealing would be required to bring the envelope up to ZNE compliance. The SCE team modeled the building envelope using various scenarios to assess how to cost-effectively meet Title 24, Part 6 of the California Energy Code. This modeling used energy consumption and other data to estimate the means of meeting the code.

Figure 8: Insulation Challenges

The building's architectural features were challenging to insulate and seal properly. These features, while visually attractive, are vulnerable to energy from thermal shorts and excessive air leakage in the form of infiltration and exfiltration depending on the stack effect cycle. Closed cell spray foam insulation was selected as the best option to insure an airtight, insulated envelope.

Figure 9: CCSF Foam Insulation

CCSF has excellent thermal properties. It also has good structural shear value and is clearly superior to fiberglass batt insulation which is still dominant throughout the construction industry.

Figure 10: Thermal Imaging

This was used on the exterior building walls, the partition walls between apartments and the top floor attic. Figure 9 shows CCSF installed between units, with a staggered-studded framed wall.

A cool-roof coating was applied to protect the structure from ultraviolet rays and make it strong enough to support the weight of maintenance staff. A cool roof is defined by its reflective finish.

The finish does not provide insulation on its own, but the use of CCSF helped the total assembly tightened the building. Figure 10 shows thermal imaging used to identify deficiencies before construction was completed.

SOLAR PV ARRAY

The building required a source of renewable energy to attain ZNE status. Rooftop solar PV was installed as the source that would serve the building. A 34-kW rooftop PV array brings the Community Center of the building up to ZNE. Additional solar PV would be needed to be needed for the entire building to qualify as ZNE.

Figure 11: Solar PV Array

ENERGY STAR

Energy Star refrigerators and dishwashers were installed in all units, and energy-efficient washing machines and dryers were installed in the community laundry room. Energy Star continuous exhaust fans were installed in the bathrooms to meet energy code requirements for fresh air as specified in ASHRAE 62.2.

LIGHTING FIXTURES AND CONTROLS

Warm white LED lighting was installed throughout the building premises. They were installed inside all of the apartments, in the Community Center and for outside area lighting. Daylight sensing controls were installed in the common areas, including hallways and grounds. Additionally, window shades with metal slats were installed on several key orientations of the building to serve as a low maintenance passive energy saving measure.

BUILDING-WIDE METERING

SCE managed the installation of the EPRI-supplied plug-load monitoring equipment on all circuits throughout the entire complex. Each individual electrical circuit is monitored in each apartment and in the common areas. Lights and outlets within the apartment units were wired so they could be monitored separately.

Figure 12: Meter Base for the 46 Apartments

Figure 13 shows the meter base for the 46 apartments. This data will be analyzed by EPRI used to develop customer and measure profiles and identify opportunities for demand response.

RESULTS AND DISCUSSION

The ZNE aspects of construction for the project are complete and all building systems are operational. The SCE team has been able to study the various technologies in a low-income multi-family building setting. The project has yielded information that CEC can consider in developing new standards. EPRI is collecting and analyzing indispensable energy usage and building performance data that will be released once completed. The project has been a success on many fronts, and problems that were encountered have been documented and offered as lessons learned for others considering a project of this type.

DUCTED MINI-SPLIT HEAT PUMPS

REFRIGERANT LEAKAGES

A new series of split system heat pumps were installed throughout the building and were studied to determine their effectiveness and reveal lessons for future projects. They are performing very well, but a few issues arose. Installers were working with a type of refrigerant piping with a metric flared fitting that they were unfamiliar with. After the units were occupied several of the systems leaked refrigerant charges and were unable to maintain setpoint temperatures. This was flagged as the smart communicating thermostats logged temperature profiles and run times. This information was provided to HVAC technicians, and necessary changes were implemented.

SYSTEM OVER-SIZING

It became evident that the heat pumps installed at Mosaic Gardens could have been sized smaller than specified in the original design. This was a result of the superior building envelope measures, in particular CCSF insulation which made the building tighter and more highly insulated than originally designed before the SCE team became involved.

LOCATION OF HEAT PUMPS

The RTUs of the heat pumps installed at this project send exhaust air out the side of each condenser. The PV arrays on the building's Community Center could have been built above the RTU compressors, shading them from direct sun. This would have made it possible to expand the size of the PV system and yield greater RTU efficiency due to shading and its positive effect on equipment life.

Problems Achieving Setpoint Temperature

In some cases the heat pump units were slow to achieve setpoint cooling and heating temperatures. This was a particular problem when construction was ongoing and concrete slabs were not fully cured. Additionally, tenants were sometimes leaving windows open during cold nights which made it difficult for the heat pumps to restore room temperatures. This highlights the importance of educating residents about how behaviors that can increase their energy cost.

Smart Communicating Thermostats

Operational Issues

The wireless thermostats installed through this project are operating well and providing tangible value. Tenants are enjoying consistent and comfortable space heat and cooling in addition to energy savings. The thermostats are able to troubleshoot problems and expedite correction and warranty call backs. Building management now receive emails with notification of mechanical failures and resident behavior that impinges on proper heat pump operation.

A situation during the winter of 2018 provides an example. A unit with low refrigerant charge was unable to achieve its 76º setpoint. Over the course of three days information was sent via text to the HVAC technician prior to a site visit. Figure 13 illustrates the situation on day 1. The team was able to observe this problem remotely and call for service. The technician picked up the needed refrigerant on the way over, saving time for both the contractor and tenant. The building management was delighted with having a tool they could review this kind of information. Many service calls can and are being solved in this manner.

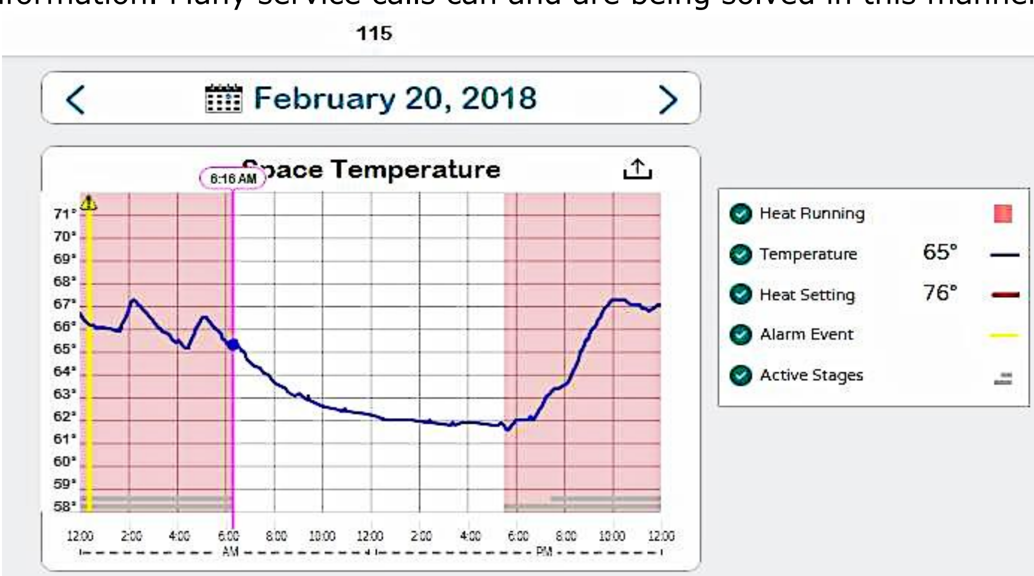

Figure 13: Identification of Problems Over the First of Three Days

DEFECTIVE EQUIPMENT

Once the smart thermostats were connected to the heat pump fan coils and power was restored, the thermostats started controlling the heat pumps autonomously. At the fan coil, the smart thermostats provide a control interface to replace the existing heat pump board where the thermostat wiring is landed. In a few cases, the boards were defective out of the box and needed replacing.

WIRELESS GATEWAY

A few issues complicated installation of the wireless gateway. During the setup and monitoring of the portal it was discovered that a few thermostats were not reliably communicating. A thermostat gateway repeater was installed inside a remote communications cabinet where installers faced competition with other building systems for limited hub ports and had difficulty initializing the smart thermostat port. Connectivity through the ISP to the internet and reliability problems with the existing CAT5 cabling from the connection hub to the ISP switch were encountered and cabling terminations needed to be redone.

FEEDBACK ON PORTAL

Property management personnel reported a positive experience with the thermostat tool when they began using it to communicate problems and address tenant complaints. Such problems are now routinely rectified through the portal without a need to visit the dwelling. The on-site property manager can make remote changes to setpoints and other parameters without the need for an in-person visit.

ADDITIONAL FUNCTIONALITY

The project encountered delays with the data monitoring system and getting the portal online to track energy usage through a centralized portal kiosk. The wireless thermostats have the capability of providing residents with information on their usage patterns to help them make economic decisions about their energy usage and participation in demand response incentive programs. The smart thermostats have embedded OpenDR capabilities although they have not yet been tested through that medium.

BETTER COORDINATION OF INSTALLATIONS

Ideally the wireless communicating thermostats would have been installed at the same time the heat pumps went in. However, the SCE team did not have the approvals required at this stage. Likewise, it would have been preferable for the control logic boards to have been installed in the fan coils prior to putting up the ceilings. The thermostat wiring from the fan coils could have been installed before the drywall and eliminated the need for extra paint and patching.

In nearly half of the cases, holes left over from the original thermostats were visible and too large to be covered up with thermostat base plates. As the installation contract did not cover paint and patch, another contractor performed these minor repairs shortly after the new thermostats were installed.

Resident Education

Each tenant is billed separately under a reduced residential rate. A couple of factors have delayed tenant education on how to make the best use of their systems. One problem has been multiple changes in building management personnel. New staff are not fully schooled in procedures and were hired after the installation stage of the project. Consequently, many tenants remain unaware of the benefits of their wireless thermostats or how uniquely their building is constructed.

Foundation for Future Demand Response

The thermostats used in this project replaced the original thermostats specified by the building owner. These new wireless smart communicating thermostats will enable future participation in demand response events using their built in OpenDR capability.

Building Envelope

Construction Delays

The project construction team found that the time required to install CCSF insulation was longer than expected and this impacted the construction schedule for other trades working in the building. About two additional weeks were needed to complete the CCSF installation, which should be considered in future projects. However, if this were known up front, scheduling adjustments within and between the various trades could have eliminated some or all of this delay.

Tenant Feedback

The tenants at Mosaic Gardens have shared their experience living in apartments that they say are much quieter than other places they have lived. In fact, the residents with apartments that abut the street were the most likely to notice how especially quiet their homes are. This is due to the enhanced building envelope which includes CCSF insulation, windows and doors that exceed code, and excellent air sealing.

ARCHITECTURAL DESIGN

The early architectural design prior to SCE involvement did not include advanced wall framing or consideration of thermal shorting issues in the context of energy savings. The windows have the appearance of being inset and have 6" to 8" of solid framing lumber surrounding them.

There are additional sills, trimmers and solid wood filler underneath the headers where not actually necessary. This is an inefficient design that is not uncommon in new construction of both single and multi-family structures. Future projects should give greater consideration of the thermal properties of the building envelope in an architectural design.

ZNE CHALLENGES

The challenge in this project was to figure out how to achieve ZNE in a building that is stacked three stories high. One problem is that the roof space was not large enough to support an adequately sized PV array that fully met renewable on-site needs. The building was constructed on a small city lot with existing buildings around it.

The project owner did not have sufficient budget to install a PV array large enough to offset total energy use to achieve ZNE status for the entire building. Only the building's Community Center and common areas are served with solar PV. The estimated peak load for the entire building is 67-kW which is well above the 34-kW that was installed. A design team could configure the rooftop equipment in such a way as to maximize the PV array size, which could help. Additional roof space over the atrium would likely be required to meet ZNE throughout the project. Any additional work should be based on a lifecycle cost analysis.

CONCLUSIONS

This project had many successes and a few setbacks as described in this report. It represents an important step toward understanding how California's multi-family low-income residential new construction market can move toward ZNE. It established that several emerging technologies can perform well both individually and even better collectively. A ZNE building is becoming easier to achieve with the new building materials and top-of-the-line mechanical equipment, lighting, and other measures that reduce the building loads and demand, then matched with enough PV to meet average annual electrical loads.

The ducted mini-split heat pumps installed in the building are providing consistent and comfortable heat and cooling to tenants, and also reducing energy cost. They could have been sized smaller if it was known at the time that advanced envelope measures would be implemented. The heat pumps are communicating well with the smart communicating thermostats once certain glitches were resolved. The smart thermostats installed in this project are a new technology. A few problems emerged, such as the need to fabricate new logic boards, but they were successfully addressed. Overall, the smart thermostats are delivering good value in remotely managing the 48 heat pumps in the building. CCSF was found to be a cost-effective insulation option when evaluated on a lifecycle basis. It tightened the building so well that it later became clear the heat pumps are now slightly over-sized

The project provides a foundation for additional research to test demand response capabilities in this underserved sector. The project did not advance to the stage at which demand response participation was an option. Nonetheless, the thermostats have been installed and may be used for research at a later date. They can be programmed to load shifting mode to reduce electricity demand in response to an OpenADR signal.

RECOMMENDATIONS

1. PERFORM ADDITIONAL RESEARCH TO ASSESS DEMAND RESPONSE CAPABILITIES

a. SCE could field test the smart thermostats installed through this project to reduce electricity demand in response to an OpenADR signal.

b. SCE could leverage the metering data that EPRI is collecting on each circuit throughout the building to estimate demand response potential. SCE could assess whether the battery storage installed in the building (not yet operational) could be a useful demand response resource by studying operational profiles.

2. ACHIEVING FULL BUILDING ZNE

a. The initial plan was to install 67-kW of solar PV to serve the entire building. This was scaled back to 34-kW due to the owner's inability to fund sufficient capacity to serve the entire building. Additional solar arrays would require additional architectural design and construction. The design team could configure the rooftop equipment in such a way as to maximize the PV array.

3. COMMISSIONING

a. Commissioning should be conducted as well as ongoing maintenance. If the maintenance crews are trained to keep equipment, particularly the ducted mini-split heat pumps, tuned up to factory specs the savings originally calculated and demonstrated through data monitoring could be maintained long-term.

4. DISSEMINATE LESSONS

a. SCE and other stakeholders should be provided with guidance based on the lessons described herein to inform future program planning and provide CEC with information to support Title 24 standards. SCE should share this information with the Emerging Technologies Program, the Emerging Markets and Technology group, the Savings by Design group, and the Codes and Standards group.

b. SCE should share lessons from this project with building owners, construction companies, architects, engineers, lenders and HVAC contractors. Two examples of critical information that should be shared are – (a) the importance of using lifecycle cost calculations to support larger loans and (b) greater consideration of the thermal properties, particularly loss of efficiency, stemming from architectural design flourishes.

4. Educate Mosaic Gardens Property Management and Tenants

a. Facilities and management staff should be educated about the building they are responsible for. This should cover several areas, including the importance of keeping equipment tuned to factory specifications to ensure long run savings. All too often this is over-looked and energy savings decline precipitously.

b. Tenants have exhibited behaviors such as leaving windows open in adverse weather conditions that made it difficult for the HVAC system to maintain baseline temperature. Tenants pay their own utility bills and need specific information to make informed decisions. Residents would benefit from additional education to take greater advantage of the special features of their building, particularly the smart communicating thermostats.