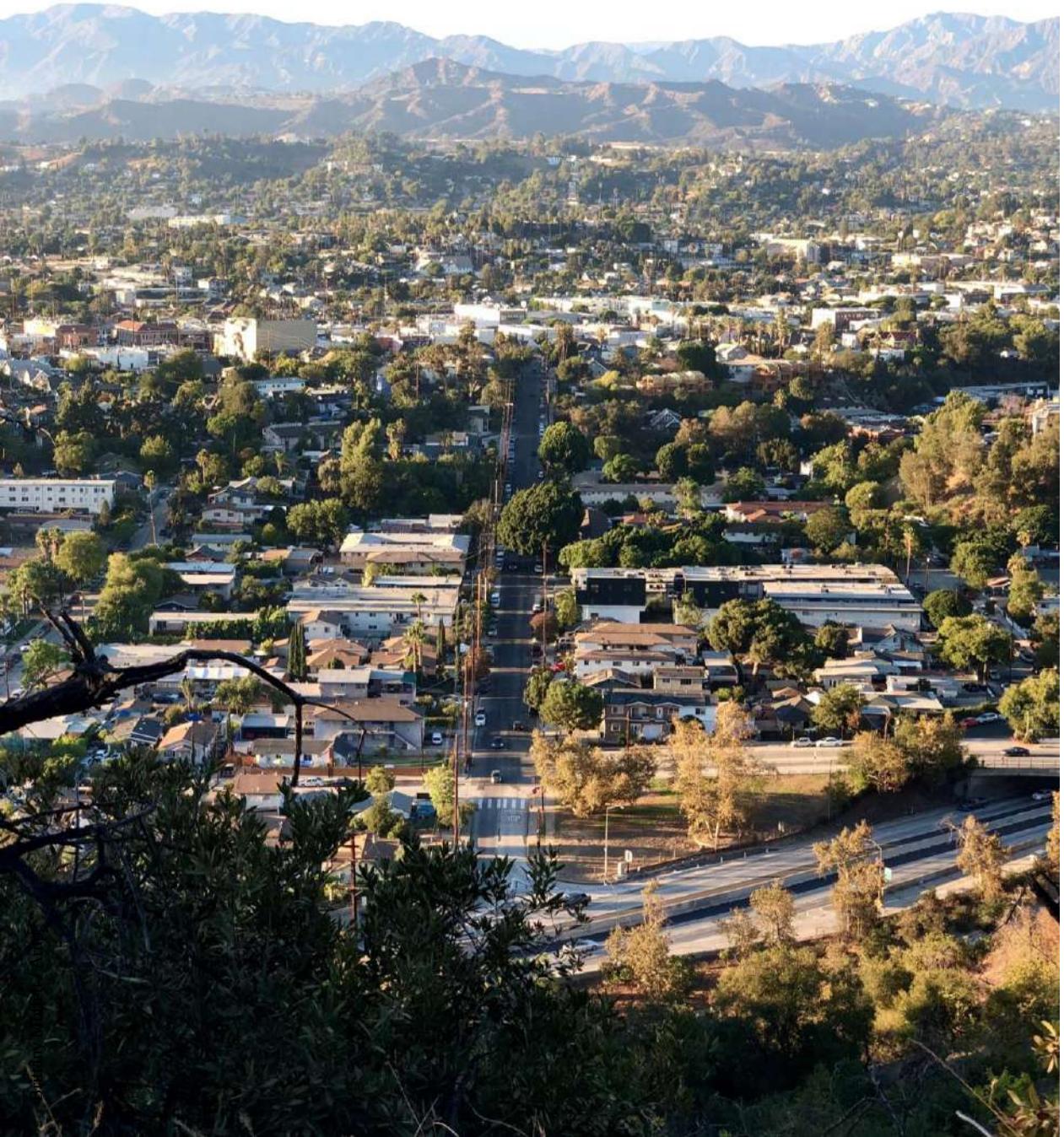

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LA Affordable Housing Decarbonization Case Studies

A report for Natural Resources Defense Council and their Advisory Committee to support equitable building decarbonization

October 2023

ARUP

Acknowledgements

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Expert Consultations

Experts Consulted

Tim Kohut – Director of Sustainable Design at National CORE
Erik Mar – Principal Architect at EMAR Studio
Andy Mannle – West Coast Design Director at Q Meccanica
Bruce Mast – Principal at Ardenna Energy
Nick Dirr – Senior Director of Programs at Association for Energy Affordability (AEA)

Advisory Council

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Health / Homes

Enterprise Community Partners
Michael Claproth

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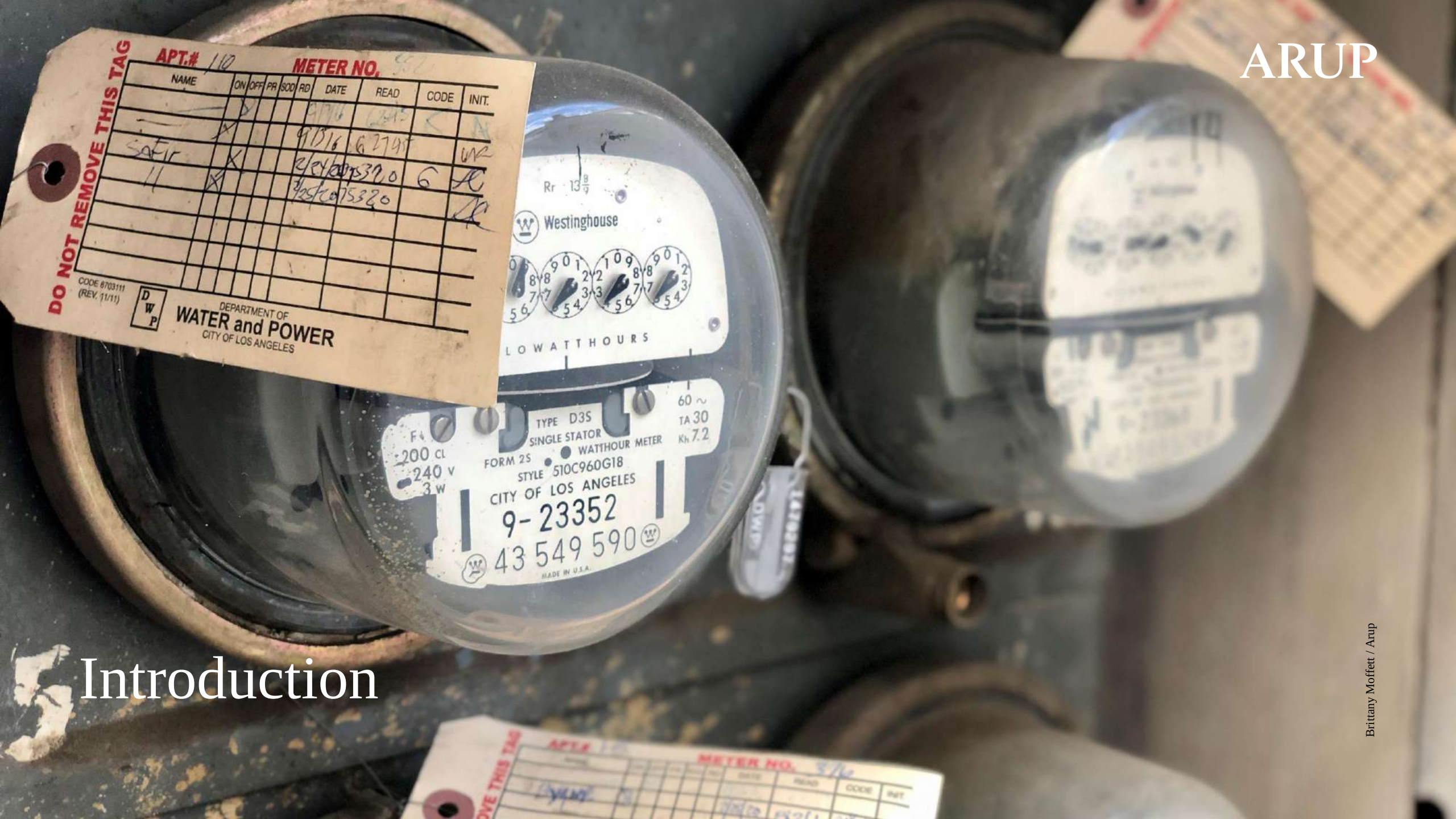
Introduction

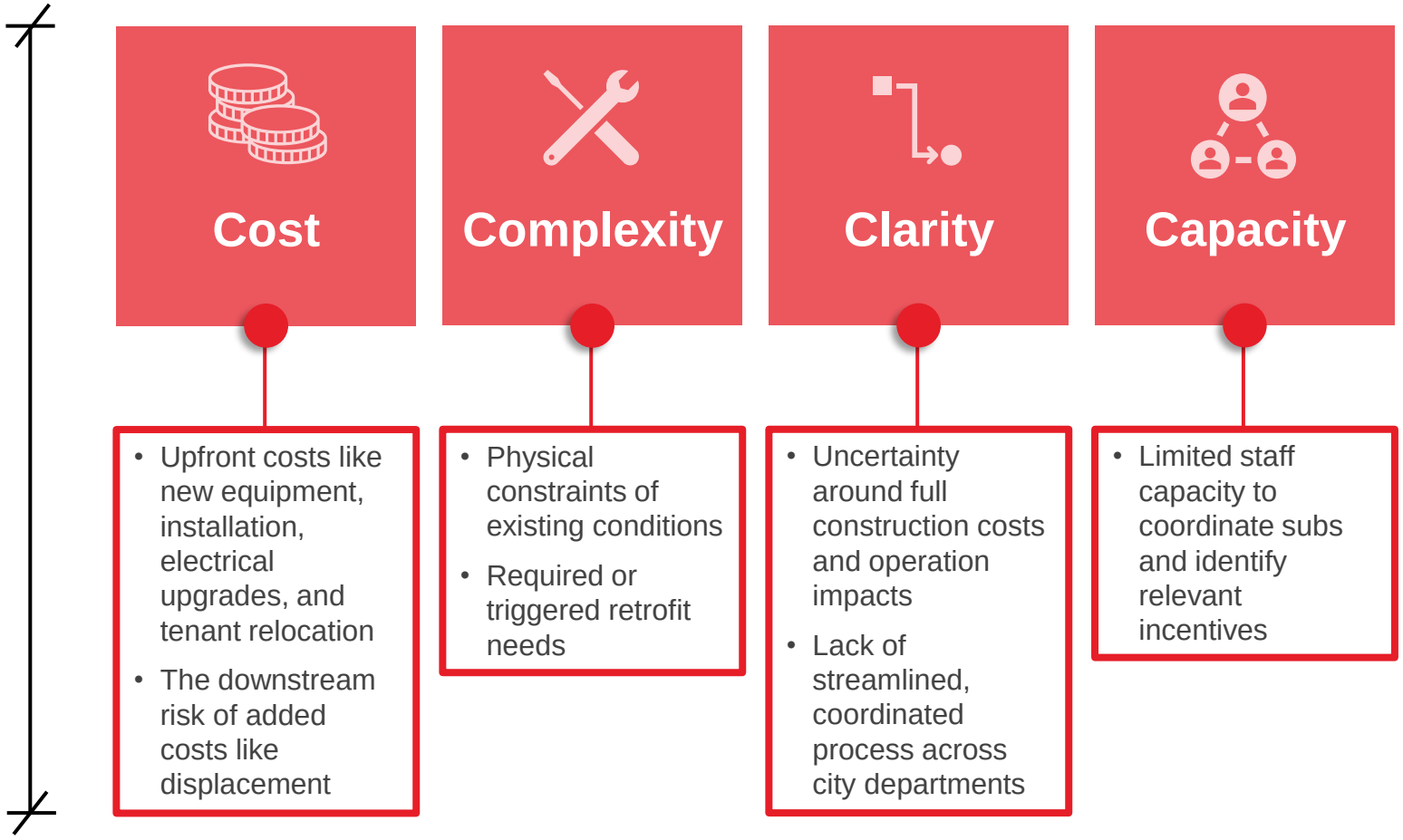


Brittany Moffett / Arup

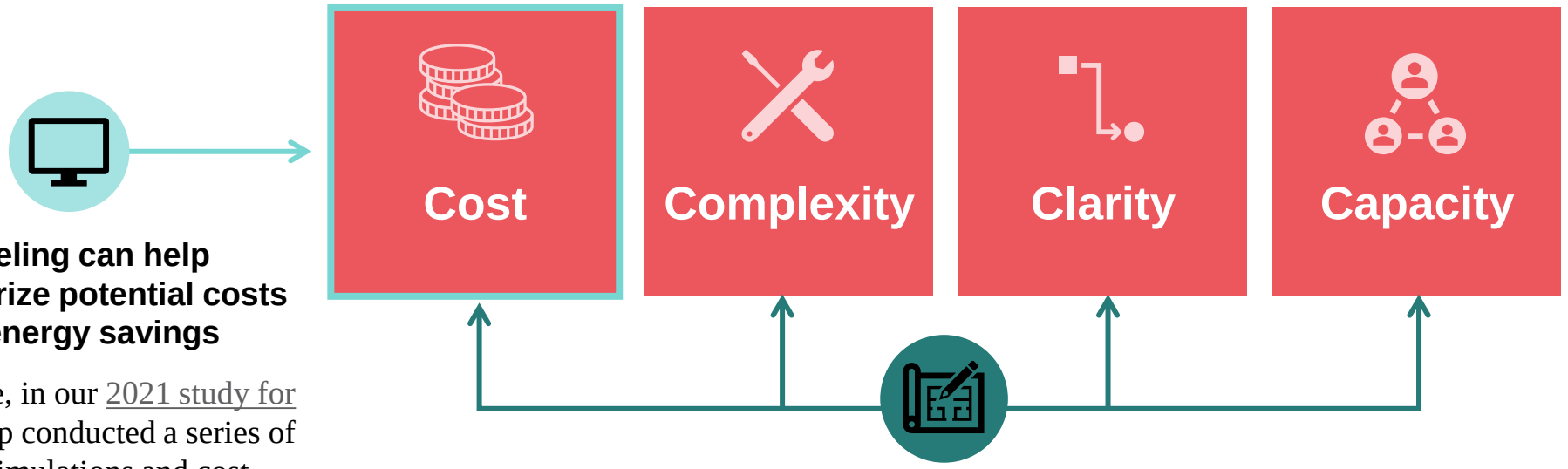
Project Background

What we've heard from the affordable housing sector prior to this study

LAHD was directed through City council motion in March 2022 to conduct stakeholder engagement across the affordable housing sector - providers, developers, asset managers, and advocacy groups. Through the NRDC Action Fund, Arup was brought in to conduct those listening sessions and provide the technical groundwork / framing. During these sessions, we heard stakeholders express these key categories of concerns.



Project Background



Modeling can help parameterize potential costs and energy savings

For example, in our 2021 study for NRDC, Arup conducted a series of energy simulations and cost estimating for a typical multi-family building model in Los Angeles and found modest savings.

But local case studies can shed light on the range of issues that emerge on real projects and needed support – hence the need for this study

Real world examples expose obstacles, inefficiencies, and opportunities encountered during retrofit processes. By mapping the ecosystem of challenges faced and the intersecting needs of the affordable housing sector, NRDC and this project's advisory council can better advocate for the supportive measures that need to accompany policy so that affordable housing decarbonization and preservation objectives can be mutually supported.

Case Study Overview

Projects

1

Ocean Avenue

Community Corporation of Santa Monica

2

Urban Soil / Tierra Urbana

Beverly-Vermont Community Land Trust's Bimini Apartments and Bimini Terrace

3

Alegria Apartments

Esperanza Community Housing Corporation

4

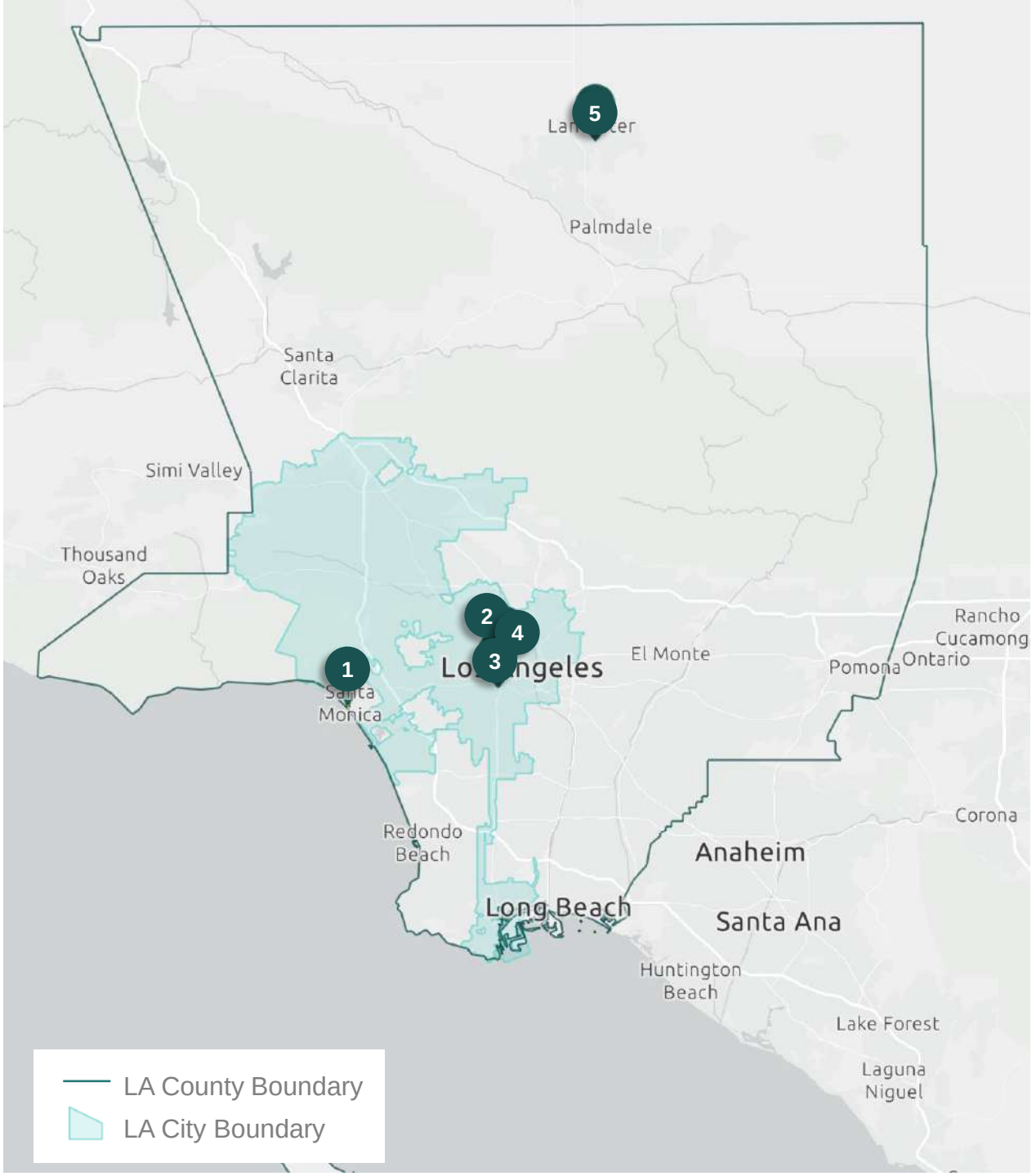
Miramar Towers

Jonathan Rose Companies

5

Village at Beechwood

LINC Housing



Report Overview

- Approach
- 5 Case Studies
- Emergent Concepts
- Findings
- Conclusions & Next Steps

Executive Summary – Key Challenges

ARUP

Policy / Regulatory

- **Rate structure design** hasn't historically facilitated retrofits
- **VNEM maligned** with multi-family affordable housing
- **Permitting** can slow down projects as well as add additional constraints and costs

Funding & Financing

- **Complicated funding structures** create hurdles for owners lacking administrative capacity to access upfront capital; timing of financing and/or reimbursement doesn't align with project's needs for capital
- **Split incentives** may lead to an inability to recover project costs
- **Delayed activation of solar credit** can create gaps in financing
- **Unforeseen scope adds** (e.g., asbestos abatement) may increase project costs

Implementation

- **Lack of technical workforce** for installing and maintaining new technology; technical providers don't have resources to scale
- **Difficult to achieve economies of scale** with purchasing of energy efficiency equipment
- **Hazardous materials** in buildings (i.e., asbestos) delays project, eats project budget, or increases project costs

Technical Assistance

- **Lack of long-term strategic planning** may result in higher costs and opportunistic approaches for retrofits

Carbon Reduction

- **Site constraints** may limit the types of equipment that can be installed for electrification**.**
- **Emerging technology –** Finding contractors and maintenance providers comfortable with heat pump and other emerging technology proves challenging.

Tenant Impacts

- **Limited monitoring** of net zero impacts and energy savings

Executive Summary – Key Opportunities

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Policy / Regulatory

- **Income-based fixed charge –** restructuring rates could improve economic feasibility of retrofits
- **Utility allowances –** combining tenant rent with utility bills into a single payment can help mitigate split incentives
- **Inflation Reduction Act –** may facilitate clean energy via tax credits
- **Gas Sunsets –** air quality regulations, building performance standards, and reach codes facilitate cleaner technologies
- **Building Zoning Relaxation –** building zoning exceptions can accommodate new equipment

Funding & Financing

- **Tailoring project scope to funding –** align project scope to funding availability and performance goals
- **Demonstrative or didactic value –** piloting new technologies can come with benefits
- **Tariffed on Bill –** financing mechanism can overcome challenge of upfront costs
- **Consider property value –** upgrades can improve the business case
- **Innovative financing –** approaches help to overcome start up costs and delays

Implementation

- **Environmental auditing –** conducting audits earlier can help avoid additional costs to projects
- **Comprehensive project execution –** design-build-operate-maintain can help to avoid costs and maximize performance
- **Strong decision-making framework** assessing upgrades against decision criteria helps to maximize benefits
- **Economies of scale –** streamlining implementation can reduce design time, construction time, and contractor markups

Technical Assistance

- **Long-term Strategic Planning –** helps to identify opportunities and to align them with capital funding opportunities and other fiscal timelines.
- **Grant Funding and Incentive Scan –** can help to unlock funding and improve alignment between scope and available funds
- **Leveraging partnerships with technical advisors –** groups like Bright Power, AEA, and National CORE offer valuable support to building owners
- **Turnkey project delivery –** helps to address technical and financing capacity gaps

Carbon Reduction

- **Measurement & verification –** setting aside funds for monitoring can ensure that the implemented measures achieve their designed intent
- **Sustainability Rating Systems –** certifications can increase the likelihood of the project achieving decarbonization targets
- **Community Solar –** establishing solar programs that allow community solar in both IOU and municipal utility territories can help sites with limited space to decarbonize

Tenant Impacts

- **Indoor air quality –** can dramatically improve inside residents' units by eliminating harmful pollutants associated with gas combustion
- **Skills training –** can help to develop the workforce required for scaling decarbonization and benefit residents
- **Utility cost savings –** can be achieved through retrofits, especially with VNEM
- **Increased thermal comfort –** improving the efficiency of HVAC can also improve its efficacy, leading to greater thermal comfort.

Executive Summary (cont'd)

Recommended Advocacy Pathways

Given these challenges and opportunities, the Study team recommends that NRDC focus on advancing decarbonization in affordable housing via the following **advocacy pathways**:

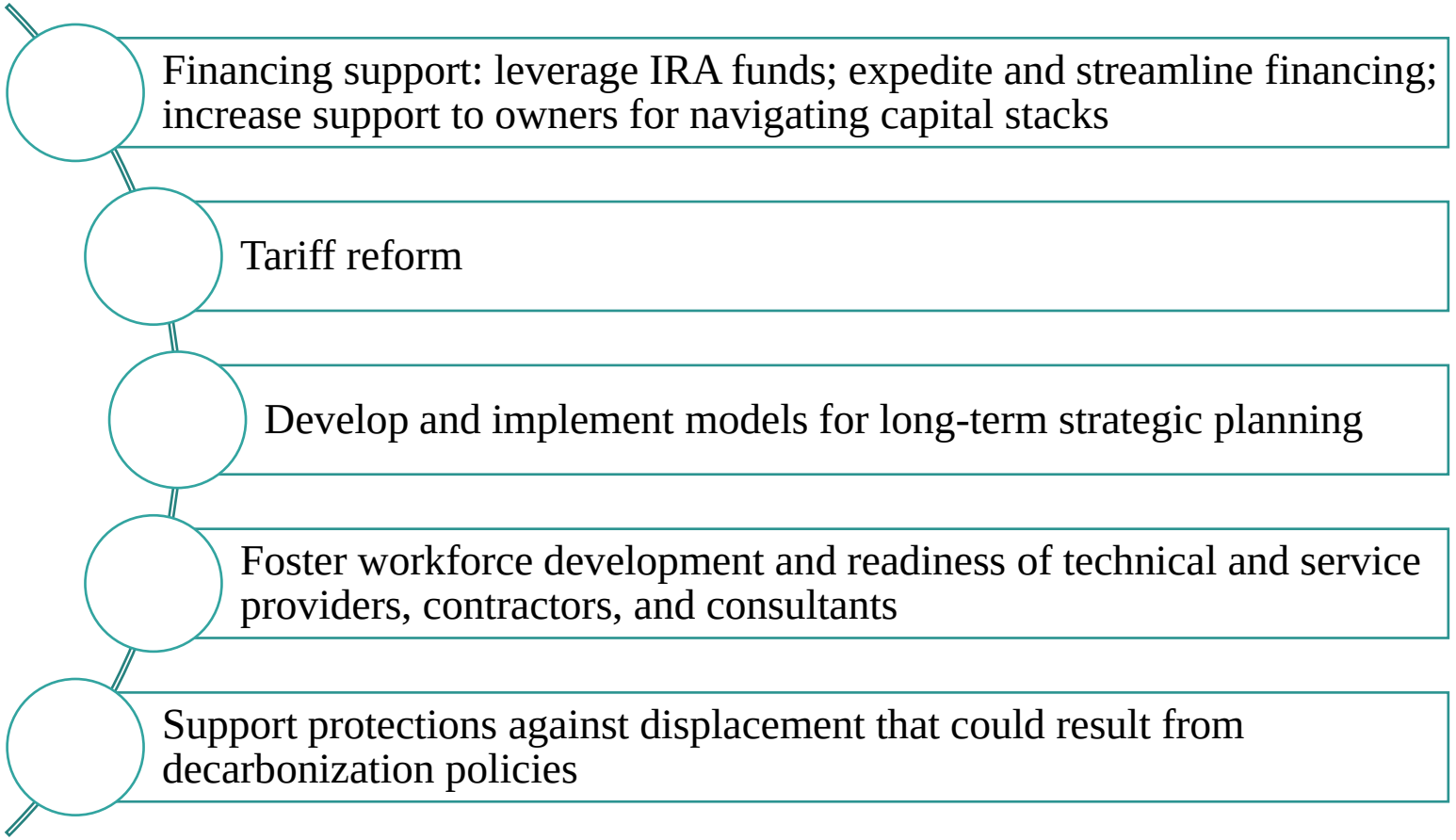

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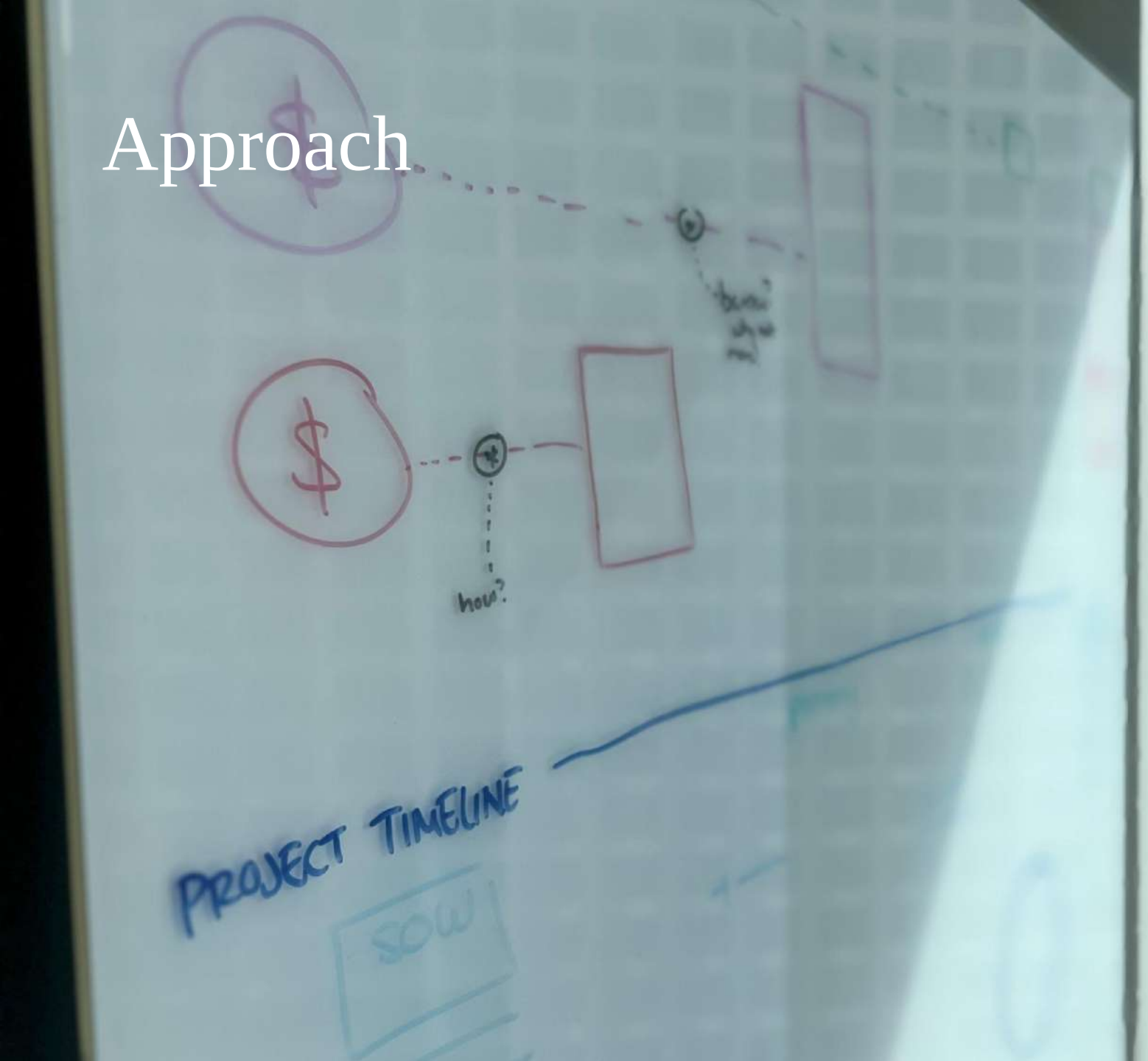
Table of Contents

Approach



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Brittany Moffett / Arup

Project Objectives

Approach

While energy and cost models are valuable tools to understand the affordable housing sector, they fall short of capturing the complexities of existing conditions, intersecting maintenance needs, and obstacles that emerge for operators seeking capital to keep housing fit for purpose in a changing climate. To address these limitations, this study utilizes case studies of affordable housing projects in the Los Angeles area that have undertaken decarbonization and energy retrofits, providing insight into current challenges and opportunities. The primary goals of this work are to help affordable housing stakeholders gain a deeper understanding of the costs and benefits of energy retrofits in real-life scenarios; to more clearly understand the barriers that currently exist in implementing these programs; and to inform the development of decarbonization programs and processes that better support affordable housing projects.

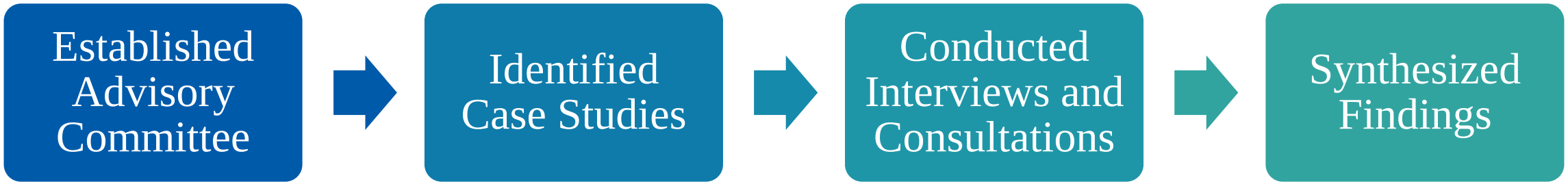
The intended outcomes of this Study are to:

- Develop the business case for investment in decarbonization by identifying barriers to realizing benefits and return on investment
- Understand the existing programs, processes and resources that are being used now, and what barriers and gaps exist
- Advance the state of practice decarbonization while protecting LA's limited affordable housing stock through the development of advocacy pathways

Project Process

Approach

To develop this study, the team followed the process outlined below, consisting of four primary steps and resulting in actionable findings. The first step involved the development of an advisory committee with knowledge and experience in the affordable housing sector. Together with the advisory committee, the study team identified potential case studies and selected five for this study according to criteria established with the advisory committee. To gather information about each of the five case study projects, the team conducted interviews with building owners, operators, consultants/contractors, and tenants, complementing interviews with research on key topics. The team then synthesized information from each of the five case studies into study findings.



Advisory Committee's Role

Approach

The Advisory Council convened by NRDC played a central role in guiding this study. Comprised of individuals with diverse knowledge and experience across different aspects of affordable housing, their input informed the selection criteria for projects, the approach to tenant engagement, and the questions posed to owners. To ensure ongoing guidance throughout the project period, the advisory committee met with the project team monthly between May 2022 and June 2023.

Advisory Council

Convener

Natural Resources Defense Council (NRDC)
Michele Hasson
Veena Singla
Olivia Walker

Los Angeles Community-based Organizations

Strategic Actions for a Just Economy (SAJE)
Chelsea Kirk

Los Angeles Alliance for a New Economy (LAANE)
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Jacqueline Woo

Health / Homes

Enterprise Community Partners
Michael Claproth

Arup team: Heather Rosenberg, Maggie Messerschmidt, Brittany Moffett, Geffen Oren, Talia Kramer

Case Study Selection

Approach

Selection criteria developed with the Advisory Council

- Affordable multi-family housing (regulated or not)
- Located in LA County, LA City preferred
- Recently completed decarbonization-related retrofits with a baseline level of documentation accessible and staff engaged with the retrofit available to provide input
- Diversity of ownership
- At least one community land trust and projects with low-income tenants with long tenure

Key takeaway: How challenging it is to find projects and project records

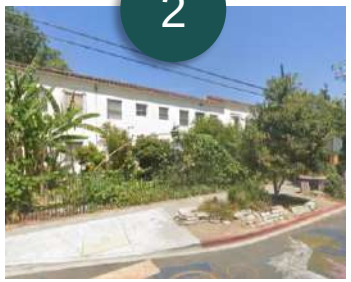
To identify case studies for this project, and due to a limited number of available local projects, the study team expanded the search from solely considering all-electric retrofits to examining broader decarbonization upgrades, such as solar, partial electrification, and envelope performance,. The scarcity of projects underscores the challenges of carrying out retrofits in the affordable housing sector. Selected projects show the differences in scale and type of retrofits. They also demonstrate the unavailability of records and background information. All case studies properties are subsidized, deed-restricted housing except Urban Soil / Tierra Urbana.

1

Ocean Avenue

Community Corporation of Santa Monica

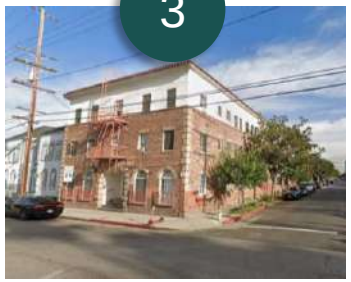
2



Urban Soil / Tierra Urbana

Beverly-Vermont Community Land Trust

3



Alegria Apartments

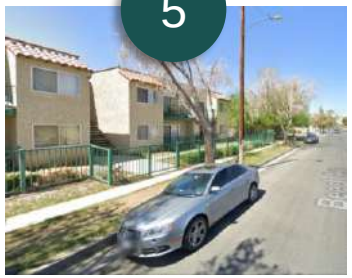
Esperanza Community Housing Corporation

4

Miramar Towers

Jonathan Rose Companies

5



Village at Beechwood

LINC Housing

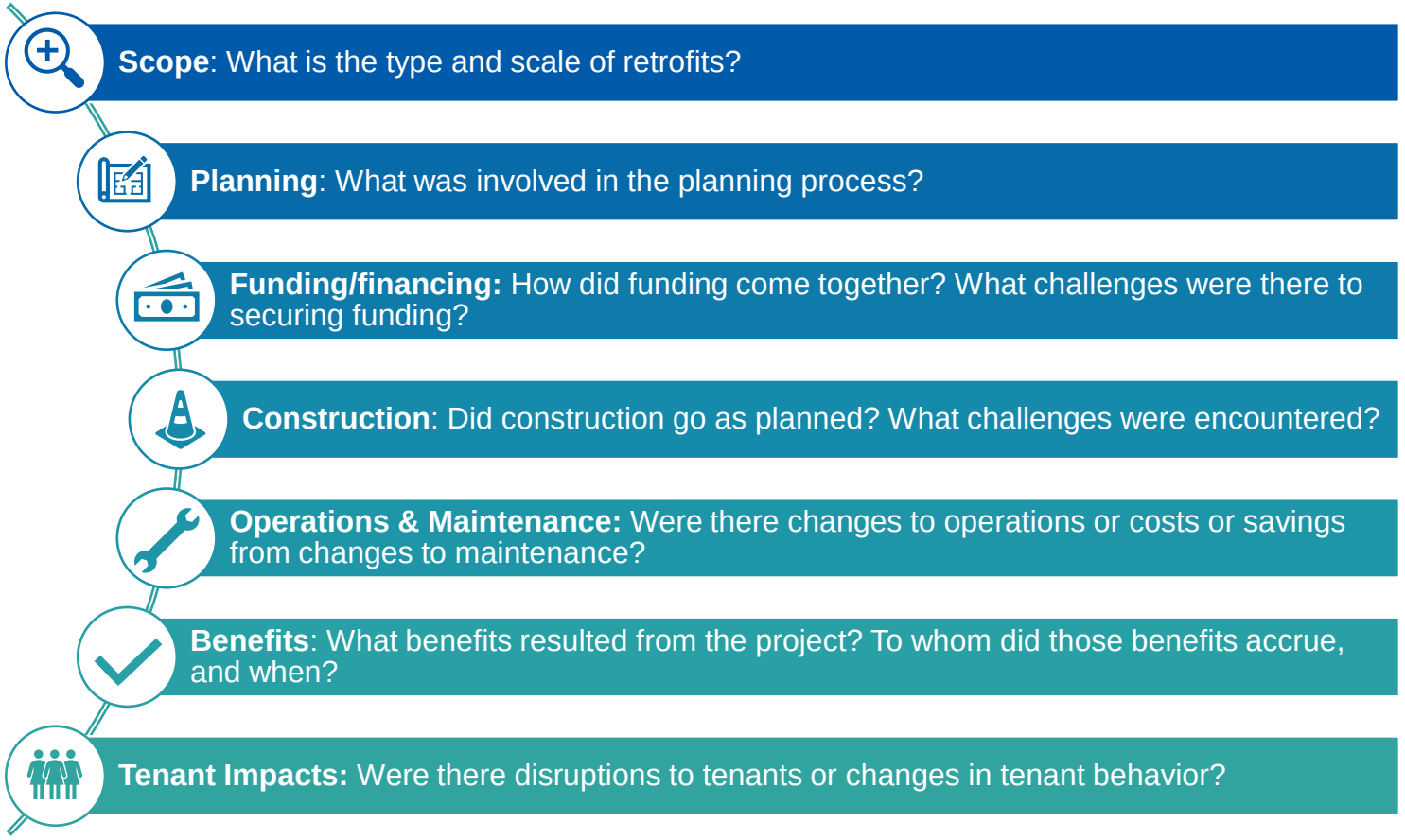
Interviews

Approach

The study team also conducted interviews with those involved or affected by the project including building owners, operators and contractors. At a couple buildings, Arup was able to secure interviews with tenants.

Interviews lasted between 60 minutes and 90 minutes. Most interviews were conducted virtually; tenant interviews were conducted at a couple of the buildings in residential meeting areas. To encourage tenant interviews, an incentive of $50 was offered. Tenants were asked questions about tenant impacts and the construction process.

Interview questions focused on the following lines of inquiry:



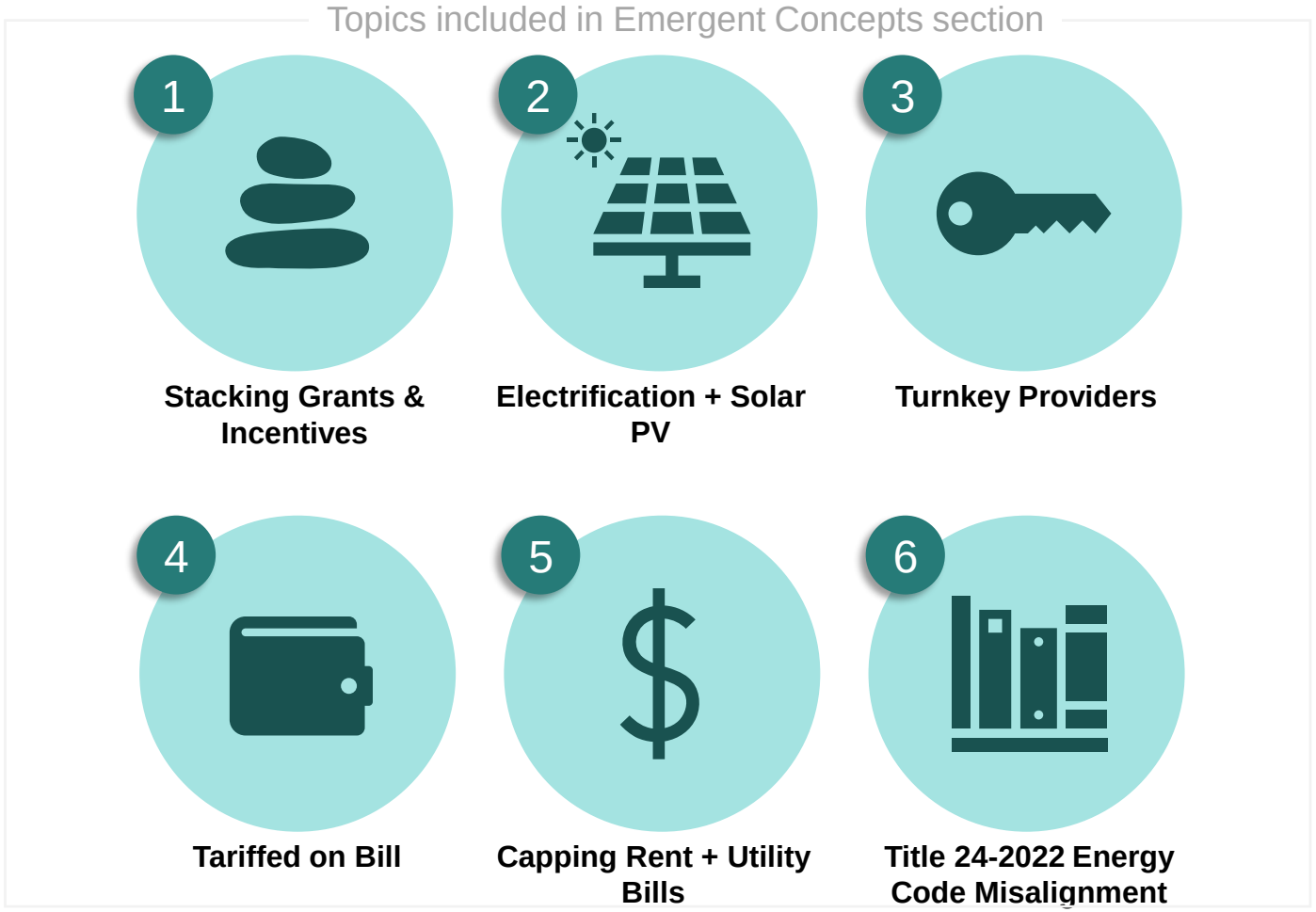
Expert Consultations

Approach

In addition to case studies, the study team solicited expert insights on issues that arose during interviews requiring additional context and information on their state of play and how they are evolving.

Experts interviewed included:

- **Tim Kohut** – Director of Sustainable Design at National CORE; Energy consultant for Ocean Ave building (while previously at Green Dinosaur)
- **Erik Mar** – Principal Architect at EMAR Studio; Architect for Ocean Ave property
- **Andy Mannle** – West Coast Design Director at Q meccanica; Solar developer for Ocean Ave property (while previously at Promise Energy)
- **Bruce Mast** – Principal at Ardenna Energy; Tariffed on Bill expert
- **Nick Dirr** – Senior Director of Programs at Association for Energy Affordability (AEA); Advisory Council member; Energy Consultant for Alegria Apartments



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Supplemental Background Research

Approach

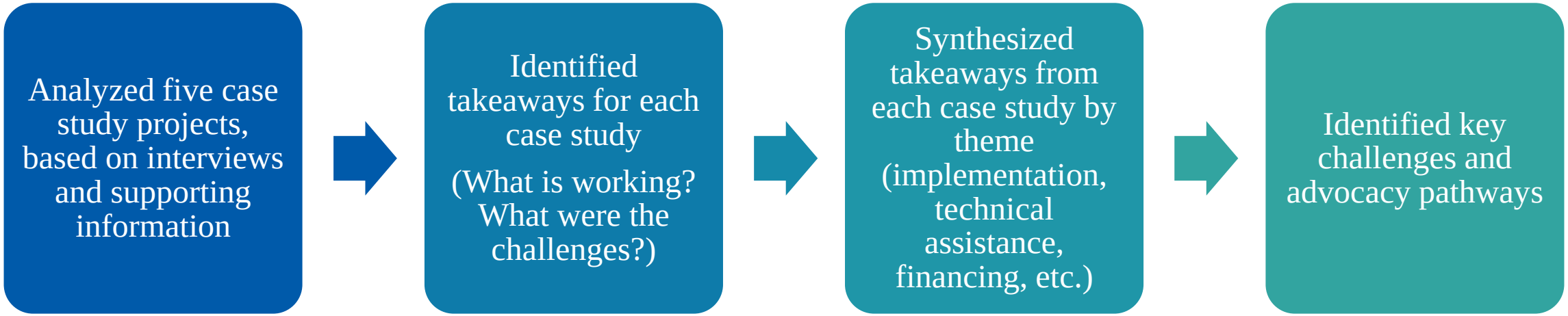
To supplement interviews and information gleaned from the case studies, the study team conducted background research on related topics, including:

- The types of social benefits occurring from deep energy retrofits
- Tariffed On Bill as a financing strategy
- Community solar in California
- Inflation Reduction Act funding opportunities
- Approaches to Virtual Net Energy Metering in multi-family buildings
- Utility allowances incorporated into tenant rent
- Income-based fixed charge for electricity rates
- Funding sources for sustainability-related projects in new and existing housing developments in Los Angeles
- Financing solutions to lower barriers to energy upgrades

Process for Synthesizing Findings

Approach

To develop findings from case studies, the team followed the steps outlined below to synthesize the information garnered from case studies into clear takeaways and actionable advocacy pathways.



Case Study Limitations

Approach

While this study provides a lot of insights about the process of conducting decarbonization retrofits, it is limited in scope. Additionally, the project team experienced some challenges with collecting data. The key limitations of our study are described below with potential impact to the findings.

Limitations of Study

1. Specific criteria for case studies in a limited pool of examples (e.g., located in LA County, affordable housing)
2. Case studies were harder to identify than expected. Biggest challenge of project was finding five projects that met criteria.
3. Most of the projects were not conducted for didactic or research purposes; therefore, retention of key lessons and documentation was limited
4. Not all projects were able or willing to provide utility data
5. Affordable housing providers had limited capacity or availability for interviews
6. Not all providers supported interviews with tenants
7. Not all tenants approached were willing to be interviewed, despite incentives offered.

Implications of Limitations

1. These study limitations illustrate the limited number of projects being implemented in region due to the variety of challenges and barriers they face
2. Many of the case studies have gaps in information, particularly financial information
3. We have provided as complete and transparent information as we could obtain within the study timeframe
4. Future projects should be documented as case studies to better capture utility information, cost savings, and other benefits

Case Studies

Brittany Moffett / Arup

Introduction

Case Studies

For each case study, Arup interviewed individuals involved in or impacted by the case study deep energy retrofits, including affordable housing developers, project contractors, tenants, etc. The information gleaned from these interviews has been reported in this section.

Each case study is organized into the following slides:

- **Cover Slide** conveying the location, size, age of the case study as well as the energy utilities serving it.
- **Project Basics** identifying the project team, goal, and retrofit scope.
- **Retrofit Scope Detailed**, if needed, to further clarify the project scope.
- **Process & Timeline** highlighting key elements in the building history as well as planning, design, and implementation of the retrofit.
- **Project Financing** comparing the funding sources against the project costs, providing numeric values where possible.
- **Economic Impacts** describing the economic benefits and penalties of completion the project, providing numeric values and calculating simple payback where possible.
- **Key Takeaways**, organized into emerging themes (defined on the next slide), outlining the key observations and points gleaned from the conducted interviews.
- **Summary** reiterating drivers of success as well as obstacles challenging the retrofit.

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Themes Emerging from the Interviews

Sorting Key Takeaways

While conducting interviews across the different case studies, the study team started to notice themes emerging from the information received. These themes helped organize and group together key interview takeaways to more effectively interpret and comment on the success of each project. Spanning project constraints, common obstacles, drivers for success, to key performance indicators, these themes are described below:

- **Policies and Regulations** – What project teams are allowed to do by law, for obvious reasons, impacts retrofits, most often hindering success rather than supporting the project. Key takeaways in this theme focus on the local regulations, policies, and programs that affected the project.
- **Funding and Financing** – The amount of money available to the project provides a constraint both on project scope and success. Key takeaways for this theme focus on the ability to obtain grants, set up financing, create new funding opportunities, apply for incentives, and pay back loans.
- **Implementation Process** – Retrofit success greatly depended on the way in which it was implemented. The key takeaways here provide commentary on the project teams' capacity to deliver the project as well as the ways in which the team planned and executed it, covering the design, construction, and operational phases.
- **Technical Assistance** – The complicated nature of these projects, which involve implementing advanced energy-saving technologies to navigating complex incentive programs, often necessitates additional support from technical advisors. This theme covers takeaways related to the presence or omission of technical assistance.
- **Carbon Reduction** – As deep energy retrofits, these projects typically measure success by the amount of carbon reduced. This theme represents the ability to which case studies were able to achieve their decarbonization goals.
- **Tenant Impacts** – In addition to reducing carbon, these projects often bring about other outcomes – both positive and negative – that are not specifically related to energy. The key takeaways for this theme encompass the supplemental benefits and/or negative impacts from the project with attention to how they affect individuals living in the building.

For each case study, key takeaways from the interviews are sorted into the above themes; some themes do not apply to all case studies.

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Icons Legend

Sorting Key Takeaways

In addition to sorting takeaways into themes, the report include icons next to each takeaway to indicate whether it is positive or negative. The types of icons are described below. A legend for these icons has been placed in the top right of each Key Takeaways slide for reference.

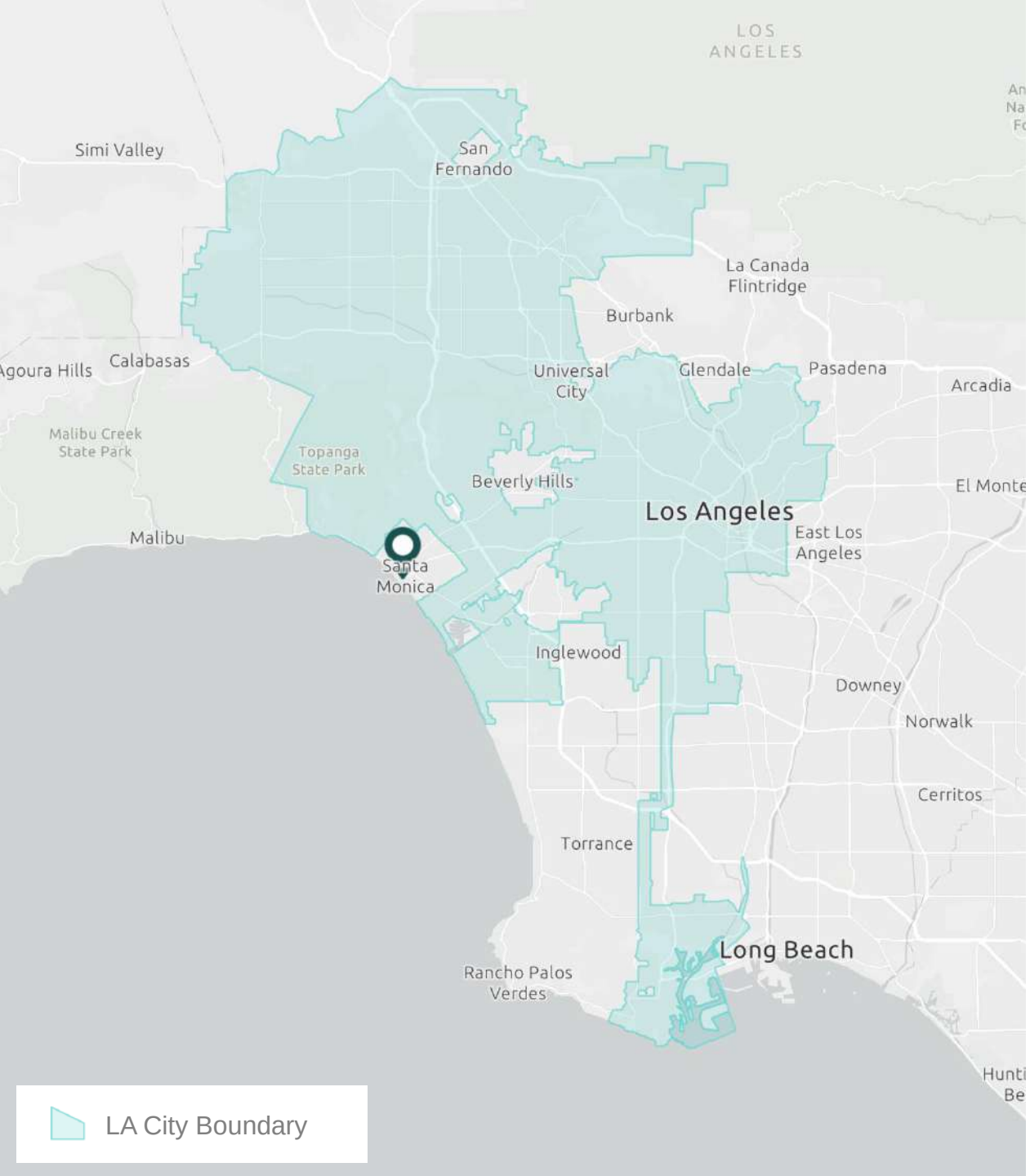
Benefit – a positive project impact for tenants, owners, or the broader public

Delay – a project setback creating barriers to implementation

Downside – a potentially negative impact created during the project's execution or following the project

Unavailable potential – limitations, constraints, and shortcomings to realizing project success


ARUP
Case Study 1
Ocean Avenue



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Type of Affordable Housing	Subsidized, expiration 2076
Location	Santa Monica
Number of Units	19
Originally Constructed	1953
Retrofit Completion	2021
Electricity Utility	SCE
Electric Metering	Units Individually Metered
Solar PV Tariff	VNEM
Gas Utility	N/A
Gas Metering	N/A
Tenant Utility Bill Responsibility	Electricity

Project Basics

Ocean Avenue

Project Team

Owner: Community Corporation of Santa Monica (non-profit owner/developer)
Architect: EMAR Studio
Energy & Title 24 Consulting: Green Dinosaur
Solar Provider: Promise Energy

Project Goal

- Zero Net Energy
- All-Electric Building

Retrofit Scope

- Electrification and energy efficiency upgrades
- Onsite PV to achieve Zero Net Energy
- Habitability, ADA, seismic, cosmetic upgrades

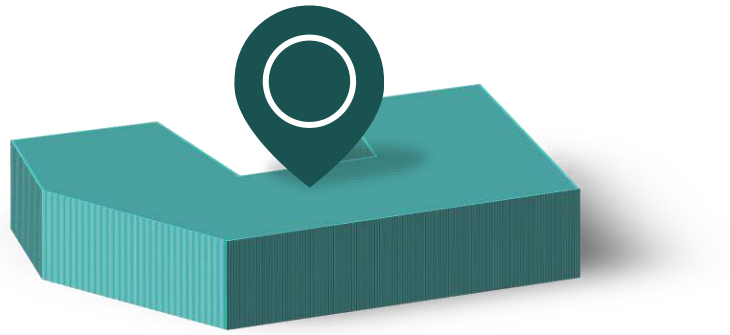
Interviews Conducted

- Owner (2)
- Architect (1)
- Energy & Title 24 Consulting (1)
- Solar Provider (1)
- Tenants (4)

Source: EMAR Studio

Retrofit Scope Detailed

Ocean Avenue



Electrification

- Electrical panel upgrades
- Electric baseboard heaters
- Electric ranges
- Central domestic water heater

Energy Efficiency

- Window replacement
- Insulation added
- Ceiling fans (in lieu of air conditioning)
- LED lighting fixture replacement in common areas
- New refrigerators
- New plumbing fixtures
- Thermostat sensors
- Electrical wiring for controls

Distributed Energy Resources

- Rooftop solar

Non-Decarbonization Work

- Minor programming upgrade (added a unit within the building)
- Asbestos abatement
- Seismic upgrades to parking
- ADA ramp
- Kitchen and bathroom upgrades
- New doors
- Bike room addition
- Landscaping & site work
- Fireproofing
- Fire alarm system

Process & Timeline

Ocean Avenue

City deeded building to SMCC for $1 (2016)
The nearly vacant (only 4-units occupied) property was deeded to convert into affordable housing and needed extensive retrofit for habitability, ADA, and seismic.

Funding roadblock: getting support for all-electric vision
Housing Trust Fund, which supports the development of affordable housing, would not fund measures beyond T24. It took two years of pre-development to line up funding sources.

A perfectly timed RFP from the Office of Sustainability
Santa Monica's Office of Sustainability issued a net zero energy pilot project RFP.

Received discretionary funding from City Council
City Council and the Office of Sustainability provided about $50K to the project as a zero net energy pilot, the first of its kind in the jurisdiction..

Initiated City of Santa Monica permitting process for building retrofit

Sought MASH rebate
for solar PV system

Construction began (February 2020)
Previous tenants were relocated to other buildings in SMCC's portfolio.

Additional rehab costs arose (e.g., dry rot, drywall issues); additional unit triggered Coastal Commission review
An office space was converted into an additional unit but parking was not added; this triggered Coastal Commission review and added 4-6 months.

Issued change order
Construction lasted 15 months total.

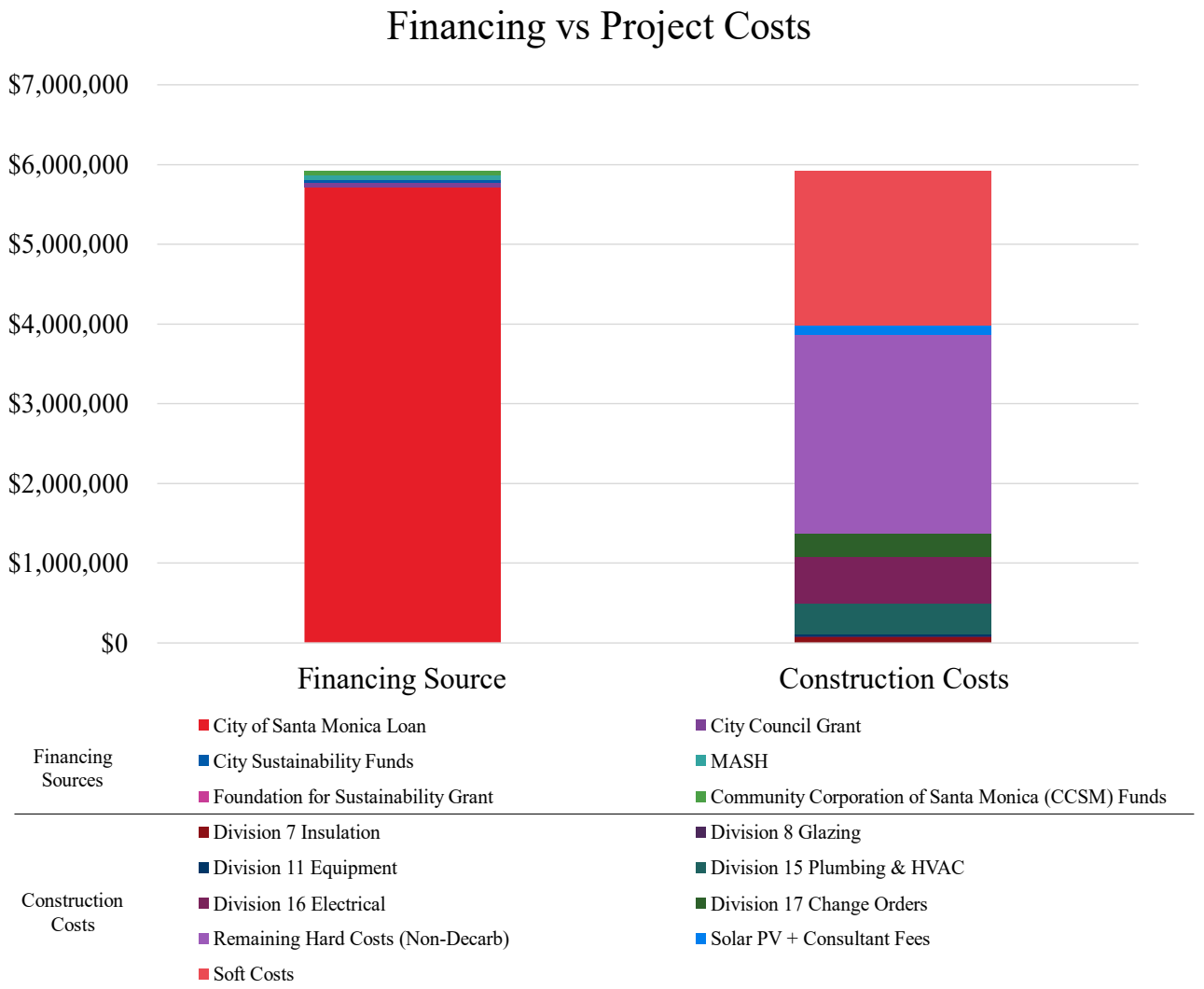
Construction complete (May 2021)
Offered previous tenants to return to building – half elected to.

Net metering benefits were delayed
As they waited for net metering benefits to come online, the City covered a portion of the project's permanent loan

Project Financing

Ocean Avenue

- **Financed primarily by City of Santa Monica Loan** – Santa Monica approved the project for a loan because of alignment with Santa Monica Housing Goals and Housing Trust Fund Plan (existing housing stock rehabilitation, energy efficiency, earthquake readiness, etc.). The loan will be paid back through tenant rent over time.
- **Decarbonization accounts for only 30% construction costs** – Non-decarbonization scope comprised most of the project's hard costs. Soft Costs in the graph include mostly consultant, lender, legal, developer, insurance, audit, etc. fees not related to the decarbonization work save for environmental consultant and MEP engineering fees.
- **Of decarbonization scope, electrical upgrades proved most expensive** – Upgrading the electrical paneling, wiring, as well as lighting cost over $500,000.
- **Change orders increased construction costs by 8%** - Cost increased by 8% relative to the approved construction budget. Only about 5% of the change order hard costs can be considered decarbonization-related.



Project Financing

Ocean Avenue

Financing

Source	Amount
City of Santa Monica Loan •Loan info (Housing Trust Fund)	$5,715,484
City Council Grant	$50,000
City Sustainability Funds	$50,000
Multifamily Affordable Solar Housing (MASH) Rebate	$48,664
Foundation for Sustainability Grant	$2,000
Community Corporation of Santa Monica (CCSM) Funds	$49,336
Total	**$5,915,484**

Notes:
- Source: Budget Documentation - “Draw Request: Draw #16 request Detail”

Project Costs

Items	Construction Costs
Division 7 Insulation	$73,308
Division 8 Glazing	$8,695
Division 11 Equipment	$32,167
Division 15 Plumbing & HVAC	$387,063
Division 16 Electrical	$577,616
Division 17 Change Orders	$290,152
Remaining Hard Costs (Non-Decarb Related)	$2,494,828
Solar PV + Consultant Fees	$110,998
Soft Costs	$1,940,657
Total	**$5,915,484**

Notes:
- Source: Application and Certificate for Payment
- Divisions are used in construction specifications to organizing products into categories.
- Equipment consists of new refrigerators and electric stoves
- Non-decarbonization measures including fireproofing, interior doors, structural upgrades were excluded from the costs in Division 7 – 16.
- Approximately 5% of the change orders can be attributed to energy-related work
- Remaining Project Costs mostly include soft costs.

Economic Impacts

Ocean Avenue

Economic Benefits	Notes
Property value	Property was previously in poor condition
O&M Savings	Minimal maintenance issues. Higher quality building (reduced deferred maintenance).
Utility Bill Savings	Tenants receive savings from VNEM and efficiencies

Economic Costs	Notes
O&M Costs	No reported increase in operational costs
Other Living Expenses	No reported increase in other living expenses

Tenant Rents Impacted?
No

Notes:

- Utility cost savings for property were not provided.
- Arup did not receive enough cost information to calculate simple payback.

Funding and Financing

Ocean Avenue

Benefit
Delay
Downside
Unavailable potential

ARUP

Limited public funding for measures beyond business-as-usual – The City of Santa Monica's Planning and Affordable Housing departments did not offer financial support for mechanical systems or renewable energy features exceeding the energy code Title 24, Part 6. As such, the CCSM had to find additional support for many of the strategies needed to achieve Net Zero Energy.

Project ambitions attracted funding support from sustainability-focused agency – The City of Santa Monica's Office of Sustainability had released a grant RFP for a Zero Net Energy pilot project at the time this specific retrofit project was starting to look for funding. CCSM applied on behalf of the building and was awarded the grant as a Net Zero Energy demonstration in an Environmental Justice community.

Free of state and federal funding deadlines – Because the project team opted for local funding sources, the retrofit was not tied to any federal or state deadlines, which were found to be stricter than those imposed by the City of Santa Monica. As such, the local funding opportunities freed the project from time restrictions that would have made it more challenging to complete.

Delay in solar PV credit impeded permanent financing – It took months after the solar PV was installed for SCE to provide the bill credit from net energy metering. At that time, CCSM had been pursuing permanent financing. Without the solar credit, their utility bill remained high, causing loan underwriters to doubt CCSM's debt repayment ability. As a result, they had to cut down the loan significantly. Fortunately, the city of Santa Monica agreed to cover the loan gap. However, this decision could negatively impact other projects by taking away funding; other developers may need to secure alternative funding sources for their own projects.

Funding and Financing

Benefit
Delay
Downside
Unavailable potential

ARUP

Ocean Avenue

Purchase agreement created project constraints – When CCSM originally purchased the property from the City of Santa Monica, they were required by the purchase agreement to provide 19 units of affordable housing. Previously, the property had been a mental health adult day acre center set up for residential use with 18 units. As such, CCSM was required to add an additional unit. To accommodate this unit, the ground floor was reconfigured which triggered both structural changes and seismic retrofits, adding complexity and cost to the project.

Additional funding requirements can create hurdles and delays – the City required the addition of one unit as part of their funding agreement, which triggered review by the Coastal Commission, creating delays.

Implementation Process

Benefit
Delay
Downside
Unavailable potential

ARUP

Ocean Avenue

Affordable housing designation helped to expedite permitting – According to CCSM, the City of Santa Monica expedites permitting for affordable housing. This enabled the project to reduce the schedule required for energy and other retrofits.

Building vacancy created an opportunity for an extensive, holistic retrofit – Prior to the retrofit, the building was relatively vacant; it only had 3 or 4 tenants. CCSM saw the vacancy as an opportunity for a retrofit: they would not have to disrupt or relocate many tenants during construction, thereby saving money and disruptions to the tenants during the project.

Future roofing upgrade conflicts with PV – The solar PV install was completed without making upgrades to the roof. Prior to the PV panels' useful life, the roof will have to be upgraded. Consequently, this future roof upgrade will end up being more challenging with the PV panels obstructing the process. The project would have benefitted from grouping the PV install with a roofing upgrade had there been funding sources available to do so.

COVID-induced construction delays led to later opening – COVID-19 created some supply chain and staffing issues that prolonged construction and the inspection period, delaying the building opening by 7 months from January 2021 to July 2021. One tenant who was slated to move in in January had already ended her lease at her previous residency. While waiting for the inspection period to end, the tenant had to find temporary housing, bouncing around a few of places. During this period, it remained unclear when the inspection period would end, which created some stress for the tenant. In July, the tenant was able to move in and has enjoyed living there since, stating that the wait was worth it.

Carbon Reduction

Benefit
Delay
Downside
Unavailable potential

ARUP

Ocean Avenue

No EV charging provided – The retrofit scope did not include providing electric vehicle charging stations (EVSE). Although most tenants do not currently have electric vehicles, lacking access to charging stations may deter them from owning electric cars in the future.

Site limitations reduced potential for heat pumps and solar – With minimal site and roof area, the project did not have room to situate heat pumps. For space heating, the project team opted for electric resistance systems, which are less efficient than heat pumps and no longer allowed by the energy code. The project did include a heat pump for domestic hot water. However, this system receives top-off heating from an electric resistance boiler; without the electric boiler, the heat pump would not have fit on the project site. Site constraints also affected PV: given the current roof design, PV could not be oriented for optimal energy generation.

Energy monitoring – Energy Star Portfolio Manager tracks Source Energy Use Intensity and Site Energy Use Intensity (EUI). EUI is the energy use per square foot of the property. Site EUI is the annual amount of all energy consumed on site, divided by square foot. Source EUI is the total amount of raw fuel required to operate the property. A Solar Edge inverter monitor tracks solar PV production on a monthly basis.

Tenant Impacts

Ocean Avenue

benefit
delay
downside
Unavailable potential

ARUP

but

Virtual net energy metering reduced tenants' bills – Tenants receive a solar credit on their utility bill via virtual net energy metering (VNEM), which is available through SCE. Pairing PV with electrification measures helps soften or fully counteract energy cost increases. Multiple tenants voiced paying little to no utility bill, which they cited as a great benefit to living in the complex. Some tenants were not aware that the benefit stemmed from the solar PV system.

Delayed solar credit benefit – The benefit was not realized for several months due to a delay from the utility in crediting solar PV via (virtual) net energy metering.

The few tenants in the building were relocated into other CCSM housing – To enable the retrofit, the 3-4 tenants living in the building were transferred to other CCSM housing nearby. After completion of the retrofit, only 1-2 elected to come back to the Ocean Ave property; the remaining stayed in their new accommodations, which suggests an appreciation for the new, "temporary" accommodations. Relocating tenants to a nearby property in a more permanent fashion helped to minizine disruption to their lives.

Initial trouble using space heating system – Multiple tenants interviewed indicated that they initially did not know how the use the heating system. After a few months, the tenants learned that the system worked well without needing to change their settings on their thermostat. Some additional training on how to use the heating system could be have been helpful to ease their transition into the building.

Tenant Impacts

Ocean Avenue

Benefit
Delay
Downside
Unavailable potential

ARUP

Green features engender feelings of safety, pride, and fulfillment – One tenant indicated they felt safer in the building because of its green features – that the building is more equipped to respond to the challenges of climate change. Multiple tenants expressed pride for living in this building, having been attracted to it because of its sustainability story. This building also enables tenants to live in alignment with their environmental values.

No AC added – Tenants are responsible for paying for and installing their own window AC units if they want air conditioning. Although air conditioning is not typically needed in Santa Monica due to the temperate marine climate, heat waves have been more frequent due to Climate Change. The tenants interviewed have complained about being too hot in their residences during the heat wave of summer 2022 and needing to install window AC units. If heat pumps were installed instead of electric resistance heaters, tenants would have been provided with space cooling in addition to heating. Unfortunately, space constraints precluded the installation of heat pumps.

Tenant Impacts

Ocean Avenue

Benefit
Delay
Downside
Unavailable potential

ARUP

- **Hot water could be hotter –** One tenant complained that the hot water is not hot enough and takes a while to heat up at night. Based on what Arup has heard from others in the industry, domestic hot water poses one of the largest challenges with electrification. Heat pumps do not produce as hot of water as gas heaters, so configuring recirculating loops can prove challenging and may require additional temperature calibration. If other tenants have issues with the hot water, the property managers could consider recalibrating the domestic hot water loop.
- **Preference for a gas stove** – When asked whether there were any downsides to living in an all-electric building, one tenant mentioned her only complaint was the electric stove: she is used to and prefers gas stoves. She had no issues with the other electric appliances and features of the apartment. Other tenants interviewed did not voice any complaints about the building being all-electric.

ARUP

Ocean Ave Summary

What enabled success?

1. **The starting point: a nearly vacant building** – By starting with a nearly vacant city-owned building, tenant relocation costs were sizably reduced, and a more extensive retrofit could be undertaken. Addressing energy, ADA, and seismic issues together is more cost-effective and allows for a more holistic, comprehensive upgrade.
2. **Support from City champions** – This project was financially powered exclusively by local jurisdiction sources. Having the momentum behind it as a pilot project effectively helped it move forward.
3. **VNEM nearly eliminated tenant utility bills –** Through the SCE VNEM program, tenants pay almost no utility bill, which they view as a huge benefit to living at this property.
4. **Electric resistance heating, which is restricted under current energy code** – The project site had limited space to accommodate heat pumps; as such, the design team opted for electric resistance space heaters. While this project successfully achieved its goal of electrification, this approach would not work under today's version of the energy code, which restricts electric resistance heating due to its inefficiency and large peak demands.

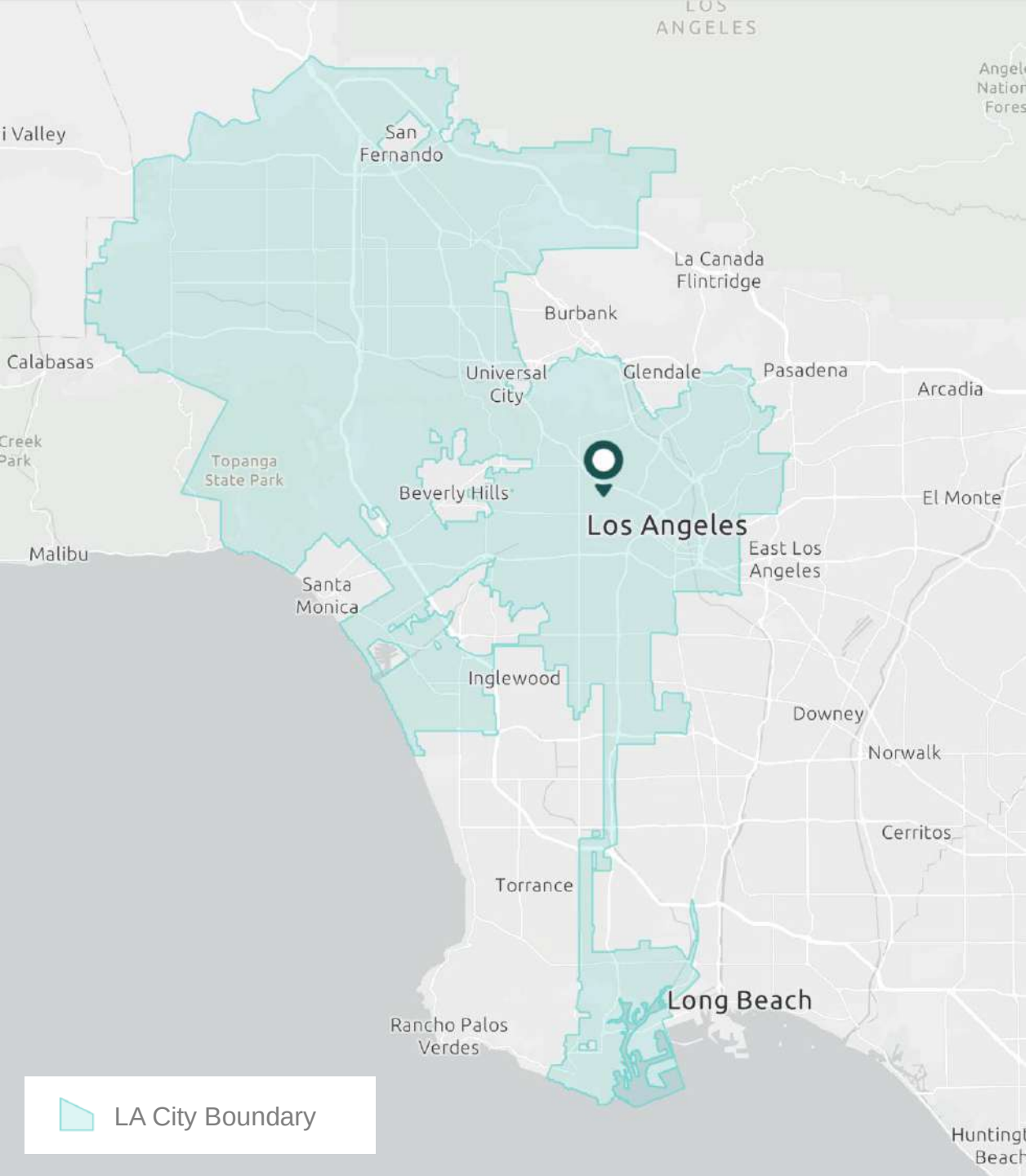
What challenges came up during the project?

1. **Delayed solar credit undermined financing** – The financing for the project was undermined because the solar credit from SCE did not come into effect until several months after the solar PV was installed. This caused the monthly utility expenses to look higher than they would be, limiting the project's ability to access additional financing.
2. **More funding to increase scope –** With more funding, it would have been possible to future-proof the retrofit by conducting upgrades during the initial process. These upgrades include reroofing before adding solar panels, adding air conditioning capacity, and installing EV charging, which will be increasingly necessary as gas vehicles are phased out in California by 2035.
3. **Stacking and tracking funding sources –** Lining up funding took about 2 years and funding sources were tied to distinct scopes of work with inflexible terms. As a result, these funding sources needed to be tracked separately.

ARUP

Case Study 2

Urban Soil / Tierra Urbana (USTU) Housing Cooperative



ARUP

Type of Affordable Housing	Naturally Occurring
Location	Wilshire Center/Koreatown
Number of Units	36 at Bimini Place; 8 at Bimini Terrace
Originally Constructed	1922
Retrofit Completion	2012
Electricity Utility	LADWP
Electric Metering	Master-metered at Bimini Place; Individually metered at Bimini Terrace
Solar PV Tariff	Unknown (Bimini Terrace)
Gas Utility	SoCalGas
Gas Metering	Master-metered at Bimini Place; Individually metered at Bimini Terrace
Tenant Utility Bill Responsibility	Electricity and gas at Bimini Terrace; None at Bimini Place

Project Basics

Urban Soil / Tierra Urbana

Project Team

- **Owner**: Urban Soil / Tierra Urbana (housing cooperative of the Los Angeles Eco Village)
- **Solar Hot Water Provider** – Altadena Energy & Solar
- **Solar PV Providing** – Solar Living Institute

Project Goal

- Create renewable energy demonstration

Retrofit Scope

- Solar PV at Bimini Terrace
  - Installed PV to serve 3 apartment units, exact size unknown
- Solar Hot Water at Bimini Place
  - 8 Sunearth EP40 collector – 320 sf of collector field
  - Pump station with new rooftop piping to collectors
  - 500-gallon storage tank
  - New domestic piping to solar preheat tank
  - Solar controlling and monitoring system
- Gas leak repair – recent gas system repair to fix a tenant-detected gas leak, decision made to not electrify

Interviews Conducted

- Owner Representative (2)
- Tenant (1)

Process & Timeline

Urban Soil / Tierra Urbana

Buildings acquired (1988)
Mission of CRSP (i.e., the Eco Village) was to serve as a resource center and demonstration of ecological community; the buildings were meant to provide affordable housing under this mission

Retrofitting process began (project by project)
Retrofits have taken place in piecemeal manner as the work has been done without additional financing

Solar panels installed (November 2005)
Solar panels were installed in 3 units of the Bimini Terrace Apartments, and tenants were invited to a solar installation workshop.

PV installed (1 month in ~2010)
PV installation was supported by a friend of the land trust, who was a solar consultant

Land trust became deed holder, with acquisition loan and mortgage to CRSP (2012)

Window replacement as part of lead remediation (2012)
Windows replaced only in the 8-plex building; improved energy efficiency

Solar hot water system installed (2-3 months in 2012)
Tenants achieved consensus and friends who were contractors (Altadena) offered economical rates.

Discovered gas leak (Winter 2020)
Sought consensus over whether to electrify or repair; decided to repair due to lack of funds and planning for electrification

Rain tanks and grey water system installed (2019)
These were installed to manage stormwater onsite for use in the garden. Not part of energy retrofits but part of the Eco Village's sustainability demonstration.

Gas system repairs completed (~2 months after leak was discovered)
During gas system repairs, the Ecovillage provided tenants with electric stoves and vouchers to eat out

ARUP

Project Financing

Urban Soil / Tierra Urbana

- **Solar PV cost –** Urban Soil / Tierra Urbana members recall that CRSP, the previous administrator of the housing cooperative, paid approximately $30,000 for the solar PV. This cost could have been offset through rebates, but CRSP did not file for them (reason not specified). The remainder of the system cost was donated by the Solar Living Institute who used the PV installation.
- **Solar hot water lease** – Urban Soil / Tierra chose to lease the solar hot water system from Altadena Energy and Solar. Lease fees were calculated based on measured solar contribution to the domestic hot water system. The lease agreement charged $0.85 for every 100,000 of BTUs provided by system. The lease also required a deposit of $8,000.
- **Solar hot water Fair Market Value estimate –** The lease contract states that the initial value of the solar hot water system was $42,000. In the agreement, it is scheduled to depreciate 40% in the first year, 60% by the 7th year, and 70% by the 10th year.
- **CSI Thermal Rebate** – The solar hot water system made use of a CSI Thermal Rebate, offered by the California Public Utilities Commission (CPUC). The amount of the rebate was not specified.

Economic Impacts

Urban Soil / Tierra Urbana

Economic Benefits	Notes
Property value	PV and solar water heater minimally improve property value
O&M Savings	No reported differences in O&M costs
Utility Bill Savings	– Certain units benefiting from solar PV – Solar water heating reduced gas use

Economic Costs	Notes
O&M Costs	– Urban Soil / Tierra Urbana financed the Solar Hot water through a 10-year lease – $0.85 per 100,000 BTU solar heat delivered to the delivery point – Minimal costs of repair to solar panel
Other Living Expenses	– Temporarily required induction stoves during gas leak repair – Used Eco Village funds for dining expenses

Tenant Rents Impacted?
No

Notes:

- Utility cost savings for property were not provided.
- Arup did not receive enough cost information to calculate simple payback.

Funding and Financing

Urban Soil / Tierra Urbana

Benefit
Delay
Downside
Unachieved potential

ARUP

Limited funds – Urban Soil / Tierra Urbana has very limited funding reserves, making sustainability measures challenging to implement. It was conveyed from the interviewees that energy efficiency tends to take a back seat to other measures needed to improve livability.

Using solar PV as a demonstration reduced cost – The solar PV was purchased at a reduced cost from the Solar Living Institute, who used the installation as a demonstration to promote their business and train their workers.

Solar Hot Water financed through lease – Urban Soil / Tierra Urbana decided to lease the solar hot water system to avoid the upfront cost. They are engaged in a 10-year solar hot water lease with the option to buy out or renew at the end of the lease.

Solar hot water rebate required piping upgrades – In order to qualify for the solar hot water rebate, Urban Soil / Tierra Urbana had to replace the highly conductive hot water galvanized steel piping in the attic. They opted for an insulated PEX piping. No other piping in the building was replaced.

Funding and Financing

Benefit
Delay
Downside
Unachieved potential

ARUP

Urban Soil / Tierra Urbana

Had no grant funding to enable electrification – When attempting to convert the building to all-electric, Urban Soil / Tierra Urbana did not have any grants or financing options lined up. This lack of funding limited their efforts since electrification was much more expensive than replacing the existing gas system. Grants typically take some time to receive; thus, to have been able to electrify their building, Urban Soil / Tierra Urbana likely would have had to apply for grants a year or more prior to the gas leak.

Limited funds for upgrades – The interviewed tenant echoed what the building manager said about Urban Soil / Tierra Urbana's reserves: The property has very little money for upgrades and maintenance. The 30-year acquisition loan competes with potential for retrofit funding. According to the tenant, Urban Soil / Tierra Urbana recently wanted to raise rents in order to cover costs for some new upgrades but were restricted because of the COVID-19 rent freeze in place at the time.

Implementation Process

Urban Soil / Tierra Urbana

Benefit
Delay
Downside
Unachieved potential

ARUP

Turnkey system – Altadena Energy and Solar provided a turnkey installation: They provided all planning, permitting, as well as rebate processing, which made the implementation straightforward. Members of the Eco Village remember a similar process for the solar installation.

Roof replacement combined with solar installation – The roof was replaced at the time of the solar panel installation since the rolled asphalt was at the end of useful life. Grouping in this additional scope helped to make sure that the roof would not have to be upgraded after the PV install, avoiding a more complicated roof replacement down the line.

Implementation Process

Benefit
Delay
Downside
Unachieved potential

ARUP

Urban Soil / Tierra Urbana

Consensus decision-making intensified discussions around gas leak resolution – Urban Soil / Tierra Urbana uses a consensus-based process to make decisions, requiring unanimous agreement among tenants. Consequently, the decision to replace the existing gas system rather than electrify the building proved challenging. Tenants were divided between the two options: to electrify, which would have been expensive and time-consuming but more in line with the sustainability goals of Urban Soil / Tierra Urbana, or to replace the gas system, which would be cheaper and take less time. Living without gas, i.e., an ability to cook, applied pressure to this decision, creating a sense of urgency among tenants.

Piping replaced only where needed for rebate qualification – During solar hot water retrofit, Urban Soil / Tierra Urbana elected to only upgrade the galvanized steel piping in that attic in order to quality for the rebate, as mentioned in the Funding and Financing section. According to a tenant interviewed, the building has old piping, which has led to issues with a few tenants accessing water in their apartments. As such, replacing more of the piping in the building could have helped improve both the use and efficiency of the domestic water systems. This system replacement, however, would have been more expensive and involved a longer construction period.

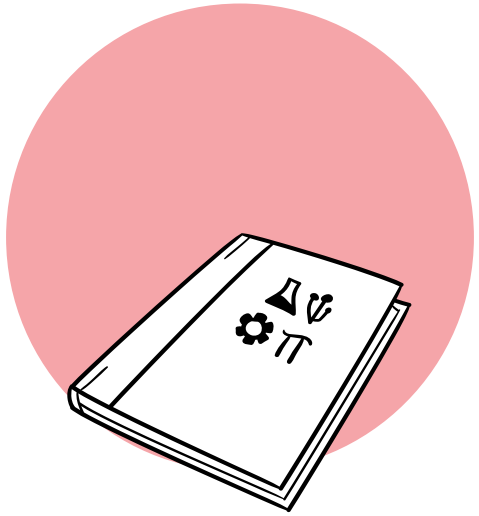
- **Calibration period for solar hot water –** The hot water thermostat had to be recalibrated a few times after the solar hot water install to make sure hot water was being provided at the correct temperature. After this start up and calibration period, the system was reported to work well.

Technical Assistance

Benefit
Delay
Downside
Unachieved potential

ARUP

Urban Soil / Tierra Urbana



Engaged contractors with personal connections – When deciding on contractors to install the solar panels (both hot water and PV), Urban Soil / Tierra Urbana chose two firms with employees that residents knew. Leveraging personal connections likely helped them reduce the cost of the two systems. As mentioned, Urban Soil / Tierra Urbana paid a reduced price for the solar PV system (exact cost was not provided), which was used as a demonstration to educate and train employees of the solar provider.

Solar hot water O&M included in lease – Through the solar hot water leasing agreement, maintenance and quarterly inspection is handled by a third-party. Outsourcing these services has supported the solar hot water system working well because the solar hot water provider is responsible for delivering, operating, and maintaining their system. Urban Soil / Tierra Urbana chose this route for O&M.

Unprepared for electrification – Building ownership initially thought that electrification should be simple; however, the process proved much more complicated and costly. Converting the building to all-electric systems would have taken at least 8 months, much longer than fixing the existing gas system. Urban Soil / Tierra Urbana found living without a means to cook food and heat water for 8 months untenable. They opted to instead replace the existing gas system.

Carbon Reduction

Benefit
Delay
Downside
Unachieved potential

ARUP

Urban Soil / Tierra Urbana

Solar hot water monitoring – The hot water tank includes sensors that monitor the quantity of heat provided by the solar hot water. This information is used by Altadena Energy and Solar to determine the lease payments, which are calculated based on solar output. With this information, Urban Soil / Tierra Urbana can also understand the extent of its renewable energy contribution.

Domestic hot water system efficiency – According to an early studied performed by Altadena Energy Storage to inform their solar hot water recommendation, the existing natural gas domestic hot water heating system for the building was very inefficient. Instead of operating at its rated efficiency of 84%, measured data showed that it was producing heat an efficiency of approximately 26%. In addition to solar hot water, Altadena thus also recommended replacing the gas heater as well as making changes to the tank and recirculation loop. Urban Soil / Tierra Urbana did not appear to move ahead with these other recommendations.

Tenant Impacts

Urban Soil / Tierra Urbana

Benefit
Delay
Downside
Unachieved potential

ARUP

- **Utility bill reductions -** Solar hot water provides a reduction in the monthly gas bills. These energy cost savings are limited, however, by the solar hot water lease, which adds to Urban Soil / Tierra Urbana's monthly expenses. Solar PV also provides utility cost savings, however, only to the 3 individually-metered units it serves.
- **Only minor disruptions from solar installation –** Both the solar hot water and solar PV installations minimally impacted tenants. In both cases, the construction occurred outside the residential units. To connect the solar hot water system, the building's hot water had to be shut off for 8 hours. Otherwise, tenants were able to go about their lives as they typically would during the construction and installation of these two systems.
- **Hotter hot water** – The tenant's specific room did not have any issues with hot water prior to the solar hot water install; however, according to her, many did. Based on what she has heard, the solar hot water now comes in hotter and faster than before.

Tenant Impacts

Urban Soil / Tierra Urbana

Benefit
Delay
Downside
Unachieved potential

ARUP

Eating expenses increased temporarily during gas leak repair – During the gas repairs, which took about 2 months to finish, tenants were given electric induction hot plates and money to eat out. Some tenants found that their pots and pans did not work with the induction stovetops. These tenants either had to borrow compatible pots and pans from their neighbors or buy their own.

Repairing gas leak improved safety – Discovering the gas leak initiated some concerns among tenants about safety. Addressing this issue assuaged their unease. Prior to the gas retrofit, a few gas pipe valves, which shut off or allow gas access, locked in place. The repairs addressed this issue, furthering tenants' feeling of safety.

Unaware of solar PV – A tenant who had lived at the property for several years was not fully aware that one of the buildings had rooftop solar PV. The panels are relatively hidden from view.

Challenging to secure tenant interviewers – Arup was only able to secure one tenant interview, despite reaching out to several and offering financial incentives ($50 Visa gift card) to each interviewee.

ARUP

Urban Soil / Tierra Urbana Summary

What enabled success?

1. **Using solar PV for training eliminated cost –** The solar provider, who residents of Urban Soil / Tierra Urbana knew prior, installed the PV system at no cost in exchange for being able to use the project to train their employees.
2. **Turnkey installation –** The design, installation, permitting, rebating, invoicing, and monitoring of the solar hot water system was handled by Altadena Energy and Solar as part of a turnkey contract. This implementation process led to an efficient installation with guaranteed performance.

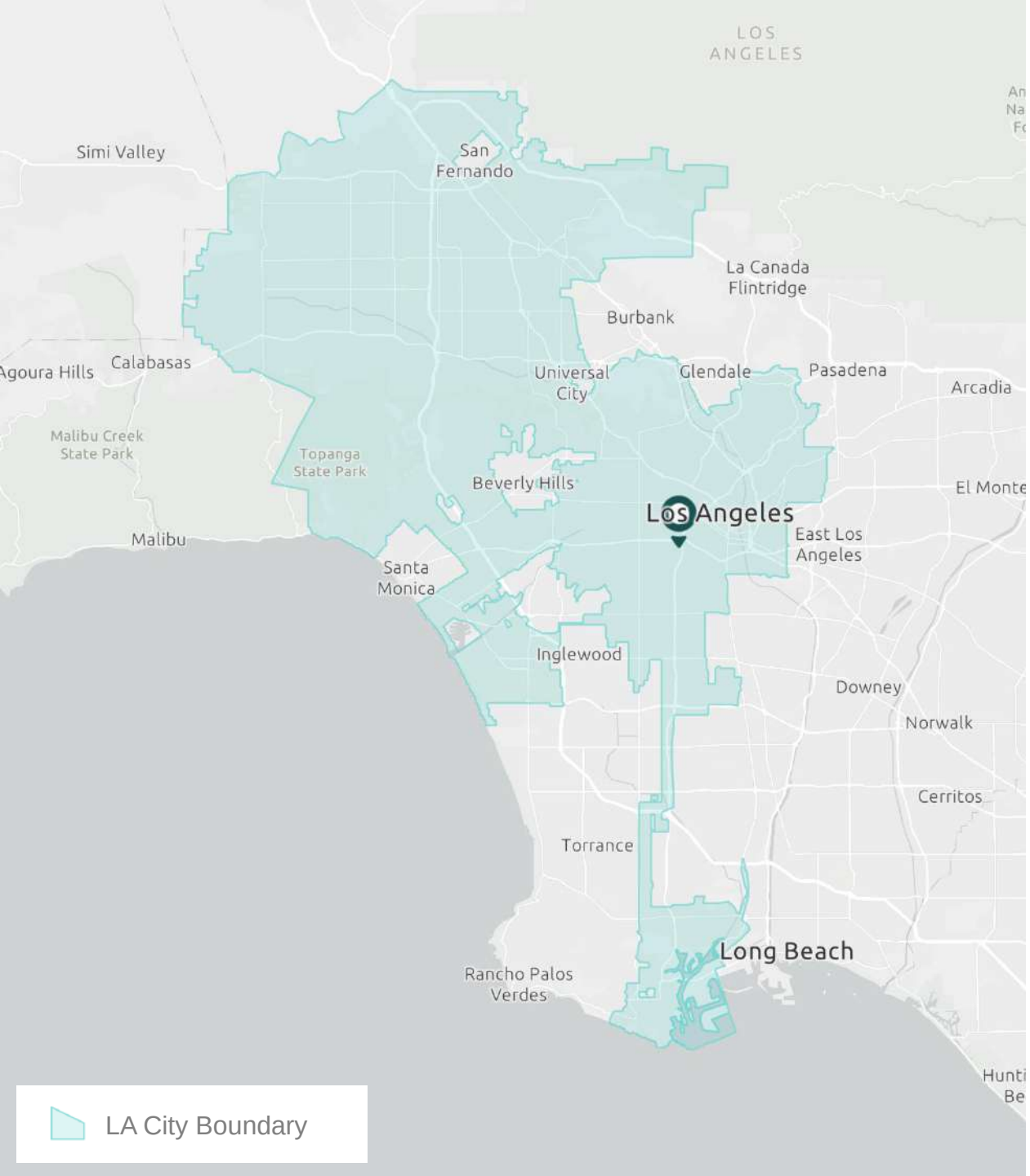
What challenges came up during the project?

1. **Reactive retrofits –** Moving from gas to electric would have required electrical upgrades, which the Urban Soil / Tierra Urbana had not been planning for and did not have reserves to support when the gas leak was detected. Regarding solar hot water, Urban Soil / Tierra Urbana did not upgrade their inefficient gas heater and replaced only the piping required to qualify for the rebate, when tenants have mentioned the poor condition of piping throughout the buildings. In both cases, the complex could have benefitted from technical assistance to support strategic planning. This planning could have enabled Urban Soil / Tierra Urbana to set long-term sustainability goals, develop scope to achieve them, and acquire funding in phases, rather than needing to react quickly during failures.
2. **Tenant consensus decision-making on urgent matters –** Because Urban Soil / Tierra Urbana has implemented a consensus decision-making process, they had to reach consensus on the decision to repair their gas system instead of electrifying the building when the gas leak arose. Unlike larger housing providers with full time operations and finance staff, Urban Soil / Tierra Urbana is more analogous to a mom-and-pop housing provider. Given the urgency of the gas leak, a decision was required quickly. Support for longer term strategic planning is needed to better inform decision-makers about phasing retrofits over time and would better align with the often slower nature of the consensus process.

ARUP

Case Study 3

Alegria Apartments



ARUP

Type of Affordable Housing	Subsidized, expiration unknown
Location	University Park
Number of Units	15
Originally Constructed	1925
Retrofit Completion	2018
Electricity Utility	LADWP
Electric Metering	Units Individually Metered
Solar PV Tariff	Feed in Tariff
Gas Utility	SoCal Gas
Gas Metering	Master-metered
Tenant Utility Bill Responsibility	Electricity

Project Basics

Alegria Apartments

Project Team

- **Owner:** Esperanza Community Housing Corporation (non-profit owner/developer)
- **Solar Provider:** Grid Alternatives
- **Energy Consultant:** Association for Energy Affordability (engaged for future decarbonization work, not involved with solar PV)

Project Goal

- Create renewable energy demonstration project

Retrofit Scope

- 35 kW rooftop PV system

Interviews Conducted

- Owner (1)
- Solar Provider (1)
- Energy Consultant (1)

Source: ncronline.org

Process & Timeline

Alegria Apartments

History of pollution by AllenCo Energy across the street

Esperanza purchased the building from the city (1994)
As part of the agreement, Esperanza would convert from single residence to 15 affordable units

Partnership with AEA, Grid Alternatives, funding from 11th Hour Project
These partnerships came as a result of connections to the environmental justice community, following years of networking

Requests to LADWP for partnership and virtual net metering (2017)
Despite Esperanza's attempts, the were not able to establish VNEM at the time

Roof replacement (~2017)
The roof was upgraded not long before the project installation, which was part of the motivation to install solar at that time

Solar permit received (November 2017)

Solar installed (2018-2019)
30 kW system purchased directly with grant funds

Annual revenue generated
About $7,800 annually generated

Monthly solar panel maintenance

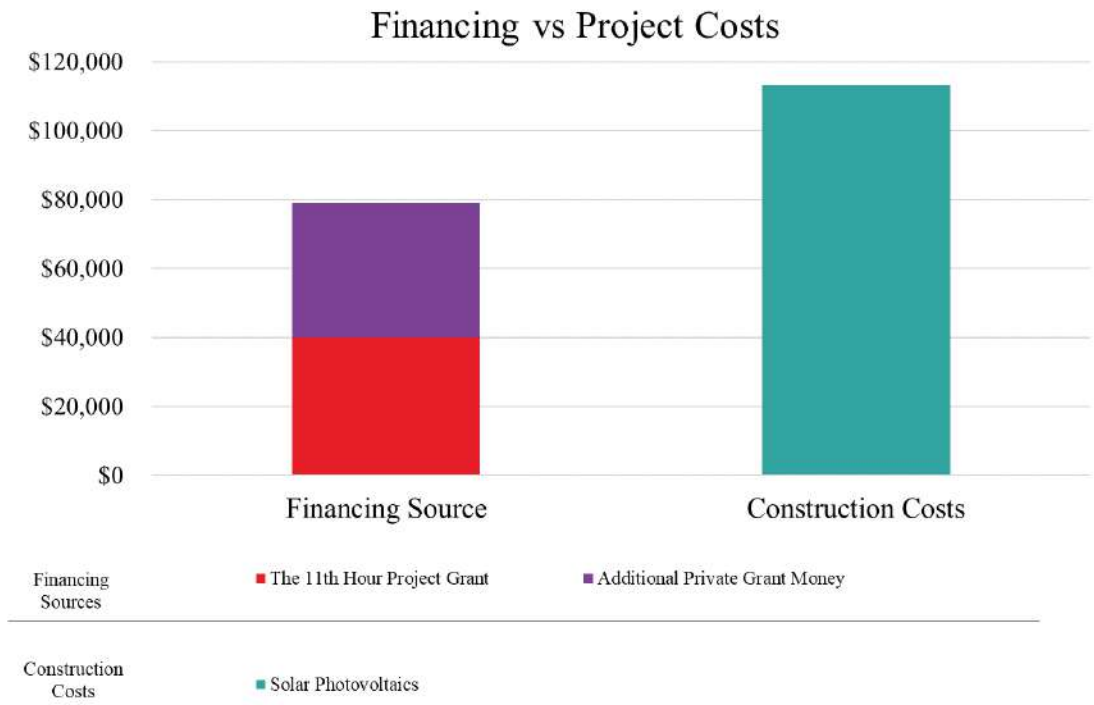
Solar panel damage (~$500)

ARUP

Project Financing

Alegria Apartments

- **11th Hour Project grant supplied majority of funding** – Grid Alternatives, the solar provider for Alegria Apartments, has been supported by the 11th Hour Project – a non-profit focused on environmental issues, especially within marginalized communities. Given their existing relationship, Grid Alternatives was able to bring in a sizable donation from the 11th Hour Project to support the solar installation.
- **70% of solar PV covered by grant money** – Based on the information provided, the combined grant money paid for approximately 70% of the PV system. In addition to what is shown, the project was constructed by volunteers from the Conservation Corps of Long Beach (donated work-hours) and received free inverters from Enphase Energy.



ARUP

Project Financing

Alegria Apartments

Financing

Source	Amount
The 11th Hour Project Grant	$40,000
Additional Private Grant Money	$39,000
Enphase Energy	Donated Equipment
Conservation Corps of Long Beach	Volunteers
Total	**$79,000**

Notes:
- Source: Interview with Nancy Ibrahim (2023-02-07); Flipping the Switch: Esperanza Community welcomes a new era of energy justice at Alegria (Grid Alternatives)

Project Costs

Items	Construction Costs
Solar Photovoltaics	$113,329
Total	**$113,329**

Notes:
- Source: Interview with Nancy Ibrahim (2023-02-07)

Economic Impacts

Alegria Apartments

Economic Benefits	Notes
Property value	PV provides building amenity
O&M Savings	No reported O&M Savings
Utility Bill Savings	$9,000 annually accruing to Esperanza Community Housing Corporation Source: gridalternatives.org

Economic Costs	Notes
O&M Costs	Negligible maintenance costs to date
Other Living Expenses	No reported increases to other living expenses

Simple Payback (Whole Building)	Simple Payback (Owner Only)	Calculation
13 years	13 years	Project costs / annual utility savings
4 years	4 years	(Project costs – grant funds) / annual utility savings

Tenant Rents Impacted?
No

Notes:

- Building owner receives all the utility cost savings.

Policies and Regulations

Benefit
Delay
Downside
Unachieved potential

ARUP

Alegria Apartments

Historic designation prevented the implementation of other energy measures – The building has a historical designation, which limited the ability to make certain changes like envelope upgrades. As such, solar PV was selected given that it could be done without affecting property's landmark status.

Funding and Financing

Alegria Apartments

Benefit
Delay
Downside
Unachieved potential

ARUP

Minimal financial reserves – Esperanza has limited funds to make building upgrades. The pandemic further reduced reserves. During this time, many tenants were impacted by COVID-19 and/or lost their jobs, exacerbating their financial strain. Several tenants were unable to pay rent. As a result, Esperanza's cashflow reduced, which limited funds for making upgrades to the building.

Financed exclusively through private funds – The project only made use of privately-funded grant money; Esperanza identified this funding through their previously existing networks.

Implementation Process

Benefit
Delay
Downside
Unachieved potential

ARUP

Alegria Apartments

A couple month delay in solar credit activation – Esperanza receives a check from LADWP for the energy it produces through PV. Their first payment was delayed a few months.

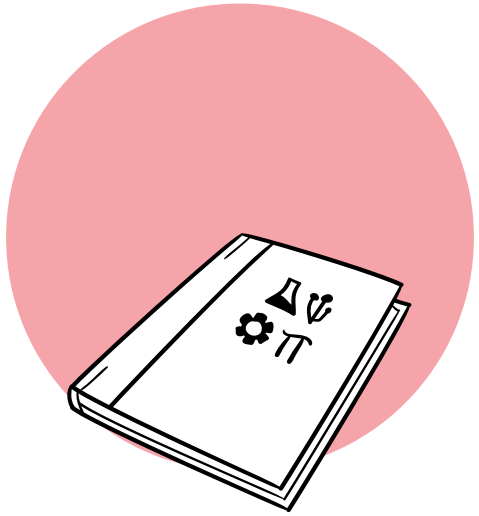
Minimal maintenance impacts – Maintenance requirements for the PV are minimal, limited to cleaning panels monthly.

Technical Assistance

Benefit
Delay
Downside
Unachieved potential

ARUP

Alegria Apartments



- **Didactic purpose attracted technical partner –** Grid Alternatives reached out to Esperanza to support the project, as they were in search of a building in the LADWP area that could serve as a learning tool in decarbonizing affordable housing. The building is located adjacent to AllenCo Oil site, which had previously caused pollution issues for the tenants. Esperanza and other partners waged a powerful community campaign called People Not Pozos with the entire community, and as a result of that people power, AllenCo was ultimately shut down. The wells have not yet been capped properly and leakage still occurs. This demonstration of community power attracted Grid Alternatives, who saw the project as an opportunity to showcase the benefits of clean electricity.

- **Recent roof upgrade facilitated PV install –** Grid Alternatives found the project to be a good candidate for a PV install since the building had just undergone a roof replacement – furthering their interest to get involved as a partner.

Tenant Impacts

Alegria Apartments

Benefit
Delay
Downside
Unachieved potential

ARUP

LADWP has no viable mechanism to reward multifamily tenants with solar credit – Although LADWP offers a VNEM pilot program, it does not operate like a true VNEM tariff. It leverages their feed-in tariff, allocating a minimum 40% of the utility credit to the tenants; the exact percentage is determined by the building owner. The credit is provided not as an on-bill benefit. Rather, it comes in the form of a reimbursement, i.e., a mailed check, thus not providing immediate benefit to customers.

Engagement with the program is capped at 5 projects or 5 MW, whichever is reached first, across the LADWP territory. Moreover, it involves an application, which involves paying the $500 - $1,000 application fee as well as $750 -$1,500 for the integration study fee

Grid Alternatives and Esperanza chose not to engage in this program, feeling that it did not reward tenants and building owners sufficiently. The fact the program, which was established in 2019, has 0 projects in service and only 1 in progress corroborates this viewpoint[1].

To work around this pilot program, Esperanza explored using Allume's virtual power plant, which could have allocated utility bill savings to tenants. Unfortunately, no agreement could be reached between LADWP and Esperanza. As such, PV could not serve the tenants' units. Through a feed-in tariff, the PV was configured to serve the house and common area loads, providing only Esperanza with a utility bill reduction.

Tenant Impacts

Alegria Apartments

Benefit
Delay
Downside
Unachieved potential

ARUP

Planned tenant computer lab derailed by pandemic – In an effort to share the utility bill benefit from the solar PV to tenants, Esperanza intended to create a computer lab powered by the PV. This idea emerged through tenant engagement. Unfortunately, the computer lab was not part of the PV install project; the plan was derailed due to pandemic impacts.

ARUP

Alegria Apartments Summary

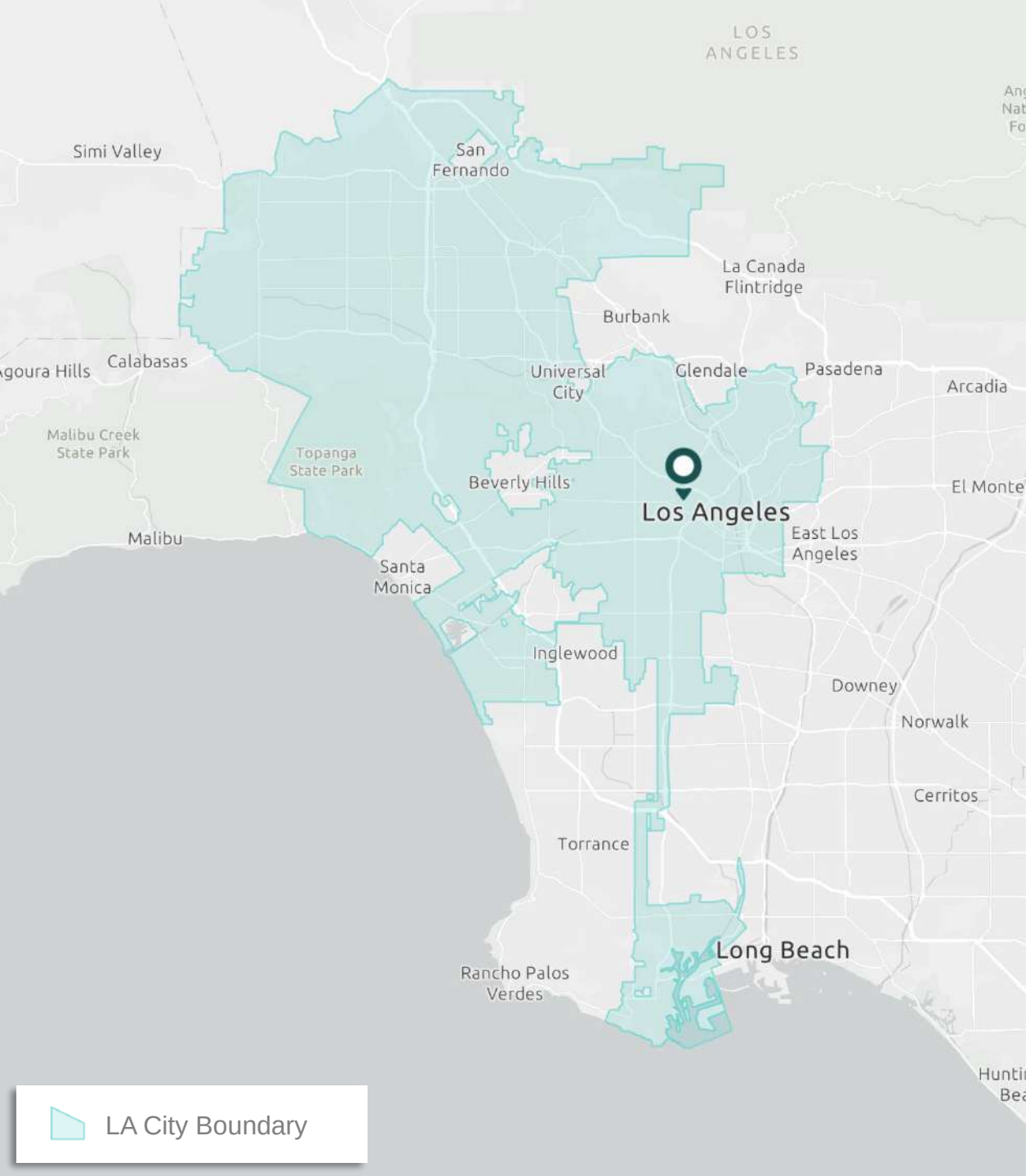
What enabled success?

1. **Inspiring story and didactic value catalyzed the project** – The community campaign People Not Pozos that ultimately led to the shut down of the AllenCo oil fields garnered positive news coverage. This coverage attracted the interest of the firm Grid Alternatives who was looking to install solar PV on top of affordable housing buildings within LADWP's service area. Grid Alternatives reached out to Esperanza to realize this project. They brought in some funding and installed the panels. Serving as a high-profile demonstration with significant didactic value, this solar project took the environmental justice story further, showing what is possible when a community comes together to protect the environment.

What challenges came up during the project?

1. **LADWP reduced the benefits tenants receive for a centralized solar PV** – Despite repeated attempts and negotiations with LADWP, Esperanza was not able to relay utility cost savings from the installed solar PV system to the tenants of Alegria Apartments; LADWP does not offer a viable VNEM program. As such, PV was configured to serve the common area / house loads, with Esperanza receiving a solar credit on their utility bill via LADWP's feed-in tariff program. To provide some sort of tangible benefit, Esperanza intended to create a computer lab that would be powered by the solar PV system. Due to funding limitations, they have not been able to realize this plan. Consequently, tenants do not receive any direct benefits of the solar PV installation.
2. **Historic designation can limit level of decarbonization possible** – Preserving the original architectural feature makes some retrofits, like envelope upgrades, much more complicated and expensive to pursue.


ARUP
Case Study 4
Miramar Towers
Google



ARUP

Type of Affordable Housing	Subsidized, expiration 2040
Location	Westlake
Number of Units	157
Originally Constructed	1979
Retrofit Completion	2021
Electricity Utility	LADWP
Electric Metering	Unknown
Solar PV Tariff	Unknown
Gas Utility	SoCal Gas
Gas Metering	Master-metered
Tenant Utility Bill Responsibility	Electricity

Project Basics

Miramar Towers

Project Team

- **Owner:** Jonathan Rose Companies (large developer of market rate and affordable housing)
- **Design Build Turnkey Contractor:** Bright Power
- **Energy Consultant:** Bright Power

Project Goals

- Reduce energy consumption by at least 20%
- Reduce carbon emissions
- Water efficiency

Retrofit Scope

- Electrification of domestic hot water
- Envelope improvements
- Energy efficiency upgrades (lighting, HVAC, appliances)
- Plumbing fixture upgrades
- Onsite PV
- ADA upgrades
- Cosmetic upgrades
- Enterprise Green Communities (EGC) Certification

Interviews Conducted

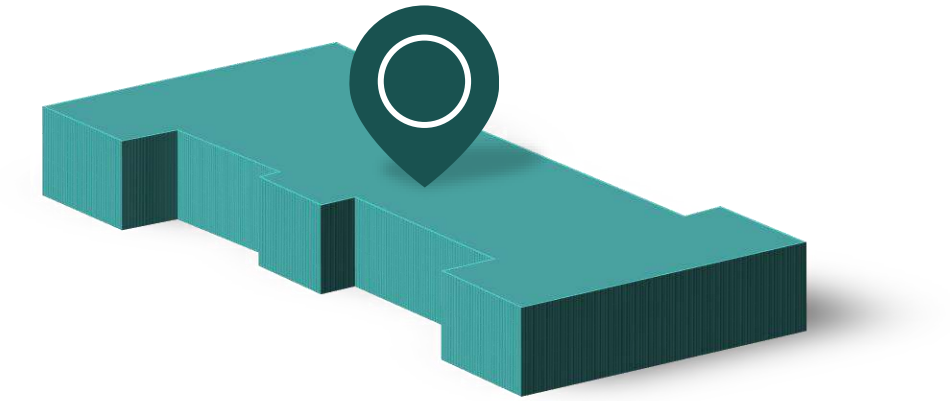
- Owner (1)

Source: la-bbc.com

ARUP

Retrofit Scope Detailed

Miramar Towers



Envelope
- Window replacements (dual pane)
- Air sealing

Energy Efficiency
- Low flow plumbing fixtures
- Lighting (fixture and controls) upgrades in apartments and common areas
- EnergyStar clothing washer replacements
- Space heating boiler upgrade (condensing boilers)
- Domestic hot water (DHW) recirculation flow controls and in unit check valves

Electrification
- Central domestic hot water (DHW) heat pump water heater + gas boiler for top up and redundancy

Distributed Energy Resources
- Installation of 72 kW rooftop solar (PV)

Non-Decarbonization Work
- Upgrades to flooring and cabinets
- Common area enhancements
- Community room upgrades including kitchen addition
- Resident Services Office
- Fitness Center with indoor and outdoor access
- Outdoor walking path
- ADA upgrades to make 15% of units Uniform Federal Accessibility Standards (UFAS) compliant

Process & Timeline

Miramar Towers

Acquired by Jonathan Rose in 2017

Performed ASHRAE Level 2 Energy Audit
to identify energy retrofit opportunities, working with Bright Power

Applied for the Low-Income Weatherization Program (LIWP)
Jonathan Rose Companies became aware of LIWP through partnership with Bright Power

Underwent a 4% LIHTC and bond resyndication
Tax credits from the state and equity for the project

Worked with sustainability consultants to meet requirements
These requirements included those of the Tax Credit Allocation Committee, the California Debt Limits and Allocation Committee, and green building retrofit standards of the City of Los Angeles

Financial transaction closed in 2019; Construction commenced
Having lined up incentives for energy retrofits, when the financial transaction closed, they were ready to begin upgrades

Challenging to put O&M agreements into place
Difficult to find a company that could develop a preventative maintenance agreement for heat pump water heaters

In Q1 2020, launched an enhanced utility alert program to monitor energy and water use
These alerts support monitoring and timely response to any unexpected issues with energy use; supports monitoring consumption for ENERGY STAR and Bright Power's Energy Score Cards

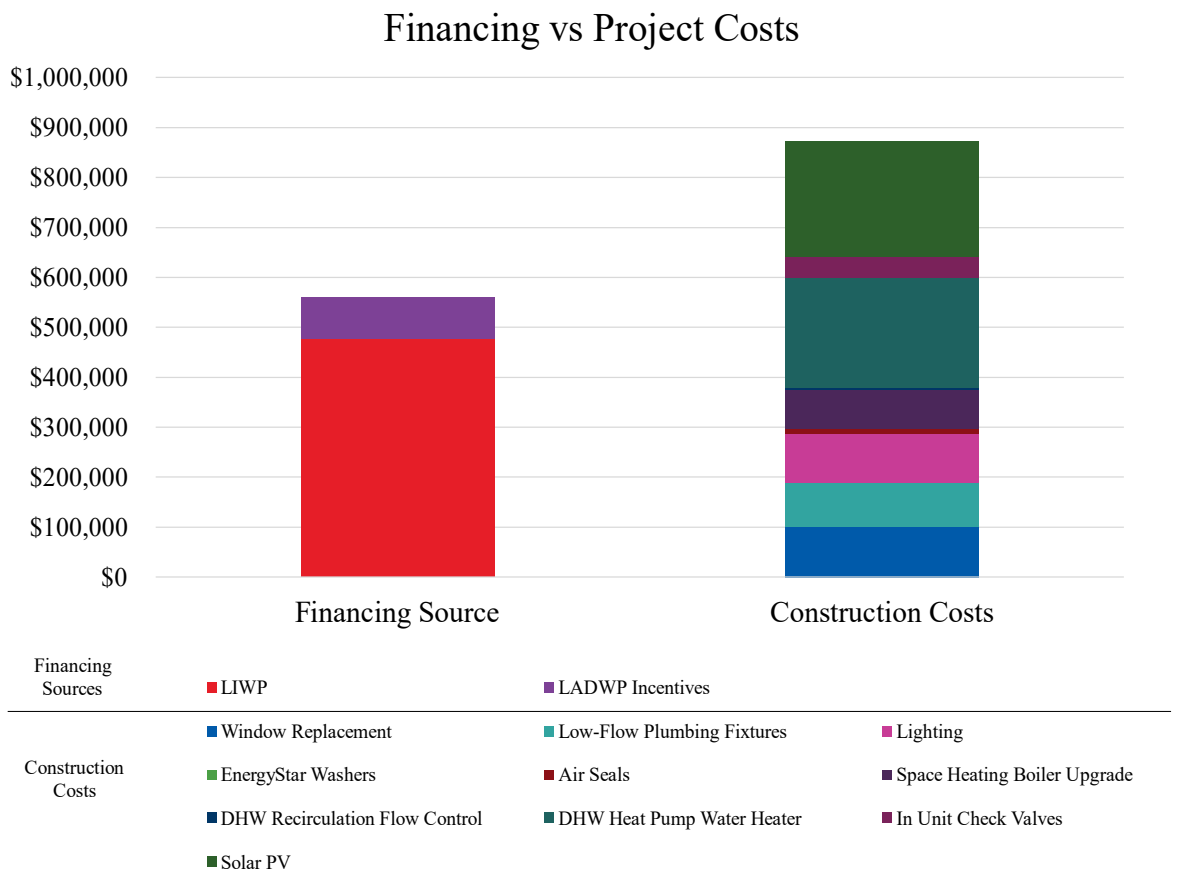
Construction completed in early 2021, during COVID
COVID presented some challenges for the construction team, but they were able to follow procedures and limited number of units entered at any given time

Project Financing

Miramar Towers

- **LIWP provides majority of funding** – Jonathan Rose and Bright Power received significant funding from the Low-Income Weatherization Program (LIWP), reducing the need to pursue additional funding options.
- **Responsible for 35% of cost** – Grants did not cover all the energy retrofit expenses. Jonathan Rose paid $310,505 from their reserves.
- **Solar PV and DHW Heat Pump make up most of the decarb-related costs** – Together, they account for 51% of the construction costs of the decarbonization measures. Since central heat pump water heating was relatively new at the time of the project, it is likely the costs have decreased since.
- **LADWP offset solar costs only by 6.5%** – LADWP provided incentives for both plumbing and solar PV. However, the solar incentive covered only a small portion of the total PV cost.

Note: the graph only shows decarbonization related costs and financing. The Non-decarbonization measures (ADA, community room, fitness center, etc.) have been omitted. The Low-Income Tax Credit, which was used to fund these measures, is also not included as part of financing source because it was not used for decarbonization measures.



Project Financing

Miramar Towers

Financing

Source	Amount
LIWP	$478,020
LADWP Solar Incentive	$15,180
LADWP Low-Flow Toilets Incentive	$68,295
4% Low Income Tax Credit	Unknown
Total	**$561,495**

Notes:

- Source: Bright Power Memo - Updated Scope of Work Table & Measure Descriptions; Interview with Lauren Zullo 2023-04-17
- The Low-Income Tax Credit provided funding for most of the non-decarbonization related scope. The tax credit was purchased by Bank of America in exchange for equity that provided the project with cash to perform the retrofits.
- Grants did not cover the entire cost of the energy retrofit. Jonathan Rose had to pay $310,505 from their reserves, accounting for the delta between Project Costs and Financing shown on this slide.

Project Costs

Items	Construction Costs
Window Replacement	$100,000
Low-Flow Plumbing Fixtures	$90,000
Lighting	$96,250
EnergyStar Washers	$750
Air Seals	$10,000
Space Heating Boiler Upgrade	$78,500
DHW Recirculation Flow Control	$2,500
DHW Heat Pump Water Heater	$221,000
In Unit Check Valves	$42,750
Solar PV	$230,250
Total	**$872,000**

Notes:

- Source: Bright Power Memo - Updated Scope of Work Table & Measure Descriptions
- These costs represent preliminary estimates, not actual costs
- The table only shows decarbonization related costs and financing; non-decarbonization measures (ADA, community room, fitness center, etc.) have been omitted.

Economic Impacts

Miramar Towers

Economic Benefits	Notes
Property value	Increase of $770,909 estimated by Bright Power
O&M Savings	Reduced deferred maintenance
Utility Bill Savings	$58,500 annually ($42,400 owner savings annually; $16,100 tenant savings annually for both energy and water)

Economic Costs	Notes
O&M Costs	No reported increases to O&M
Other Living Expenses	No reported increases to other living expenses

Simple Payback (Whole Building)	Simple Payback (Owner Only)	Calculation
15 years	21 years	Project costs / annual utility savings
5 years	7 years	(Project costs – grant funds) / annual utility savings

Tenant Rents Impacted?
No

Notes:

- Simple payback includes water and energy retrofits
- Most utility savings are accrued to the building owner except for the air seals, apartment lighting upgrades, and a portion of the solar PV

Funding and Financing

Miramar Towers

Benefit
Delay
Downside
Unachieved potential

ARUP

LIWP offered most funding – From reviewing the energy efficiency incentive landscape in the Southern California region at the time, Bright Power identified LIWP as the most promising source.

Funding-imposed requirement guided the design – LIWP, which awarded funding based on the reduction of CO_2 emissions for the entire building, required the use of heat pumps for domestic hot water heating. To satisfy this requirement, Jonathan Rose initially planned for a complex design of aligning multiple domestic hot water heat pumps in series. The complexity stemmed from hot water heat pumps being a relatively new technology with limited availability in the local market in 2018. As described under the section Implementation Process, heat pump technology advanced rapidly during the project. The project team ended up adapting the design to make use of newer heat pump technology better suited to meet the demands of the building.

Multiple funding sources compounded compliance documentation needed – In addition to LIWP, a few other funding sources were pursued. Each had different requirements, increasing the amount of compliance documentation that had to be produced.

Long funding queue delayed project – Informed by Bright Power's incentive landscape assessment, Jonathan Rose applied for LIWP funding. It took 2 years for their application to get approved due to a long queue of applications.

Resyndication captured new tax credits – While waiting for LIWP funding, Jonathan Rose took advantage of resyndicaiton to infuse the project with low-income tax credits that could be used to finance a whole building retrofit.

Funding and Financing

Miramar Towers

Benefit
Delay
Downside
Unachieved potential

ARUP

Converting funding source to upfront capital – LIWP funding was structured to come in as a reimbursement after project completion rather than as a source of funding at the beginning of the project to pay directly for the energy retrofit. Jonathan Rose preferred to use the grant money as a funding source in order to avoid paying for the retrofits upfront as well as to maintain more ownership over the project's energy saving benefits. Bank of America, which had supplied the project with equity in exchange for the low-income tax credits, would otherwise retain ownership.

In order to use LIWP as a funding source, Jonathan Rose engaged a non-profit to help them access funds up-front to enable the project. The financial structure for the project thus ended up being complex, requiring additional work and negotiation to arrange. maintain more ownership over the project's energy saving benefits

Scope tailored to funding – Bright Power proposed a project scope that considered the potential amount of grant money from LIWP and incentive funding from LADWP that could be received. During this planning process, they conducted cost estimation as well as energy analysis of the recommended measures, determining a budget, amount of carbon savings realized, as well as the simple payback for each measure. The recommended strategies were then included as part of the LIWP incentive application.

This method of developing scope in concert with applying for funding ensured the project team had sufficient funds, if awarded the grant, to carry out the scope. No value engineering was necessary in order to deliver the retrofit within the original budget.

Implementation Process

Benefit
Delay
Downside
Unachieved potential

ARUP

Miramar Towers

Turnkey design-build contract aided project success – After performing an ASHRAE Level 2 audit and incentive review, Bright Power was engaged to provide a turnkey retrofit through a design-build contract. They handed all the design, construction, and incentive requirements. This type of contract simplified project coordination and, according to Jonathan Rose, was key to a successful project.

Rapid advancements in heat pump technology altered design – During the approximately two-year wait for the approval of the LIWP application, there were significant advancements in heat pump technology. Consequently, the initial domestic hot water heating solution became outdated. Instead of installing multiple heat pumps as originally planned, the project was able to procure a single, larger heat pump. This deviation from the documented plan in the LIWP application was prompted by the technological progress and improved efficiency of heat pump systems.

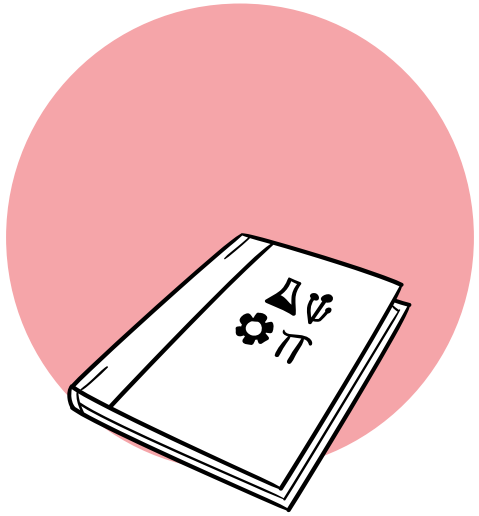
COVID Delays – Construction started in 2019 and dragged out longer than anticipated due to COVID-19 impacts on supply chains and workforce availability.

Technical Assistance

Benefit
Delay
Downside
Unachieved potential

ARUP

Miramar Towers



Jonathan Rose leveraged existing business relationship for technical assistance and market entry – After acquiring the property, Jonathan Rose brought on Bright Power as a partner in the project because of their decarbonization work in Southern California. Bright Power is an energy and water management provider with which Jonathan Rose has worked extensively. At the time, Jonathan Rose did not have a presence in the region; Miramar Towers was their first building there. Bright Power, as such, introduced them to the decarbonization landscape in California, providing insight on the types of incentives and designs that work well. This partnership enabled them to deliver the Miramar Towers, which ended up being their first project in Southern California.

Small number of heat pump maintenance providers – As part of the LIWP requirements, Jonathan Rose had to secure maintenance contracts for all newly installed mechanical equipment. However, finding a suitable maintenance provider for the domestic hot water heat pump heater proved to be a challenge. It took up to six months because there were very few firms at that time locally with experience in working with this technology. Unlike traditional gas heaters that could be serviced by a plumber, heat pump water heaters have a greater number of electrical components, necessitating electrical expertise.

Carbon Reduction

Benefit
Delay
Downside
Unachieved potential

ARUP

Miramar Towers

Domestic hot water heating reduced but did not eliminate gas usage – Per the LIWP requirements, the project had to incorporate a heat pump for domestic hot water heating. Instead of meeting the entire demand, the heat pump water heater was sized to meet 90% of the domestic hot water load, likely due to size limitations and spatial constraints – a heat pump sized to meet 100% of the demand would have been much larger. A gas boiler was provided for top-up heating and redundancy. Retaining some gas usage slightly restricted the extent of carbon reduction realized by the project.

Impact investing firm incentivized to delivered on carbon goals – Jonathan Rose operates as an impact investing firm. Sustainability initiatives a key part of their mission, and they have set a target of achieving a minimum 20% reduction in carbon emissions for every property they acquire. This goal served as the cornerstone for the project and was supported by their investment framework, ultimately leading to its success. Remarkably, the property surpassed expectations by achieving a remarkable 53% reduction in carbon savings upon completion of the retrofit.

Tenant Impacts

Miramar Towers

Benefit
Delay
Downside
Unachieved potential

ARUP

ADA upgrades triggered temporary tenant relocations – To fulfill the necessary ADA upgrades, semi-invasive construction was undertaken, involving the reconstruction and addition of various features in the apartment such as grab bars, wall reinforcements, door replacements, and more. Jonathan Rose temporarily relocated tenants from the affected unit to facilitate these modifications. If the ADA upgrades had not been needed, it's likely that tenants could have remained in their units throughout the duration of the energy retrofit scope of work.

Additional tenant amenities provided via tax credit – In addition to the energy efficiency and renewable energy measures, the retrofit included providing new resident services programming, common areas, community rooms, fitness centers, and walking paths. Most of these non-decarbonization additions were financed through the federal low-income tax credits.

Windows improved thermal and acoustic comfort – The new double-pane windows reduced both solar heat gain during summer as well as heat loss in the winter, improving thermal comfort in the apartments. With two layers of glass, they also provided enhanced sound insulation, reducing the impact of exterior street noise.

ARUP

Miramar Towers Summary

What enabled success?

1. **An incentive landscape scan enabled an incentive-tailored scope and smoother delivery –** As a first step, Jonathan Rose engaged Bright Power to survey grant funding and incentives for low-income housing in Southern California. This approach to finding funding before developing the project scope resulted in an energy retrofit package tailored to the funding available, preventing value engineering during design or construction.
2. **Repeat partnerships and turnkey project delivery –** Jonathan Rose's strong partnership with Bright Power catalyzed project's success. Leveraging this existing business relationship brought Jonathan Rose into a new market and enabled a robust turnkey contract that facilitated efficient construction and project delivery.
3. **Adapting to emerging technology –** The heat pump industry advanced quickly during the project, which led to initial project design becoming outdated. The project team was able to quickly adapt and redesign the domestic hot water heating system to make use of better, simpler technology.
4. **Resyndication injected project with funding –** The project was timed well to make use of a property resyndication for low-income tax credits. If planned at a different time, this additional money may not have been available.

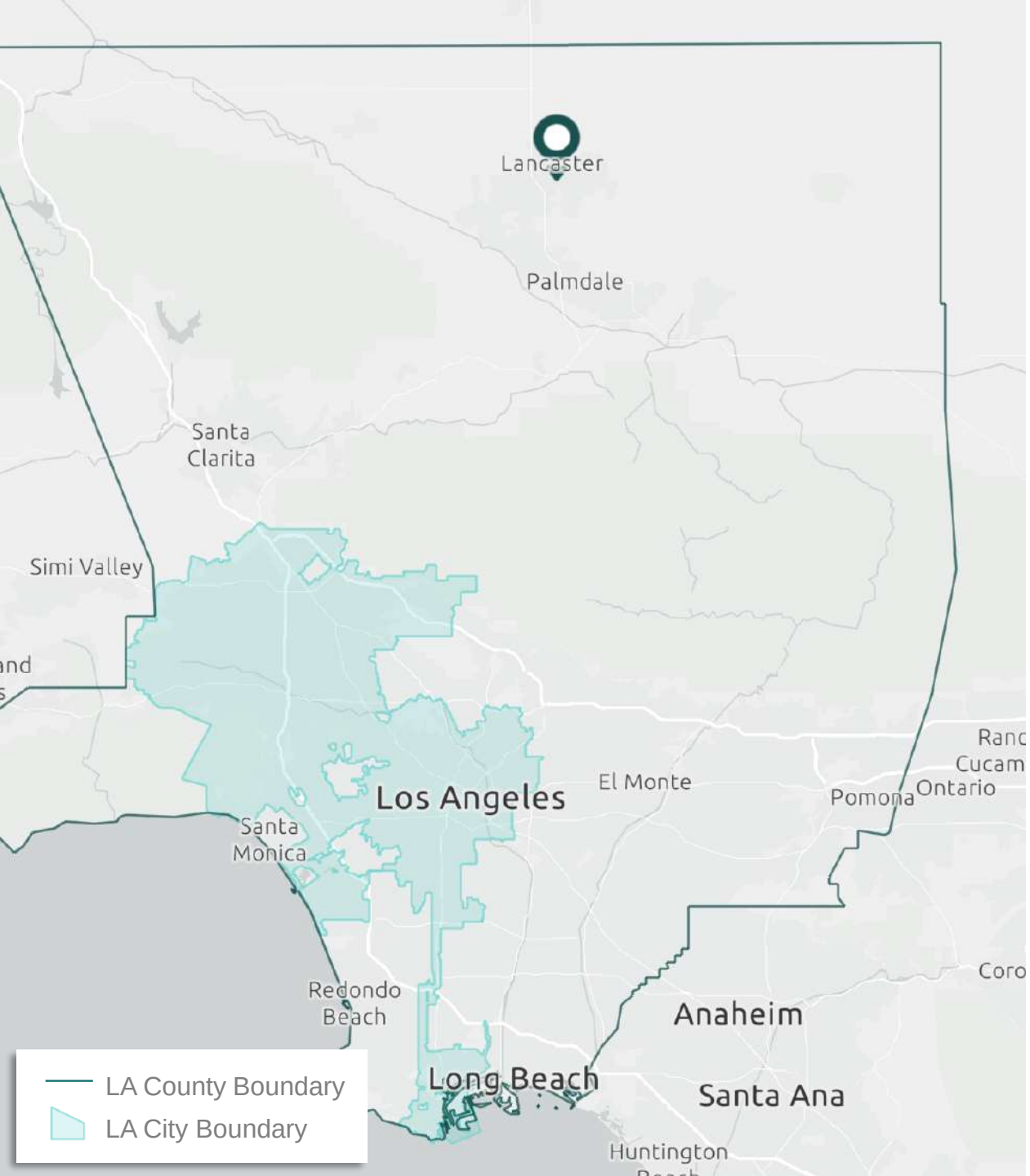
What challenges came up during the project?

1. **LIWP lead time impacted project timeline and design –** Jonathan Rose faced a lengthy two-year wait after submitting the application before receiving approval for LIWP funding. There was lack of clarity around the wait time length and the result was not only a project delivery delay but design impacts: market availability of heat pump water heaters advanced.
2. **LIWP reimbursement structure required third party lender for upfront capital –** To convert LIWP funding from a reimbursement received after the project to a grant source, Jonathan Rose engaged a non-profit to front the money. This arrangement created a complicated financial structure. If LIWP had been set up to provide funding a source, additional work created by this financial structure including negotiation and complicated invoices could have been avoided.
3. **Challenging to find local heat pump providers and maintenance contracts –** The project began at a time when heat pumps were a relatively new, emerging technology. Given the limited level of market saturation, heat pump service providers were challenging to find.

ARUP

Case Study 5

The Village at Beechwood



ARUP

Type of Affordable Housing	Subsidized, expiration 2038
Location	Lancaster
Number of Units	100
Originally Constructed	1970s
Retrofit Completion	2016
Electricity Utility	SCE
Electric Metering	Units Individually Metered
Solar PV Tariff	VNEM
Gas Utility	SoCal Gas
Gas Metering	Master-metered
Tenant Utility Bill Responsibility	Electricity

Project Basics

The Village at Beechwood

Project Team

- **Owner:** LINC Housing (non-profit owner/developer)
- **Contractor:** EPRI
- **Project Manager:** Kliewer and Associates (for SCE)
- **Energy Consultant:** BIRAenergy
- **Utility:** Southern California Edison

Project Goal

- Net Zero Source Energy

Retrofit Scope

- Efficiency upgrades in 30 out of 100 residential units and in common area
- Solar hot water for community water
- Solar PV over carports
- Near-Zero Net Source Energy for the 30 units
- Asbestos abatement

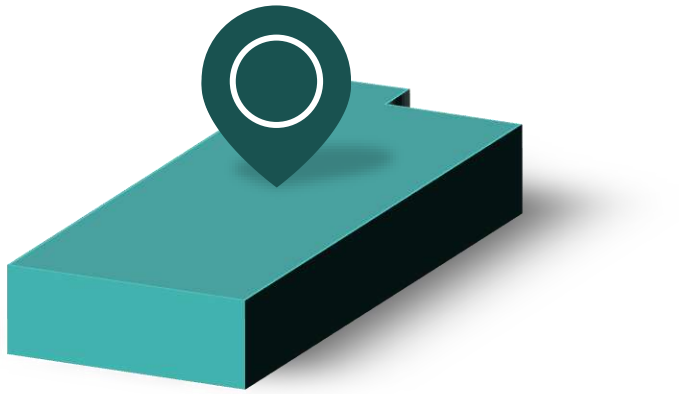
Interviews Conducted

- Utility Project Representative (1)
- Energy Consultant (1)

Source: Linc Housing

Retrofit Scope Detailed

The Village at Beechwood



Energy Efficiency – Residential Units

- Attic insulation
- Cool roof spray foam insulation (in 10-plex building)
- Envelope air-sealing
- Duct retrofits (whole replacement, added insulation, and/or sealing)
- Boiler replacement and improved piping for community water heating
- Tankless water heaters replacement (in duplexes)
- Home Energy Management Systems / smart thermostats
- Low flow showerheads
- New refrigerators (select units)

Energy Efficiency – Common Areas

- Aerosol sealing of building envelope
- Smart thermostats
- HVAC fault detection
- Roof insulation
- Spray foam insulation and sealing of rooftop units (RTU) “L” ducts
- Airside economizer for RTUs
- Smart plug strips
- 99% efficient tankless water heater replacement

Distributed Energy Resources

- 84 kW solar PV installation on existing carports
- Community scale solar hot water with 1,250 water tank

Non-Decarbonization Work

- Asbestos abatement
- T-Mobile hotspots (included with smart thermostats)
- New carports

Process & Timeline

The Village at Beechwood

EPRI awarded PIER 308-5 grant (2013)
EPRI and LINC Housing selected the project location; EPRI support commenced formally as project manager; Prior connections between Bira, EPRI, LINC Housing, SoCalGas, and SCE facilitated the project

SCE conducted audit

Accessing state programs was difficult, confusing, and time-consuming
For example, the team collected data for the Energy Upgrade California program only to learn that the program was not a good fit

BIRA monitored energy performance 1 year before the retrofit (2014)
Grant scope had included monitoring; results of observed

BIRA developed EE packages using model simulations; determined that net zero would not be possible

Developed construction scope and selected contractor (Proteus)

Construction over about 6 months (2015)

Asbestos abatement required
Asbestos mitigation required use of project funds and required temporary relocation of tenants during mitigation

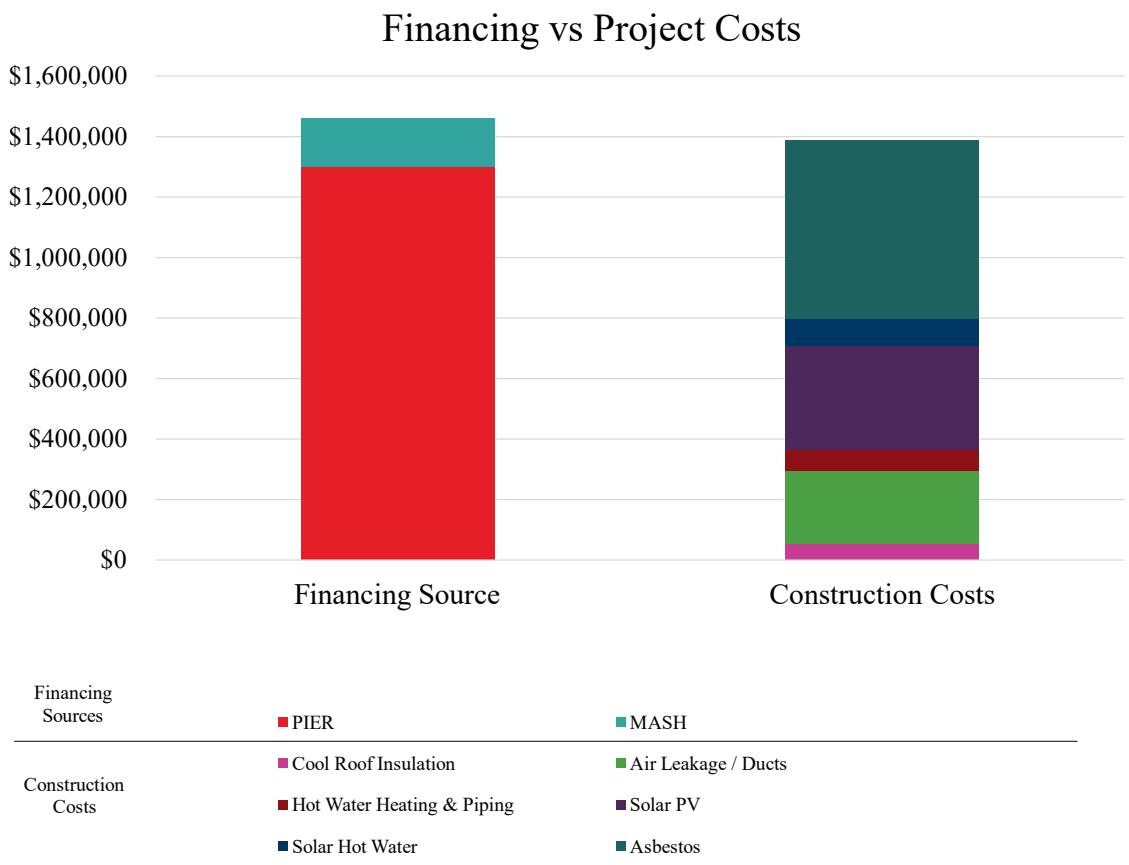
BIRA monitored energy performance 1 year after the retrofit (2016); ongoing QC by Kliewer & Associates

Kliewer & Associates submitted the project to ASHRAE and won 1st place for 2018 ASHRAE Region 10 Chapter Technology Transfer Committee Award (Residential) for the project, **“**Deep Retrofits in Low-Income Multi-Family Housing,” Ron Kliewer (PM) and Waymon Arnold (Engineer of Record)

Project Financing

The Village at Beechwood

- **Public Interest Energy Research (PIER) Grant provided majority of funding** – The California Energy Commissioning (CEC) awarded the project funding to develop and demonstrate a replicable and scalable model to achieve Net Zero Energy retrofits of affordable housing. Project scope was roughly tailored to the amount of funding provided through this grant.
- **MASH Rebate covered almost half of solar PV costs** – The Multifamily Affordable Solar Housing (MASH) helped to reduce the price of solar, enabling the project to benefit from a larger system.
- **Asbestos abatement accounted for 40% of project costs** – It was the largest expense of the project, diverting funds from the decarbonization work.
- **Solar PV makes up 41% of decarbonization costs** – Outside of asbestos abatement, solar PV represents the most expensive item followed by Air Leakage / Ducts.



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Project Financing

The Village at Beechwood

Financing

Source	Amount
CEC Public Interest Energy Research (PIER)	$1,300,000
SoCal Gas ESA	Unknown
SCE Direct Install	Unknown
Multifamily Affordable Solar Housing (MASH) Rebate	$160,000
Total	**$1,460,000**

Notes:

- Source: Interview with Ian Hammon-Hogan from BIRAenergy (2023-04-13); Southern California Edison - Replicable and Scalable Near-Zero Net Energy Retrofits of Low-Income Multifamily Housing: Electric Energy Efficiency; Replicable and Scalable Near-Zero Net Energy Retrofits for Low-Income Housing (ACEEE Summer Study 2016); A Brighter Future For This Lancaster Community (newsroom.edison.com)
- SoCal Gas ESA provided funding for some measures that indirectly saved energy including weatherization, minor repairs to interiors, and water saving features.
- SCE Direct Install funded the refrigerators, interior CFL lights, and smart power strips.

Project Costs

Items	Construction Costs	Budgeted Costs
Cool Roof Insulation	$51,759	$48,000
Refrigerators	Unknown	Unknown
Lighting	$35,253	$35,253
Air Leakage / Ducts	$243,689	$231,000
Smart Thermostat	$7,227	$9,850
Hot Water Heating & Piping	$70,302	$30,350
Solar PV	$341,189	$341,000
Solar Hot Water	$89,980	$89,980
Asbestos Abatement	$590,000	$0
Total	**$1,430,000**	**$785,433**

Notes:

- Source: Southern California Edison - Replicable and Scalable Near-Zero Net Energy Retrofits of Low-Income Multifamily Housing: Electric Energy Efficiency
- The cost of asbestos abatement had to be estimated since the report did not provide one. The estimate was calculated based on the statement in the report that asbestos abatement comprised approximately 40% of the total project costs.

Economic Impacts

The Village at Beechwood

Economic Benefits	Notes
Property value	Improved property value due to asbestos removal and measures
O&M Savings	T-mobile hotspots provided to tenants
Utility Bill Savings	BIRA energy estimated: $4,280 savings in gas, $7,194 savings in electricity, and $19,390 savings from PV. Utiltiy savings could have been larger Lancaster had not created a CCA.

Economic Costs	Notes
O&M Costs	No reported increases to O&M
Other Living Expenses	No reported increases to other living expenses

Simple Payback (Whole Building)	Simple Payback (Owner Only)	Calculation
27 years	196 years	Project costs / annual utility savings
0 years	0 years	(Project costs – grant funds) / annual utility savings

Tenant Rents Impacted?
No

Notes:

- The calculation excludes the cost of asbestos
- Tenants receive the majority of utility savings
- The calculation above assumes that all electricity savings including those from solar PV are accrued by tenants and all gas savings go to the building owner.

Funding and Financing

benefit
delay
downside
Unachieved potential

ARUP

The Village at Beechwood

Split incentives make financing challenging without grant money – BIRA Energy indicated that split incentives – the misalignment of financial reward when the building owner pays for the energy retrofit but the tenant benefits from a utility cost savings – would have made this project impossible if it had not received grant money. In this project, LINC Housing received very little monetary benefit. Since they could not raise tenant rent due to Section 8 provisions, the consultant believed it would not be possible for the building owner to recoup capital investment without the grant.

Implementation Process

benefit
delay
downside
Unachieved potential

ARUP

The Village at Beechwood

Experimental aerosol seal viewed as detriment to project – In the community center, the project team employed an aerosol seal, an experimental technology at the time that seals up cracks in the building by blowing aerosol through the space. The seal ended up create a large mess on top of office equipment and furniture left in the space. From this experience, the consultants would not recommend aerosol seals and would caution the use of experimental technology in general.

Meter installation error resulted in increased utility bills initially – At first, utility bills increased because the energy meters were installed backwards. Once the mistake was corrected, utility bills showed a reduction.

Funding restricted the number of units retrofitted – Energy efficiency retrofits were implemented in only percentage of the units due to funding limitations. The units upgraded were in a building deemed to be best set up for a retrofit.

Carport provided opportunity for PV system – When the project began, the intention was to install rooftop solar PV. The team discovered many challenges with rooftop installation: the roofs would likely have to be replaced, ceiling insulation would have had to be added, and duct penetrations would have been limited. To remove these items for the project scope, the project team decided to install PV over the carports, which was not part of the original scope. This opportunity, however, helped the project get closer to achieving its sustainability goals.

Implementation Process

benefit
delay
downside
Unachieved potential

ARUP

The Village at Beechwood

Consensus decision-making seen as cumbersome – The project team had implemented a consensus approach between all key players on the project: SoCal Edison, EPRI, LINC Housing, construction manager, etc. When asked what he would change about the project, one consultant stated removing consensus and letting one person or party make the final call. Consensus slowed down decision-making.

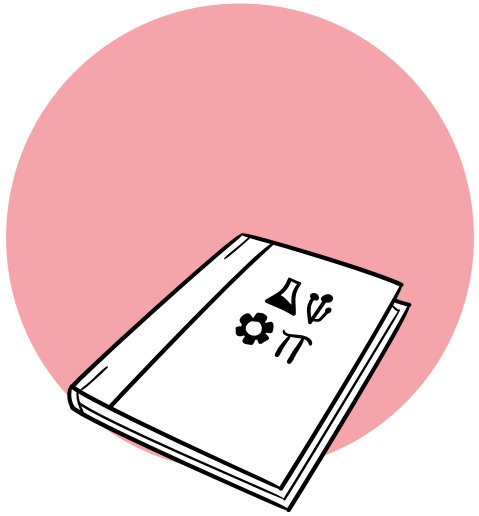
Grant funding redirected to asbestos abatement – Upon project start, asbestos was found on the property and had to be remediated. A large portion of the grant funding, about 40%, was reallocated to asbestos abatement.

Technical Assistance

benefit
delay
downside
Unachieved potential

ARUP

The Village at Beechwood



The project team leveraged existing business relationships – BIRA Energy wrote and was awarded the CEC contract but decided to bring on EPRI as the project lead to carry out the retrofit given that they already had significant experience in successfully delivering projects together. EPRI, for similar reasons, brought on LINC Housing as the housing operator with whom they had a strong business relationship. This team has since worked on more projects together.

Energy monitoring included in the scope – To verify energy savings, BIRA monitored energy performance 1 year before and 1 year after the retrofit to assess and demonstrate the reduction in carbon emissions. As a result, the team was able to quantify the tangible impact they have had on the affordable housing complex.

Carbon Reduction

The Village at Beechwood

benefit
delay
downside
Unachieved potential

ARUP

- **Despite large energy savings, Net Zero Energy was not achieved –** The initial intent of the project was to achieve California's definition of Zero Net Energy, which allows gas consumption. The project was not able to achieve this goal. About 50% of the source energy had to be offset. However, the project still realized large energy savings: the electricity bill was reduced by 90-95% and gas usage decreased by about 30-40%.

- **In retrospect, consultants would have focused on HVAC and DHW –** Instead of implementing many envelope measures including the experimental aerosol sealing, the consultants believe that that focusing on HVAC, water heating, and electrification would have resulted in a greater carbon reduction. The envelope measures proved costly and challenging to implement.

Tenant Impacts

The Village at Beechwood

benefit
delay
downside
Unachieved potential

ARUP

Tenant relocation due to asbestos abatement increased project costs – Tenants had to be relocated for 1-2 days to remediate the asbestos. Relocation costed about $2,500 per unit. If asbestos abatement were not part of the project scope, the consultant indicated that tenant relocation could have been avoided.

Reduced utility costs – Tenants saw a reduction in their utility bill due to the energy retrofits and PV credit allocations from VNEM. However, the utility bills did not decrease as much as anticipated because of the rate change. At the time of the project, the City of Lancaster formed a Community Choice Aggregator (CCA), which increased the rate of electricity. Lancaster created the CCA as a step to provide cleaner electricity and lower carbon emissions.

Improved thermal comfort – The energy efficiency improvements, primarily the HVAC sealing, greatly improved thermal comfort in the units renovated. Prior to the retrofit, air conditioning units were discharging air at 80°F instead of 50°F in cooling mode. The improved summer cooling relieved and satisfied tenants immensely: some were inspired by the effect of better air conditioning that they expressed interest in wanted to enter the HVAC industry. Since only a percentage of the units were retrofitted, however, tenants who did not receive a retrofit became jealous of those that had.

Reduced living expenses – Since tenants received a reduction in their utility bills while rent was held stable, tenants living expenses decreased due to the retrofit.

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Beechwood Summary

What enabled success?

1. **Thermal comfort benefits garnered project support from tenants** – The upgrades made in the 30 units dramatically improved the performance of air conditioning systems, making the residences comfortable. For these tenants, the improved thermal comfort underscored the importance of these retrofits. Unfortunately, tenants whose units were not upgraded did not receive these thermal comfort benefits.
2. **Carport solar** – Limiting ancillary work while allowing for optimal layout, the carport provided a greater opportunity for solar PV than the building roof.
3. **SCE's VNEM** – Solar installed provided a utility benefit for all tenants at Beechwood via SCE's VNEM program. Residents appreciated this bill reduction especially since savings from the other energy efficiency measures impacted only 30 out of 100 units.
4. **Grant money to overcome split incentive** – Split incentives would have made the project impossible without grant money – Due to split incentives, LINC Housing had no way to recover the cost of implementing energy efficiency and renewable energy measures, since the tenants received most of the utility cost savings. The project otherwise would not have been possible from a financial standpoint.

What challenges came up during the project?

1. **Unanticipated asbestos abatement** – The team had to redirect about 40% of their PIER grant to asbestos abatement, decreasing their budget for the deep energy retrofit. The scope of the retrofit, as a result, shrunk to 30 apartment units out of the 100 at Beechwood. Less energy savings were realized than initially estimated, which prevented the project from achieving its goal of Net Zero Energy.
2. **Emerging technology as a requirement for funding** – To be eligible for the PIER grant, the project had to make use of emerging technology. The emerging technology contractors chose to implement – the aerosol sealing – created a mess, resulting in additional work during construction. In retrospect, they would have preferred to focus on electrification strategies including HVAC, PV, and water heat pumps, which they feel would have provided greater savings at a lower cost and effort based on the results of their energy monitoring. Implementing emerging technologies has the potential to offer high reward in terms of energy and cost saving but at a higher risk than tried-and-true technology. For financially constrained affordable housing projects, this risk may not pay off.

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Emergent Key Concepts

Introduction

Emergent Key Concepts

While being interviewed, a few contractors broached emergent ideas not specifically tied to their case studies but relevant to our study of affordable housing decarbonization in Los Angeles. Some of these insights warranted additional exploration, for which the study team pursued interviews with named experts and conducted additional research to provide further knowledge on the matters.

These emergent key concepts are captured in this section. They include a discussion on the following:

- Stacking Funding and Financing
- Electrification with EEMs + Solar PV
- Turnkey Construction
- Tariffed On Bill
- Utility Allowances
- Line-side Solar PV for VNEM Drawback
- Batteries with VNEM
- Income-Based Fixed Charges

Stacking Funding and Financing

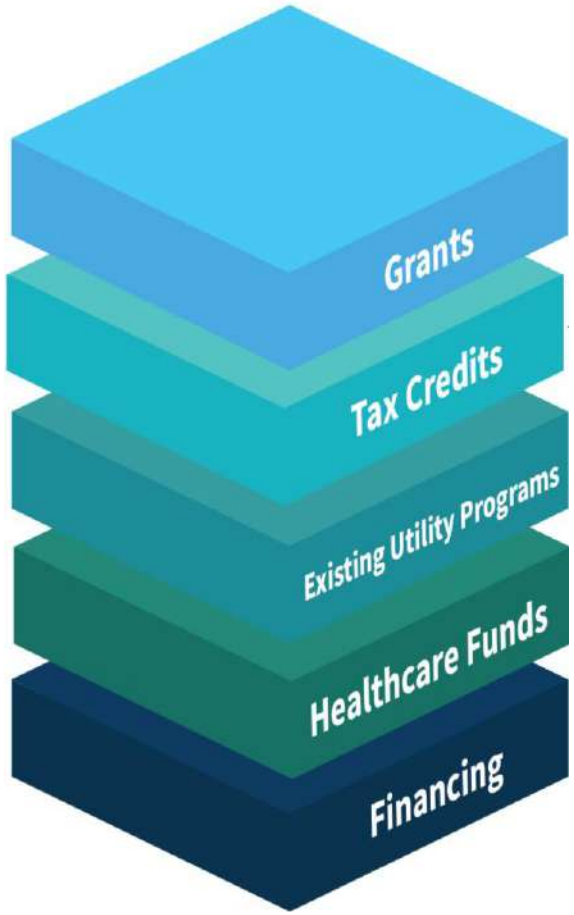
Emergent Key Concepts

To set up an energy retrofit project for success, project teams must stack grants & incentives, which involves layering funding from multiple sources including federal, state, and local programs, as well as private philanthropy and impact investors. Chasing funding as a first step enables affordable housing developers to know how much money they can spend to ensure an economically feasible project. Scope can then be tailored to the funding.

Unfortunately, **the process of securing funding is time consuming**. Typically, developers go from source to source in a linear fashion while bearing in mind that certain grant or incentive programs cannot be pursued in tandem. Identifying funds and completing applications is difficult and complex. As mentioned, securing funding took about 2 years for CCSM (Ocean Ave) during the project's predevelopment phase.

Exacerbating this issue, **grant applications can take a long time to process**. In the case of the Miramar Towers, the LIWP funding was approved two years after the application had initially been submitted. Although the long wait for approval ended up providing an additional funding opportunity for Miramar (property resyndication), a timeline of this length also has the potential to undermine financing, especially as certain incentive programs or tax credits expire.

Moreover, **each grant has its own specific set of eligibility criteria, application requirements, and supporting documentation needs**. Stacking grants thus can be complex and may require significant coordination and planning to ensure that the funding sources are aligned and that the project meets the requirements of each program.



Example stacking of funding sources for a home retrofit
Source: RMI.org

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Stacking Funding and Financing

Emergent Key Concepts

Affordable housing developers sometimes may not have enough capacity to identify applicable grants, prepare applications for them, and ensure compliance with their requirements. The described challenges involved in stacking grants point to a **need for greater technical assistance**. A few technical consultants and energy retrofit providers like Bright Power, Association for Energy Affordability (AEA), etc. can manage grant application and implementation.

This need for additional capacity, especially in the form of technical assistance, is only growing, as new funds for decarbonization retrofits have become available through the Inflation Reduction Act (IRA). Based on Arup's ongoing review of this new legislation, **IRA provides significant funding for decarbonization but does not solve the challenges around stacking grants**. It has created many new incentive programs, but each program has unique eligibility criteria and requirements. Grant identification and management thus still will play a large role in the process of securing funding.

In summary, stacking funding and financing is complex and time consuming. Grant and incentive programs, moreover, don't seamlessly fit together, so significant technical assistance is needed to navigate this complicated task. Solving these issues **does not negate the need to develop better financing mechanisms** to make deep energy retrofits of affordable housing cost-effective and less administratively burdensome. Grants and incentives will eventually diminish in quantity and/or expire. In the meantime, finding ways to expedite stacking grants will help to deliver many more affordable housing deep energy retrofits in the Los Angeles area.

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Electrification with EEMs & Solar PV

Emergent Key Concepts

Since combusting fossil fuels will always produce carbon emissions, the building industry has been moving towards electrification as a key method of decarbonization. Going all-electric creates a pathway to zero emissions as the electrical grid becomes cleaner.

However, electrification at times can increase energy costs depending on the price of utilities and the measures implemented. Often, the price of electricity per unit of energy is more expensive than that of gas. An expert we spoke to recommended **combining electrification with solar PV and/or other energy efficiency measures (EEMs)** to guarantee utility cost savings. If sized appropriately, PV along with EEMs can provide enough utility cost savings to outweigh the potential cost increases from electrification, especially in the Los Angeles area, which has an ideal climate for PV.

Pairing electrification with solar and efficiency measures, however, is not always straightforward. Incentives are often separate for solar PV and electrification/efficiency, in part because solar makes greater use of tax credits. Thus, multiple incentive streams still need to be pursued to finance electrification.

Phase III of the Battery, Philadelphia, PA – New Market Rate All Electric Housing with Rooftop Solar PV
Source: onionflats.com

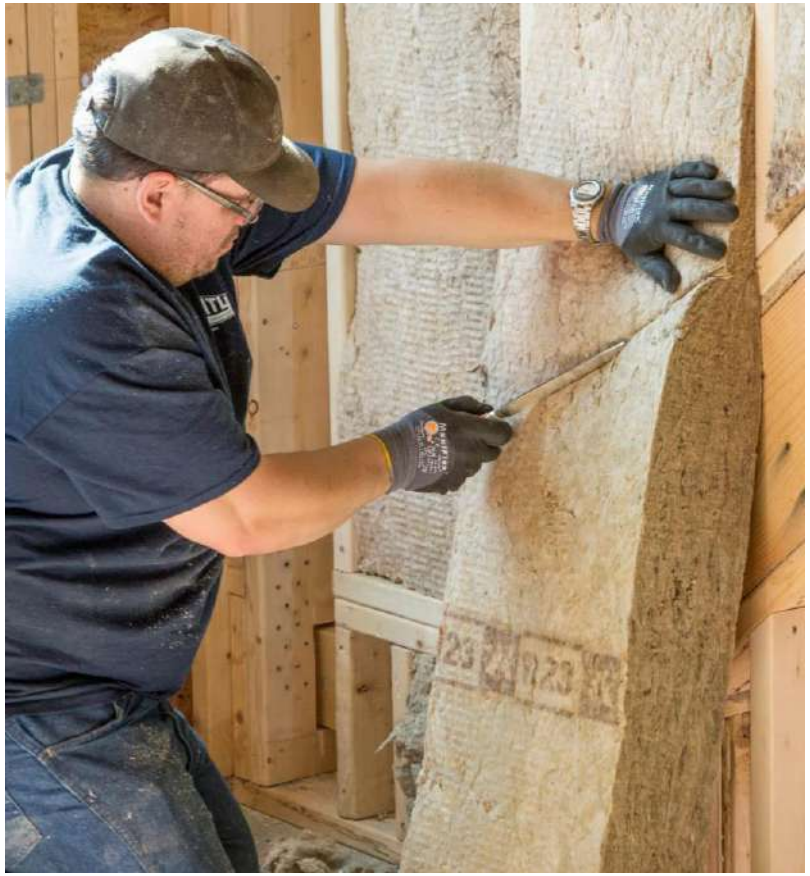
Electrification with EEMs & Solar PV

Emergent Key Concepts

Furthermore, existing buildings may struggle to incorporate PV due to roof limitations. In some cases, the roof may not provide enough space for optimally oriented PV panels. In other cases, the roof may not be able to structurally support PV or may need to be resurfaced before installing PV Roof retrofits are generally not covered by energy incentive programs. Carport mounted PV may be able to provide a workaround for such roof issues like in the Beechwood property, but not all affordable housing buildings in LA have carports.

Implementing certain EEMs can also be a challenge. In older buildings, envelope improvements, such as adding insulation in the walls and roofs, enhancing envelope air tightness, and replacing windows, provide some of the largest opportunities to reduce energy consumption. These EEMS, at the same time, can improve thermal comfort as well as acoustic comfort by limiting exterior noise from entering a building.

Envelope measures, however, can be difficult to implement in existing buildings. In the Beechwood property, for example, the air sealing technology, for example, created a large mess that had to be cleaned up. Moreover, depending on the climate, adding interior insulation can alter how moisture travels through the envelope, creating a potential for moisture damage and/or mold issues. As an alternative, project teams can pursue exterior insulation but may run into issues with zoning limits as well as aesthetics by virtue of changing the appearance the façade. Certain existing buildings, like the Alegria Apartments, also have to contend with historic preservation laws that preclude façade work. Lastly, envelope measures may involve a large upfront investment, which can take many years to pay back through utility cost savings.



Source: https://www.thisoldhouse.com/

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Electrification + Solar PV

Emergent Key Concepts

Therefore, to enable electrification, fuel switching as well as energy efficiency measures should be packaged more effectively with solar PV. Ways to strengthen this pairing include the following:

- **Joint incentives –** Incentive and/or grants for solar PV could be combined with those for electrification and efficiency measures into a single program. Treating these strategies as one from a financial standpoint may help achieve faster paybacks. It will reduce the time it takes to secure funding.
- **Community solar –** If projects are spatially restricted, affordable housing developers should be able to invest in community solar: PV located offsite on a nearby property that can be leased or purchased by multiple individuals. Introduced in 2013, community solar in California has struggled grow: these projects currently only make up 1% of the California's solar PV capacity. Poor program design that increases rather than reduces participators' electric bills has hindered development. Community solar programs are also capped in terms of how much capacity can be installed, and those who buy electricity from a community choice aggregation (CCA), like Clean Power Alliance in Los Angeles, are not eligible to participate in community solar.

  Fortunately, the bill AB 2316 has recently passed, which will dramatically reform community solar in California by ensuring lower electricity rates for community solar subscribers. At the same time, the Inflation Reduction Act (IRA) has allocated significant money as well as federal tax incentives to community solar programs. AB 2316 does not, however, provide further incentives for low-income customers. Furthermore, it will affect only those who receive power from investor-owned utilities (IOUs), such as SCE, but not municipal utilities, such as LADWP.

  As next steps, community solar programs must be established and approved by the California Public Utility Commission (CPUC). In addition, bills should be developed that allow community solar in municipal utilities and create incentives for lower-income residents[2].

ARUP

Electrification + Solar PV

Emergent Key Concepts

- **Incentives for enabling work –** Since installing rooftop solar PV depends on the quality and design of the roof, additional incentives and/or grants should be developed for ancillary roof work that enables solar PV installations. LADWP currently offers a cool roof rebate. However, additional grant programs could be developed that pair roof work with solar PV installation to reduce costs further.
- **Envelope technical assistance –** The nature of adding insulation or replacing windows to improve the exterior building envelope often can be technical. As such, these measures could likely benefit from greater technical assistance. Such assistance could, for example, help fund THERM and/or WUFI studies to analyze how heat and moistures flows through the improved envelope. It could also be used for envelope detailing, code compliance consulting, as well as thermal comfort studies.
- **Leeway with zoning and historic preservation –** To facilitate energy efficiency, cities could offer leeway with zoning restrictions as well as historic preservation laws that currently hinder work on building envelopes.

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Turnkey Construction

Emergent Key Concepts

Experts sung the praises of contractors who provide turnkey services: engaged to **execute the whole project** from planning the scope of work to constructing the retrofit and managing operation. Engaging with this type of contractor simplifies coordination between stakeholders in the project and makes sure that the measures implemented realize tangible savings. With a **turnkey contract**, the contractor manages the project and becomes responsible for performance of the systems installed, rather than the affordable housing developer.

As an example, an expert pointed us to Bottom Line Utility Solutions, which provides energy and water saving retrofits as well as solar and electric vehicle charging station installations in the Los Angeles area. This firm offers the below services, which helps to streamline energy retrofits. The expert specifically mentioned their rebate management being instrumental to the success of their projects. Bottom Line Utility Solutions took care of all coordination with the involved utility, making sure it received all the necessary documentation and receipts needed to award the project with rebates.

- Utility Bill Audits & Site Surveys
- Rebate Identification
- Rebate Management (including Invoicing)
- Design
- Permitting
- Construction
- Inspection
- End-user Training
- Measurement & Verification
- Financing

Source: BLUSinc.com

Turnkey Construction

Emergent Key Concepts

Handing off large parts of the scope to a turnkey contractor may end up costing more to an affordable housing developer than managing the scope themselves and hiring a standard contractor only to provide construction services. In cases where turnkey contractors provides financing, the affordable housing developer may also not reap the full financial benefit of the implemented energy efficiency measures. These minor tradeoffs, however, do not outweigh the significant benefits, which usually lead to faster, more streamlined retrofits that perform better. Turnkey contractors also provide a solution to the limited capacity of developers, who usually lack resources to manage all the complexities of such a project. The city of Los Angeles could look to incubate local small businesses capable of providing turnkey services. The following options can be explored:

- **LA Retrofit Accelerator** – The Los Angeles Better Building Challenge – a collective of building owners, managers, and stakeholders working together to promote energy efficiency, sustainability, and resilience in Los Angeles – has developed the Retrofit Accelerator Platform. This program provides turnkey services for building developers looking to perform a decarbonization retrofit. Currently, the program helps to identify project goals, streamline funding applications, and match developers with potential contractors. Going a step further, this program can consider starting to incubate small business contractors capable of providing turnkey services. It could establish a fund meant to kick start small businesses as well as provide training program for new contractors.

- **Building Performance Standards Incubation Fund** – Although the city has yet to adopt a building performance standard (BPS) for existing buildings, one is likely on the way. Los Angeles has played a large role in the National BPS Coalition and has a building decarbonization ordinance for new construction. A BPS is a set of legislation and/or policies aimed to decarbonize building stock in a specific region, applicable to both new construction and existing buildings. Typically, BPS creates a penalty fee for buildings not being able to meet the required carbon reduction levels. This penalty fee is used to invest in clean technology. If a BPS were to be implemented in Los Angeles, the penalty fee could be used to create a fund to incubate small business enterprises focused on providing turnkey services for deep energy retrofits, as has been established in other cities. Washington DC has successfully implemented this approach with 2019 Act 22-583, which establishes a fund to promote capacity development of qualifying enterprises. Precedent has also been set by Denver, CO with their Energy Denver Hub as well as Montgomery Country, MD with their Green Bank.

Tariffed On Bill

Emergent Key Concepts

Experts recommend **Tariffed On Bill financing** as an alternative to more traditional mechanisms for implementing decarbonization measures. Tariffed On Bill, also called Inclusive Utility Investment, involves having the **utility pay for the efficiency upgrades** and/or renewable energy upfront and recoup costs through placing a **cost-recovery tariff** on the ratepayers' utility bills. This mechanism eliminates the need for a loan.

Tariffed on Bill is especially beneficial for affordable housing projects because it does not require a verification of financial means for eligibility to access capital. Customers who struggle to meet underwriting criteria for loan and incentives programs could be able to participate in energy retrofits through this system.

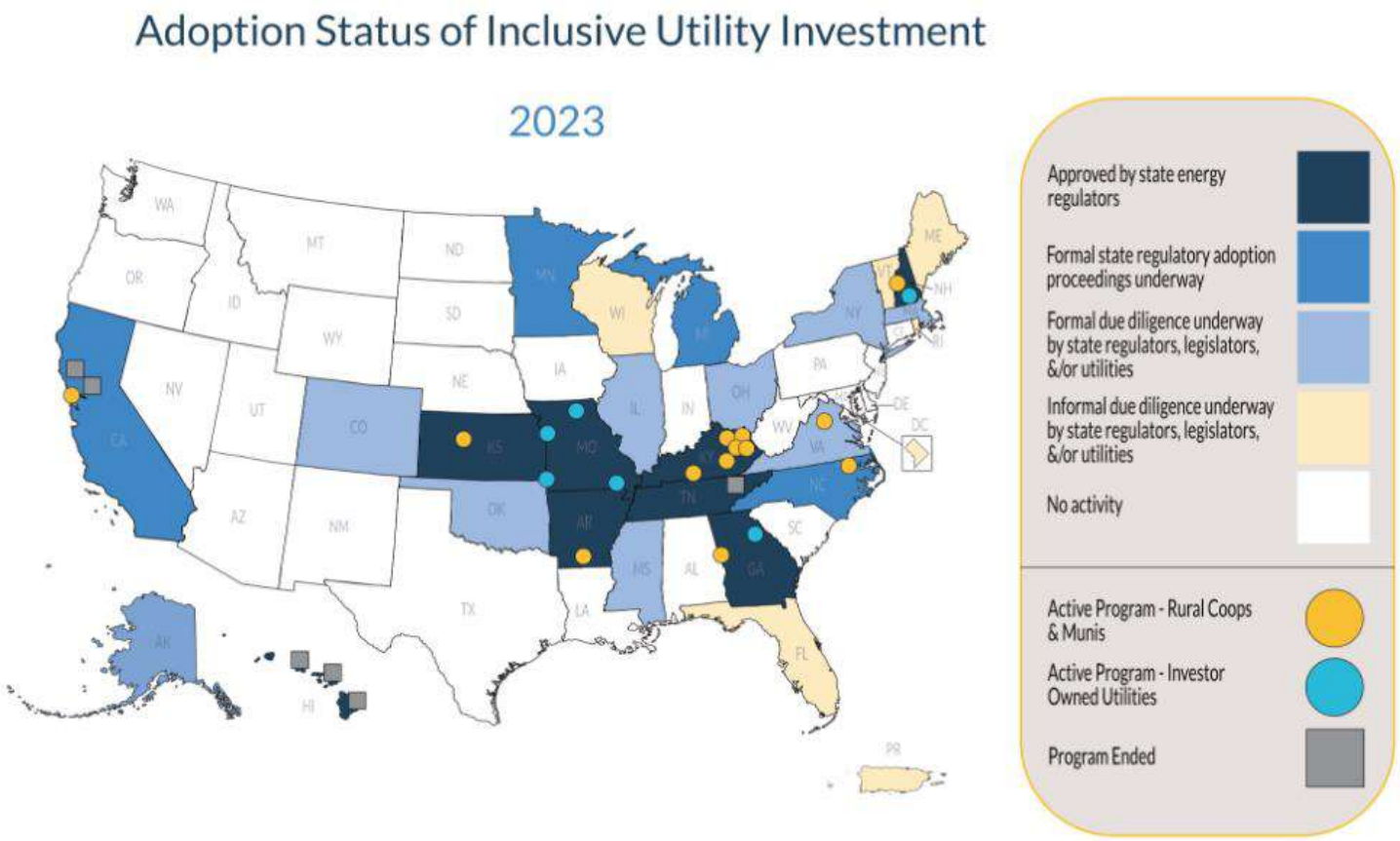
A Tariffed On Bill or Inclusive Utility Investment program is usually designed as follows:

- **The cost-recovery tariff should be less than the utility savings achieved** – If designed correctly the rate payers' bill should be less than what it was prior to the decarbonization retrofit, meaning that the energy savings should outweigh the tariff.
- **The on-bill charge is associated with the meter / property** – If the property is sold or occupied by a different tenant, the new building owner or tenant takes on the on-bill charge.
- **The cost recovery charge is treated as equal to other utility charges** – The payment obligations for the tariff are the same as all other charges on the utility bill.

Tariffed On Bill

Tariffed on Bill / Inclusive Utility Investment programs are **available in 9 states** as shown in the image to the right. These programs make use of the **Pay As You Save® (PAYS®)** trademarked system created by the Energy Efficiency Institute that delivers a standardized a Tariffed On Bill structure for participating utilities.

Adoption of Tariffed On Bill for decarbonization projects may be underway in the State of California. Silicon Valley Clean Energy, a community owned agency that provides green power by way of Pacific Gas & Electric Company (PG&E), has put in a proposal with the California Public Utility Commission (CPUC) to adopt a Tariffed On Bill pilot program for decarbonization based on the PAYS ® system. The CPUC has already allowed for the use of PAYS ® for water saving retrofits but has yet to allow it for energy.



Source: cleanenergyworks.com

Tariffed On Bill

Emergent Key Concepts

Tariffed On Bill is advantageous for the following reasons:

- **No loan** – As mentioned, Tariffed On Bill does not require a loan, meaning that it also does not require a credit check. Removing this criteria from financing allows more affordable housing owners and tenants, which are known to be income strained and credit limited, to engage in decarbonization.
- **Payment ends if upgrade fails** – Programs are set up in a way that makes utilities responsible for providing energy cost savings. If the implemented decarbonization measures fail to do so, residents are not obligated to pay the cost-recovery tariff.
- **Renters are eligible** - Typically loan programs for decarbonization restrict or make it challenging for tenants to participate. With Tariffed On Bill financing, both building owners and renters are eligible to participate.
- **Tariff is associated with property** – If tenants leave the building, they are no longer obligated to pay the cost-recovery tariff.
- **Mitigates split incentive issue** – In conventional financing, the building owner is responsible to pay back the loan even though the tenants receive most utility cost savings. With Tariffed On Bill, the cost-recovery tariff is distributed among all units impacted by the retrofit, helping to mitigate this split incentive issue.

Tariffed On Bill

Emergent Key Concepts

However, Tariffed On Bill has the following downsides:

- **Potential upfront cost –** Depending on how Tariffed On Bill is configured, those looking to engage may have to pay for portion of the decarbonizations measures upfront. However, it is also possible that the utility may not require any upfront costs.
- **Environmental benefits stay with the property** – If tenants leave, they can no longer accrue the benefits of owning an environmental asset.
- **Works better with high EUI buildings** – Because Tariffed On Bill requires the energy cost savings to outweigh the cost-recovery tariff, it works better with older, high energy use intensity (EUI) buildings. These buildings provide a greater potential for energy savings. Good candidates include buildings with limited envelope insulation, single pane windows, etc. that drive up heating and cooling energy. Newer buildings, built post-2008, tend to use less energy by virtue of being designed to a more stringent energy code. These buildings do not work as well with this financing scheme. In the Los Angeles region, there are still a number of affordable housing complexes built prior to 2008 that would benefit from Tariffed On Bill.
- **Challenging with electrification** – Since electrification tends to increase energy costs (electricity is more expensive than natural gas), Tariffed On Bill does not work well with electrification measures. It requires energy cost savings, not carbon savings. Electrification combined with PV can reduce utility costs; however, tariffed on bill is also challenging to apply to solar, as described in the next bullet.
- **Challenging with solar PV** – While it could be feasible to finance solar with Tariffed On Bill, it currently does not make sense to do so in California. The Solar on Multifamily Affordable Housing (SOMAH) provides significant incentive money for multifamily homes seeking solar, in many cases reducing the capital costs in half, which limits the need for financing. Moreover, SOMAH requires the reduction in utility bill to be passed along to the tenants. If Tariffed On Bill were implemented, this cost-recovery tariff would hinder the required utility bill reduction, making the project ineligible for SOMAH. Lastly, solar involves tax credits, which pose a challenge when creating a Tariffed On Bill financing agreement. Solar tax credits are often purchased from the building owner by a lender in exchange for equity, which unlike cash, is tricky to folder into a cost-recovery tariff. Fortunately, there already exist many incentives and other financing schemes for solar PV.

Tariffed On Bill

Emergent Key Concepts

Tariffed on Bill / Inclusive Utility Investment has the potential to break down significant barriers to financing deep energy retrofits in the affordable housing space. Although it is not applicable to all types of carbon reduction measures, it expands the customer pool for decarbonization significantly by avoiding credit risks and mitigating split incentives. It should be **supported through lobbying and writing proposals** to ensure that it becomes an available financing mechanism in both in Los Angeles and greater California.

ARUP

Utility Allowances

Emergent Key Concepts

Due to split incentive issue, financing energy retrofits in multifamily housing proves challenging. If the building owner pays for the energy measures but the tenants primarily benefit from lower utility bills, the building owner cannot recover costs over time. Their monthly expenses pre and post retrofit would remain similar.

To get around this issue in market rate housing, building owners tend to raise tenant rent to pay for the decarbonization measures. In deed-restricted affordable housing, however, rent cannot be increased directly after performing a retrofit. Rent restrictions may also apply in natural-occurring affordable housing. To reiterate a key takeaway from the Village at Beechwood case study: Affordable housing developers typically need grant money to make deep energy retrofits financially feasible.

An expert we spoke with broached an idea to challenge the rent-increase restrictions on such affordable housing. This expert proposed **allowing rent to increase but preventing the sum of rent and utility bills from increasing** after a deep energy retrofit. If this were the case, tenants' monthly apartment expenses would be capped, which would achieve the intent of the deed-restrictions on rent. Utility savings on the tenants' bill could then be captured by the building owner through increasing rent by an amount equal to or less than the savings.

Utility allowances aim to do just this. A utility allowance (UA) is an estimate of tenants' utility bills that can be combined with rent to become a singular payment requirement.

Utility Allowances

Emergent Key Concepts

To ensure that building owners and developers do not use UAs to take advantage of tenants (i.e., charge them more money) utility allowances are heavily regulated. In California, affordable housing developers are only allowed to use two methods to estimate UAs: using a public housing authority (PHA) schedule or using the California Utility Allowance Calculator (CUAC).

Using actual utility bill consumption data to calculate UAs is possible but limited to select properties that are part of the following federal programs: Project Based Rental Assistance (PBRA), USDA Rural Development (RD) Rental Assistance, HOME, Public Housing, and Low-Income Housing Tax Credit (LIHTC). It is less common to go this route.

** Note: In HUD and RD Rental Assistance programs, the "Total Tenant Payment" is supplemented by a housing assistance payment to reach the total "contract rent" for the unit.*

Source: Facilitation Building Decarbonization through Utility Allowances | An Electric Program Investment Charge (EPIC) Report for the California Energy Commission (CEC)

Utility Allowances

Emergent Key Concepts

The PHA schedule is a prescriptive calculation method that involves estimating utility bills from a table. The table, or schedule, includes average values for energy uses; it is not property-specific. Different values are provided for residential units depending on the number of bedrooms as well as systems they use, i.e. if they uses gas heating, electric heating, etc.

Although simple, this calculation methodology has little granularity and often produces UAs that are not aligned with tenants' actual utility bills. Values in the table are averages of utility bills from existing building stock within the public housing authority's territory. Relying on average utility data poses an issue in Los Angeles County, which is vast, contains many different microclimates, and has buildings of all different ages. Energy usage in one property could thus be very different from the average due to its location and age.

Additionally, the schedules do not include energy values for HVAC systems vital to a decarbonization retrofit. As of March 2022, the two public housing authorities in Los Angeles – the Housing Authority of the City of LA and the LA County Development Authority – do not provide energy values for electric heat pumps. Only a few PHA schedules for jurisdictions in California, less than half found online, incorporate values for them. Moreover, none of the schedules found online include values for domestic hot water heat pumps, induction cooktops, or solar PV.

Locality: **Sacramento Housing and Redevelopment Agency, CA**	Unit Type: **Apartment/Walk Up**					
Utility or Service:	0 BR	1 BR	2 BR	3 BR	4 BR	5 BR
	Monthly Dollar Allowances					
Heating						
a. Natural Gas (includes Climate Credit)	$13.00	$16.00	$18.00	$20.00	$22.00	$24.00
b. Bottle Gas/Propane	N/A	N/A	N/A	N/A	N/A	N/A
c. Electric	$11.00	$13.00	$16.00	$19.00	$22.00	$26.00
d. Oil	N/A	N/A	N/A	N/A	N/A	N/A
Cooking						
a. Natural Gas	$3.00	$3.00	$6.00	$7.00	$9.00	$10.00
b. Bottle Gas/Propane	N/A	N/A	N/A	N/A	N/A	N/A
c. Electric	$5.00	$6.00	$9.00	$11.00	$14.00	$16.00
Other Electric & Cooling						
Other Electric (Lights & Appliances)	$19.00	$22.00	$31.00	$39.00	$48.00	$57.00
Air Conditioning	$8.00	$9.00	$13.00	$16.00	$20.00	$23.00
Water Heating						
a. Natural Gas	$7.00	$8.00	$11.00	$14.00	$19.00	$22.00
b. Bottle Gas/Propane	N/A	N/A	N/A	N/A	N/A	N/A
c. Electric	$12.00	$14.00	$17.00	$21.00	$25.00	$29.00
d. Oil	N/A	N/A	N/A	N/A	N/A	N/A

Example PHA Schedule
Source: Facilitation Building Decarbonization through Utility Allowances | An Electric Program Investment Charge (EPIC) Report for the California Energy Commission (CEC)

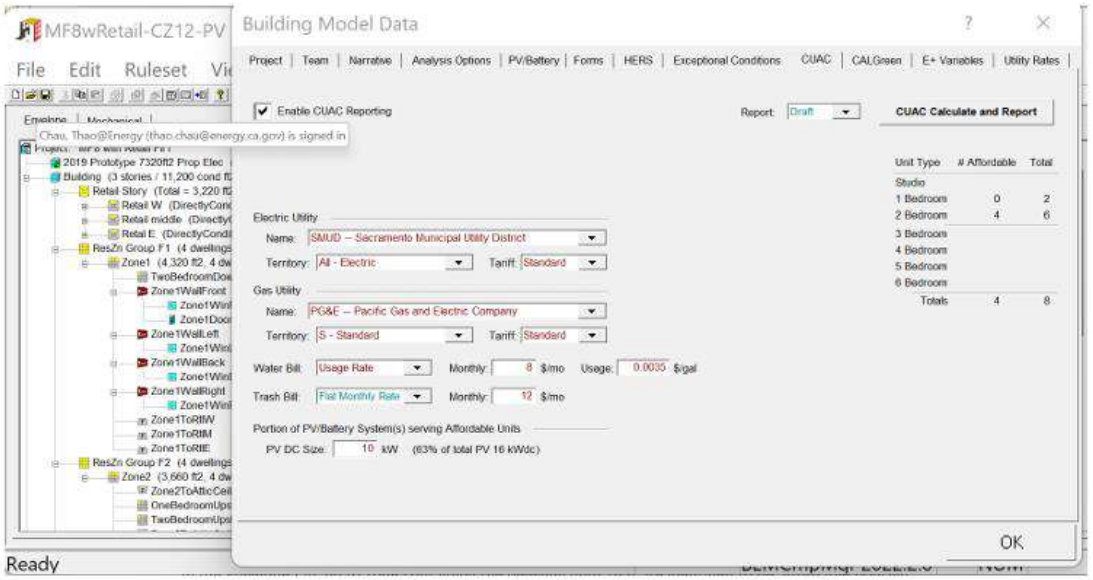
Utility Allowances

Emergent Key Concepts

The other method is using the **California Utility Allowance Calculator (CUAC)**, which involves creating a project-specific energy model in the approved software CBECC-CUAC; Title 24 compliance software cannot be used. By virtue of creating project-specific energy model, this method tends to result in UAs much in line with the actual utility bills. The software, however, is also rigid, not to the same extent as the PHA tables.

CUAC tends to be more expensive to use. Developers must hire a certified third-party consultant to create the model. The model then must be reviewed by The Tax Credit Allocation Committee (TCAC), which can prolong the process and result in comments that must be addressed in the energy model. Per TCAC regulations, the model must be updated once a year to reflect changes to the utility rates as well as any updates made to the building – establishing on-going costs for the affordable housing developer / owner.

Moreover, eligibility is limited. It can only be applied to rehabilitation projects that have applied for tax credits in 2018 if they demonstrate 20% energy savings or install solar PV that offsets at least 50% of the residential energy usage. The only existing tax credit projects that can use CUAC must have installed new solar PV through Multifamily Affordable Solar Housing (MASH) or another solar program offered by a municipal utility.



CBECC-CUAC Interface
Source: CBECC-CUAC User Guide

Utility Allowances

Emergent Key Concepts

Given the drawbacks with both methods, UA should be reformed to be easier to use and produce allowances that better incentive decarbonization work while keeping tenant living expenses low. The following options should be explored:

- **Allowing greater use of actual utility bill data** – More types of properties should be allowed to estimate UAs from their actual utility bills. This method produces the most accurate UA values, thereby providing the largest potential to mitigate the split incentive issue.

- **Refine PHA schedules** – Additional PHA schedules within the LA area should be offered to reflect buildings in different microclimates. In addition, schedules need to incorporate more systems requisite for decarbonization including space heating heat pumps, domestic hot water heat pumps, solar PV, and induction cooking.

- **Increase CUAC eligibility** – Only a few rehabilitation projects can use CUAC to estimate their UAs. Eligibility should be increased so that more properties can create UAs more in line with the tenants' actual utility bills.

- **Allow Title 24 compliance documentation for CUAC** – Projects pursuing both CUAC and code compliance must build two energy models, one for CUAC and the other for Title 24, even though both models make use of the same software. Allowing the Title 24 compliance documentation to be used for CUAC would simplify the CUAC process, reducing both time and effort needed.

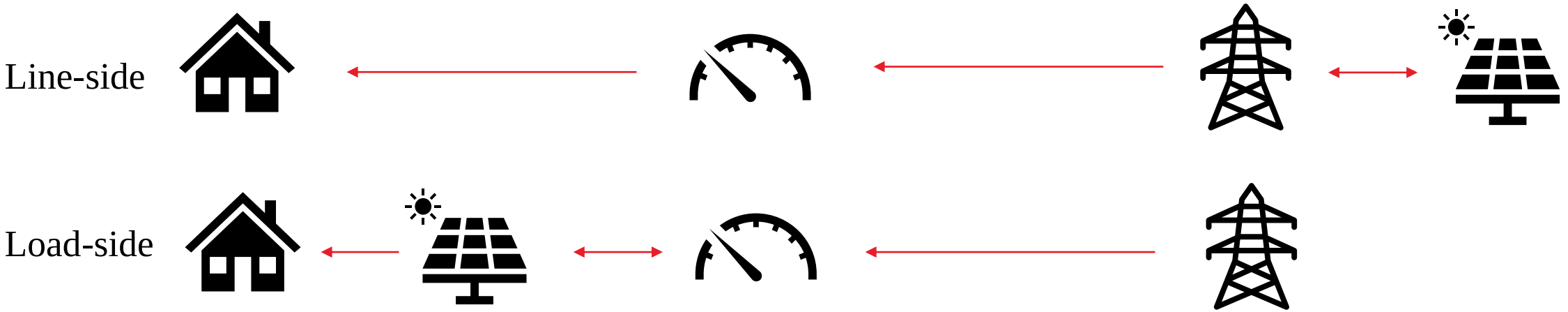
- **Grant funded technical assistance for CUAC** – Given the time and costs involved in using CUAC, money through grants or incentives should be provided to cover energy model costs. Ideally, this money should be folded into other incentive programs that are awarding money based on decarbonization measures implemented.

Line-side Solar PV for VNEM Drawback

Emergent Key Concepts

When installing PV on a property, it can be configured either line side or load side. These two set ups are described and conveyed graphically below.

- **Line side** – This configuration for PV can be thought of being set up in front of the main breaker / meter. The PV feeds the grid with electricity, and its operation is tied to the grid's service. Solar credit for every hour of energy produced by the PV array is then virtually distributed to the building, showing up as a reduction on the utility bills.
- **Load side** – This set up can be thought of as setting up the PV behind the main breaker / meter. PV feeds the building with electricity. The utility cost savings stem from not using grid electricity during times of the day when the PV generates electricity; excess PV energy is sold back to the grid.



Line-side Solar PV for VNEM Drawback

Emergent Key Concepts

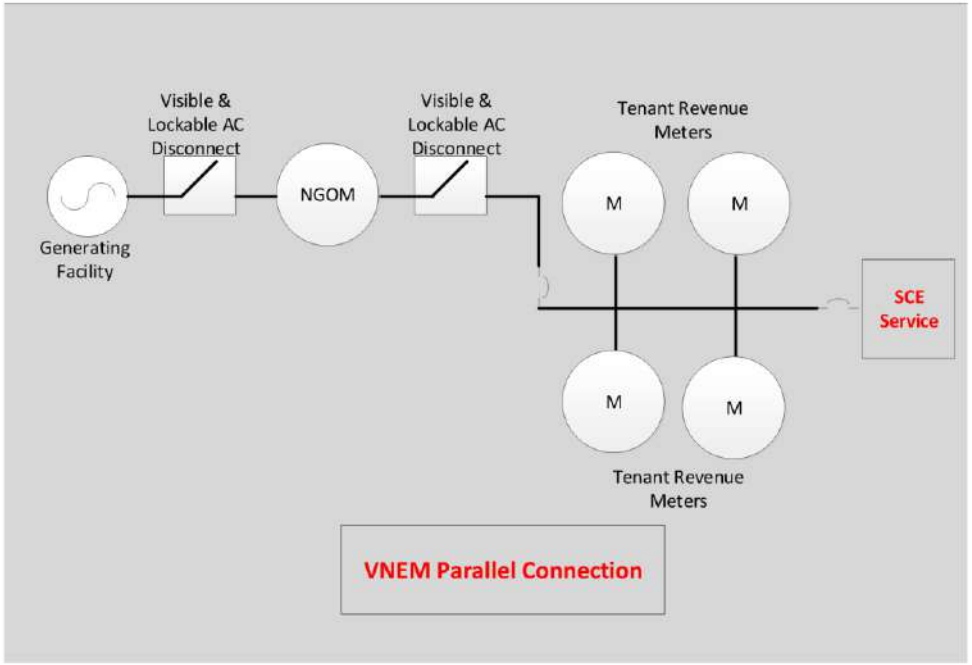
When applying a Virtual Net Energy Metering (VNEM) tariff to distribute solar credit to tenants, PV typically has to be installed line-side.

SCE requires that the Net Generation Output Meter (NGOM), which measures and credits PV energy generation, to be installed in parallel to other SCE revenue meters. Line-side taps are usually the only way to achieve parallel meters. For most load-side installations, the NGOM would be behind, i.e., in series to, the SCE revenue meter.

The same is true for LADWP. Most of their programs including their VNEM pilot program require all PV energy generated at a building to be sold directly to LADWP (source: Virtual Net Energy Metering Pilot Program Guidelines). Achieving this criterion usually requires setting up a line-side tap.

Line-side PV enables VNEM, which has the potential to greatly benefit tenants. However, this configuration has a resiliency drawback:

- **No backup power** – Because operation of the PV is tied to the grid's service, the PV goes out if the grid goes out: It cannot provide back up power. In other words, the PV can only be used as a cost saving measure; it no longer provides an energy resilience benefit.



Example of VNEM Parallel Coordination
Source: Southern California Edison Net Energy Metering Interconnection Handbook

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Line-side Solar PV for VNEM Drawback

Emergent Key Concepts

Applying a load-side set up usually prevents tenants in multifamily housing from receiving a solar credit on their utility bills. Load-side PV can only serve one ratepayer such a single tenant or the house/common room area loads on the building owner's meter. In this case however, the PV would provide the resilience benefit of back up power.

Losing the resilience benefit from PV is a detriment to multifamily houses with solar. Back up power has the potential during a power outage to maintain critical building services, that if interrupted could be damaging and costly to tenants and the building owner. As such, the line-side configuration limitation needs to be mitigated. The following ways may provide a solution:

- **Allowing series connections** – If possible, ways to connect NGOM load-side under the VNEM tariff should be explored and developed by SCE.

- **Allow master metering** – If a load-side configuration is not possible, the utility should allow master metering, whereby the utility installs one revenue meter for the whole property. The building owner would be responsible for paying the energy bill; as such they would need to set up a method to collect payments from tenants based on their energy usage.

  With master metering, PV could be installed load-side since it would be serving a single entity. Typically, buildings are only allowed to master-meter if they already had a master meter in place. In housing built after July 1st, 1982, SCE requires each residential unit to be metered separately with certain exceptions[3]. For this reason, master metering is not common. To facilitate equitable and resilient PV installations, master metering should be allowed and encouraged to claim both the cost savings and resilience benefits of onsite renewable energy.

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Batteries with VNEM

Emergent Key Concepts

Currently, SCE's virtual net energy metering program cannot be paired with battery energy storage systems (BESS) in a way that directly serves tenants in multifamily housing. Virtual net energy metering involves complex accounting and crediting mechanisms to distribute solar credit to tenants. Incorporating BESS on top of VNEM for solar PV adds a layer of complexity to the accounting, which SCE has yet to solve. Consequently, few multifamily housing properties have incorporated BESS. The only battery option available for multifamily housing involves installing a small energy storage system designed to provide back up power for only the house / common area rather than the tenants' units.

The challenge with VNEM primarily stems from a mismatch in the timing of when batteries and solar PV discharge energy. Batteries store energy and discharge it a different times of the day depending on building controls. Virtual net energy metering, on the other hand, credits tenants as PV is generated. Timing creates an issue because of time-of-use electric rates, which vary the rate of electricity depending on the time of day it is consumed. PV energy discharged immediately likely has a different cost than PV energy stored and discharged later.

To ensure effective decarbonization of affordable housing, this battery compatibility issue must be resolved. There is a growing need for BESS to make the grid more reliable. It is also starting to be required as part of the California Energy Code Title 24, Part 6 for new buildings; in future cycles of the code, existing buildings may also have to abide by this new requirement.

Building Energy Storage Systems
Source: https://www.sce.com/safety/bess

Batteries with VNEM

Emergent Key Concepts

To address the combability between BESS and VNEM, the following options should be explored:

- **Alter the VNEM tariff** – SCE can explore adjustments to the VNEM that establish crediting mechanisms for BESS. These adjustments must pass on both the benefits of energy cost savings and enhanced resilience from the batteries to tenants.

- **Separate tariff for batteries** – SCE can also look to develop a separate tariff that would apply only to the batteries. In this case, both the VNEM tariff for PV and a tariff specific to batteries would be applied to the same property. Dividing the tariffs in this way could help to simplify the accounting and make sure that tenants are awarded appropriately for each system.

- **Smart Meters** – Advanced metering technologies, such as smart meters, allow for more granular and accurate measurement of energy flows. These meters record and transmit data in real-time, enabling better tracking and crediting of energy generated, consumed, and stored by battery systems. Thus, to ensure effective pairing of batteries with VNEM, SCE should continue to deploy smart meters.

Income-Based Fixed Charge

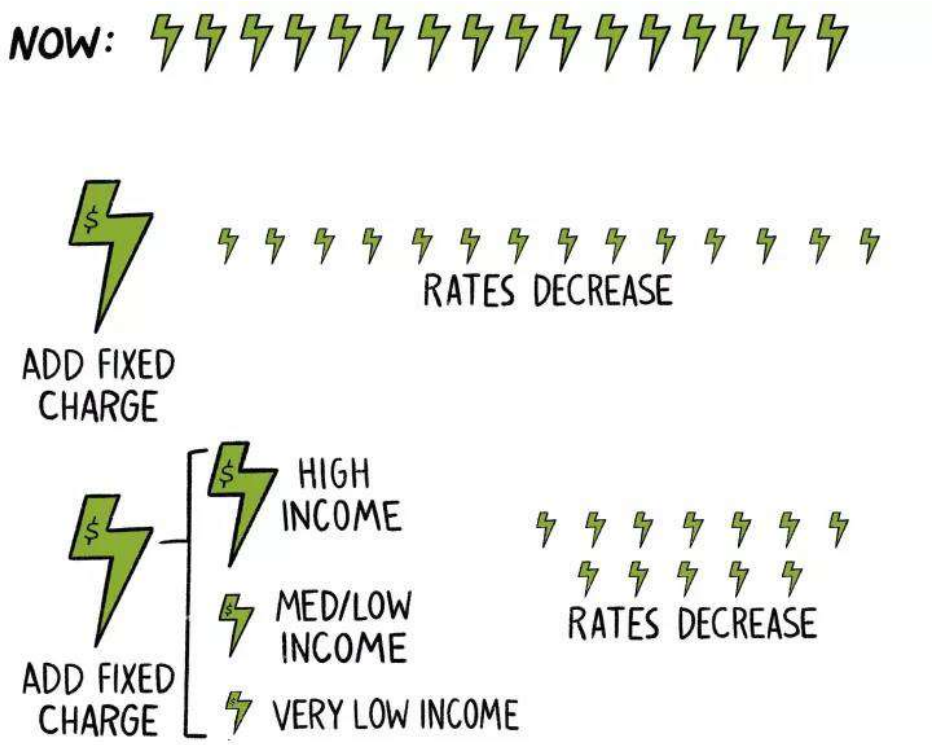
Emergent Key Concepts

Under Assembly Bill 205, the three California investor-owned utilities Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) will have to implement **income-based fixed charges**. Income-based fixed charges are fixed rates electricity consumers would have to pay, depending on their income, to cover the cost of basic utility operations. These fixed rates are intended to cover costs such as grid maintenance and expansion as well as wildfire prevention. Those in higher income brackets would pay more than those in lower income brackets.

Currently, electricity charges are based mostly on electricity usage in terms of kilowatt hours (kWh). Transitioning to have part of the electricity bill include a fixed charge would mean lower kWh rates for electricity, as can be seen in the image to the right. This change could benefit affordable housing decarbonization projects by providing savings for those in lower income brackets and potentially encouraging electrification.

Fixed charges are used in many states across the country. Mississippi, for example, is one state that uses fixed charges and has the highest residential fixed charge in the country at $37.41/month with Mississippi Power[4].

California, however, would be the first state to determine the fixed charge based on income.



Source: https://www.nrdc.org/

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Income-Based Fixed Charge

Emergent Key Concepts

Below is a breakdown of what consumers could pay for the fixed charge with the proposition the three California utilities have put forward:

- Households with an annual income from **$28,000-$69,000** would pay between **$20 a month and $34 a month**
- Households with an annual income from **$69,000-$180,000** would pay between **$51 a month and $73 a month**
- Households with an annual income **above $180,000** would pay between **$85 a month and $128 a month**

These are among the highest fixed rates proposed for the bill. According to SCE, over one million of its customers who are lower income could see their bills drop between 16% and 21%. It is also expected that overall rates will decrease by about 33% per kWh for residential customers.

In their proposal to the CPUC for establishing the income-based fixed charge (Application No: R.22-07-005), the NRDC recommends an average fixed charge of $36, which is quite high when considering that Mississippi Power is the highest in the country at $37.41/month[5]. Below is a breakdown of what the volumetric charges would be with this fixed charge:

- Those a part of **CARE** would go from paying between **$0.24-$0.38 a month** to between **$0.19-$0.31 a month**
- Those **not** a part of **CARE** would go from paying between **$0.39-$0.59 a month** to between **$0.30-$0.47 a month**

Consumers would not be able to revert to their old rates. Qualifying consumers, however, could receive waivers, such as those included in CARE. According to the proposal to the CPUC from the three utilities, “Low-income customers who currently receive assistance to pay their electric bills would not be exempt. These California Alternate Rates for Energy (CARE) customers—whose annual earning are at or below the federal poverty level (FPL)—would pay $15 to $24 per month in fixed fees[6].”

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Income-Based Fixed Charge

Emergent Key Concepts

An income-based fixed charge is advantageous for the following reasons:

- **Improved affordability and equity** – With the fixed charge being income based, the wealthier would pay for the bulk of utility costs. This would be beneficial for customers who live paycheck to paycheck and cannot afford electricity bills.
- **Encouraged transition towards electrification** – The lower volumetric electricity rates that come with the income-based fixed charge would mean the cost burden of running electrical devices is improved and switching to electric, like an electric stove or car, could provide a lot of savings, thus encouraging this transition.
- **More transparent and predictable electricity bills** – Since the fixed charges and volumetric charges would be displayed separately on an electricity bill with the new California law, customers will be able to better understand how their bill is broken up and predict what their next month's bill will be.

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Income-Based Fixed Charge

Emergent Key Concepts

However, an income-based fixed charge has the following downsides:

- **Reduced energy efficiency** – As consumers would be paying a fixed rate as part of their bill regardless of how much energy they use, this would mean the rate would provide more savings to high energy users than low energy users, almost acting as an incentive towards more energy use. Additionally, the volumetric rates would still be quite high in California, since they would only see about a 20 to 25% reduction with the NRDC's proposal. Thus, this would still incentivize consumers to conserve.
- **Discouraged transition to solar** – These income-based fixed charges would not be favorable towards solar because rooftop solar customers would be charged the fixed fee even if they mostly use their own solar energy. Thus, this would disincentivize new installations. However, with the fixed charges being similar to a progressive tax, if the fixed charge becomes high enough for high income earners, it could incentivize them to transition to solar and disconnect from the grid completely. It should be noted that transitioning to solar and completely disconnecting from the grid is not common but could possibly become more so with an income-based fixed charged.
- **Difficult to prove income** – It will be challenging for utilities to obtain up-to-date information from residents on their incomes for setting fixed rates.

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Income-Based Fixed Charge

Emergent Key Concepts

An income-based fixed charge has the possibility of making the transition to electric from gas more accessible and could reduce the cost of energy for low-income consumers who spend a large part of their wages paying their electricity bills. To make sure income-based fixed rates are implemented in a way to promote decarbonization of affordable housing, the following steps are recommended.

- **Actively track rate development** – Since this fixed charge will influence the cost effectiveness of decarbonization, NRDC should take a proactive role in monitoring how rates develop. Tariff proposals that promote equity while effectively fostering decarbonization through electrification, energy efficiency, energy storage, and renewable energy should be supported.

- **Eliminate additional fixed fees** – When moving forward with the income-based fix charge, it should be made sure that utilities do not include fees that are not fixed within these fixed charges. An example include distribution costs that are related to how much energy is being used. Utilities including many different fees under the fixed charge would also allow them to justify increasing this charge which will already be well above the national average of about $10 with their current proposition.

- **Consider lower fixed chargers** – It would also be worth considering having those below the poverty line pay $0 in monthly fixed charges. This would make the fixed charge even more equitable. In addition, this would provide more savings to those below the poverty line if they switch to electrification, further encouraging those that may be most hesitant to make the transition and supporting affordable housing decarbonization.

- **Time of use (TOU) rates** – Even with a fixed charge implemented, it is important to keep time varying rates as this will help address the issue of peak usage and encourages using energy use when solar energy is in abundance.

- **Reporting income level** – When deciding how to verify income for this income-based fixed charge, programs requiring less paperwork on the consumer side should be prioritized. Income reporting should be standardized to remove the opportunity for fraudulent claims.

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Findings

Key Challenges & Barriers

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Policy / Regulatory

- **Rate structure design** hasn't historically facilitated retrofits
- **VNEM maligned** with multi-family affordable housing
- **Permitting** can slow down projects as well as add additional constraints and costs

Funding & Financing

- **Complicated funding structures** create hurdles for owners lacking administrative capacity to access upfront capital; timing of financing and/or reimbursement doesn't align with project's needs for capital
- **Split incentives** may lead to an inability to recover project costs
- **Delayed activation of solar credit** can create gaps in financing
- **Unforeseen scope adds** (e.g., asbestos abatement) may increase project costs

Implementation

- **Lack of technical workforce** for installing and maintaining new technology; technical providers don't have resources to scale
- **Difficult to achieve economies of scale** with purchasing of energy efficiency equipment
- **Hazardous materials** in buildings (i.e., asbestos) delays project, eats project budget, or increases project costs

Technical Assistance

- **Lack of long-term strategic planning** may result in higher costs and opportunistic approaches for retrofits

Carbon Reduction

- **Site constraints** may limit the types of equipment that can be installed for electrification**.**
- **Emerging technology –** Finding contractors and maintenance providers comfortable with heat pump and other emerging technology proves challenging.

Tenant Impacts

- **Limited monitoring** of net zero impacts and energy savings

Key Opportunities

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Policy / Regulatory

- **Income-based fixed charge –** restructuring rates could improve economic feasibility of retrofits
- **Utility allowances –** combining tenant rent with utility bills into a single payment could mitigate split incentives
- **Inflation Reduction Act –** The IRA may incentivize clean energy via tax credits
- **Gas sunsets –** air quality regulations, building performance standards, and reach codes facilitate cleaner technologies
- **Building zoning relaxation** can help accommodate new equipment

Funding & Financing

- **Tailoring project scope to funding –** align project scope to available funding terms
- **Demonstrative or didactic value –** piloting new technologies can come with benefits
- **Tariffed on Bill –** financing mechanism could help overcome challenge of upfront costs
- **Consider property value –** upgrades can improve the business case
- **Innovative financing –** approaches help to overcome start-up costs and delays

Implementation

- **Environmental auditing –** conducting audits earlier can help avoid additional costs to projects
- **Comprehensive project execution –** design-build-operate-maintain can help reduce costs and improve building performance
- **Strong decision-making framework –** assessing upgrades against decision criteria could help maximize benefits
- **Economies of scale –** streamlining implementation can reduce design time, construction time, and contractor markups

Technical Assistance

- **Long-term strategic planning –** early identification of opportunities to align with capital funding and other fiscal timelines
- **Grant funding and incentive scan –** landscape analysis can improve alignment between scope and available funds
- **Leveraging partnerships with technical advisors –** groups like Bright Power, AEA, and National CORE offer valuable support to building owners
- **Turnkey project delivery –** helps to address technical and financing capacity gaps

Carbon Reduction

- **Measurement & verification –** setting aside funds for monitoring can ensure that the implemented measures achieve their designed intent
- **Sustainability rating systems –** certifications can increase the likelihood of the project achieving decarbonization targets
- **Community solar –** establishing solar programs that allow community solar in both IOU and municipal utility territories could help sites with limited space to decarbonize

Tenant Impacts

- **Indoor air quality –** eliminating harmful pollutants associated with gas combustion can improve indoor air quality of units
- **Skills training –** workforce development can help support decarbonization at scale and provide co-benefits to residents
- **Utility cost savings –**retrofits have the potential to yield cost savings, especially with VNEM
- **Increased thermal comfort –** improving the efficiency of HVAC can also improve its efficacy, leading to greater thermal comfort.

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Policies and Regulations

Challenges & Barriers

The building energy policy landscape is shifting dramatically. Cities across California are adopting all-electric codes for new buildings and planning for building performance standards to address existing buildings. Rate structures are being reconsidered and new federal funds are becoming available through the Inflation Reduction Act. However, this report's case studies show that energy retrofits in existing buildings beyond basic installations are difficult to achieve. To bring the benefits of holistic decarbonization retrofits to the affordable housing sector, it is essential to address policy and regulatory barriers. The study has identified the following key barriers:

- **Virtual Net Energy Metering (VNEM)** – VNEM programs are maligned with multi-family affordable housing. VNEM is especially important for facilitating tenant utility bill savings from solar PV installations. Though a new VNEM program was piloted at LADWP, it has not been successful for multifamily housing because it does not effectively reward tenants with solar credit. Solving for this issue could require updating LADWP's billing infrastructure to facilitate virtual allocations of utility bill savings to residents. SCE (which serves Los Angeles County outside of the City of LA) has a VNEM program that facilitates PV savings to both house/common loads and to the residential units, benefitting tenants. VNEM tariffs, however, have limitations with battery energy storage systems, which need to be resolved.
- **Permitting** – One barrier to implementation faced by owners is the time-consuming permitting processes. To address this, incentives could be offered. For example, specific requirements with cost or time impacts could be waived for affordable housing pursuing decarbonization retrofits (e.g., parking requirements). Additionally, or alternatively, the permitting process could be streamlined or expedited for affordable housing decarb retrofits. The process support could look like a dedicated staff member within the authority having jurisdiction could act as a case manager, guiding specifically affordable housing projects through, and/or the establishment of retrofit permitting pathways tailored to different types of decarbonization projects.

Policies and Regulations

Opportunities

On the other side, there are many emerging opportunities that may help to advance decarbonization work. The following should be considered and investigated further:

- **Income-based fixed charge** – An emerging area of opportunity is the restructuring of rates to improve the economic feasibility of retrofits. Assembly Bill 205 mandates the inclusion of a fixed charge in residential rates in addition to the volumetric charge based on how much electricity a resident consumes. Currently, there are proceedings at CPUC that aim to alter the rate calculation methodology to an income-based approach. This change could potentially enable previously unaffordable types of retrofits under the existing rate structures. However, it is important to note that income-based fixed charge rates may also have unintended consequences, requiring further study and monitoring.
- **Utility allowances** – Combining tenant rent with utility bills into a single payment requirement through a utility allowance (UA) can help mitigate the split incentive issue. This method allows building owners / developers to adjust rents if utility bills are reduced as long as the combined payment – UA + rent – is kept the same or reduces. UA however are challenging to calculate and often produce estimates of utility bills that do not align with actual utility bill data. As such, UA requires reform to incentivize decarbonization.
- **Inflation Reduction Act** – The Inflation Reduction Act may facilitate solar, wind, and energy storage projects by allowing more organizations to utilize clean energy tax credits.[7] Bonus credits are available for Investment Tax Credit projects focus on solar and wind projects that meet certain environmental justice criteria.

Policies and Regulations

Opportunities

- **Gas Sunsets** – One of the biggest drivers of decarbonization in California are gas purchase sunset regulations that are emerging. For example, the Bay Area Air Quality Management District is banning the purchase of gas-powered heating appliances, including furnaces and water heaters, after 2027. Broken heating appliances will be replaced with heat pumps. Policies discouraging gas and supporting cleaner technologies are anticipated through air quality regulations, building performance standards, and reach codes.
- **Building Zoning Relaxation –** Building decarbonization often involves siting new HVAC equipment and renewable energy systems that have spatial requirements. Space constraints at the Ocean Avenue building, for example, prevented the installation of air source heat pumps. Consequently, the design team decided to use electric resistance heating, which does not require as much space, in order to electrify the building. This option, which is no longer allowed by code, is much less efficient than heat pumps and usually results in high electrical peaks. As Title 24 and the industry moves towards heat pumps, solar PV, and other equipment with large spatial requirements, building zoning should create exceptions that allow such equipment to extend beyond the building zoning limitations.

Funding and Financing

Challenges & Barriers

There are major challenges associated with securing funding for retrofits that include the complexities of funding structures, split incentives, etc. Housing providers typically have complex capital stacks that can impede use of loans for retrofit capital. The following represent key financing challenges and barriers identified through this study:

- **Split Incentives** – The most common challenge for affordable housing developer is the split incentive issue, whereby developers / owners pay for the energy saving measures, but tenants receive the utility bill savings. Grant money thus becomes necessary to make such projects feasible. Fortunately, additional financing mechanisms are becoming available that may help to mitigate split incentive, discussed on the Opportunities slide for Funding and Financing findings.
- **Stacking funding and financing –** Navigating grant funds and incentive programs is a burden for housing providers that already lack administrative capacity and who already have complex capital stacks. Grant funding may have large lead times and competitive processes. Rebate and incentive programs require substantial time and effort to administer.
- **Emerging technology requirements** – Grants to fund decarbonization projects often include an emerging technology requirement for which project teams must evaluate and implement an emerging technology not commonly used in building projects. This requirement helps to advance decarbonization market but tends to introduce challenges. The case studies showed that emerging technology like the aerosol seal was challenging to implement and complicated construction. In many cases, few contractors have the knowledge and experience to implement such technology as well as maintain it. Although, emerging technology is an essential part of decarbonization; the use of it may not be as appropriate for affordable housing projects, which are typically restricted in terms of funding and financing and do not have room for added complications.

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Funding and Financing

Challenges & Barriers

- **Solar credit delay** – Projects that have installed solar PV on site sometimes do not receive the cost savings on their utility bills for a few months after installation. This solar credit delay can make operational expenses temporarily high, especially in electrification projects. For the Ocean Avenue building, this delay derailed CCSM's permanent loan underwriting. Utilities should try to expedite the solar credit so that affordable housing developers and residents can start benefiting immediately from their solar installation.
- **Resyndication timelines** – Resyndication to receive Low Income Housing Tax Credits is only allowed every 15 years, making retrofits harder to conduct within a shorter time frame. The 15-year timeframe helps to ensure tenants' rent remains affordable into the foreseeable future, however, at the expense of making their residences more livable and energy efficient. Short-time frames for resyndication, allowed in certain exceptions, could help dramatically catalyze habitability as well as decarbonization retrofits.
- **Grant money reimbursement** – Grant funding is often structured to come in as a reimbursement rather than as a source of funding to pay directly for the decarbonization retrofit. This structure poses challenges for developers with limited capital reserves as well as those who want to avoid involving additional lenders. Where possible, grant money should be provided as a source to simplify complicated finances including the work involved to maintain the financial, e.g., invoices, negotiation, etc.
- **Grant approval lead time** – The case studies showed that it can sometimes take a while to receive approval for a grant. This time frame for approval, which can take as long as 2 years, slows down decarbonization work by keeping retrofits in limbo. Grants approval needs to be expedited in order to ensure that affordable housing developers can realize their projects in a timelier fashion. In the meantime, projects pursuing grant funding may need to anticipate waits and simultaneously make provisions to address future factors, e.g., code changes, technology improvements, etc., that may come into effect while waiting for approval.

Funding and Financing

Opportunities

Through this study, the following strategies arose as potential opportunities to improve the financial feasibility of decarbonization projects:

- **Tailoring project scope to funding** – Projects such as those at Miramar Towers and The Village at Beechwood were successful because the project scope was tailored according to previously identified funding streams. They were able to implement retrofits to meet specific performance goals, even as challenges arose around asbestos abatement and ADA compliance. It will be helpful to have dedicated funds for asbestos abatement and other upgrades so that these upgrades do not use up grant money initially intended for decarbonization. Case studies demonstrate the importance of trusted partners that can provide housing owners with both technical assistance as well as administrative support for managing rebates or navigating complicated financing structures.
- **Demonstrative or didactic value** – Projects that have a didactic value, pilot new technologies, or have an articulated narrative around the project's social value can overcome some funding challenges. They may receive discounts for demonstrating new technologies.
- **Tariffed on Bill** – Some solutions have been proposed to address split incentives, such as Tariffed on Bill programs, also known as Inclusive Utility Investment programs. Tariffed on Bill programs should be supported by changes to related policies, including consumer protections, utility rates, program evaluation, and certification of contractors.
- **Consider property value** – Owners should also consider improved property values, which are demonstrated to be higher in green certified buildings and buildings that have undergone energy retrofits. (Source https://www.iea.org/reports/multiple-benefits-of-energy-efficiency/asset-values)

Funding and Financing

Opportunities

- **Innovative financing** – Some innovative financing mechanisms are evolving to overcome some of the more common barriers to financing green energy upgrades. For example, rapid financing programs can provide capital (e.g., Enduring Planet) for federal grants to begin project work to awardees while they wait on government funds.

  Construction and term financing that can be repaid using operating cost saving are being used to upgraded buildings where there are restrictions on adding new debt. These loans can also be used in combination with rebates and incentives, such as from the IRA. Flexible loan structures with progressive interest rates can be used to incentivize high energy performance through pre-development and design work on existing buildings. None of the case studies implemented these innovative financing mechanisms.

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Implementation Process

Opportunities

Case studies signaled the following strategic opportunities to address common challenges encountered during implementation:

- **Environmental auditing** – Conducting audits for environmental issues, such as asbestos and lead, ahead of energy projects can prevent project funds from being misappropriated to deal with those issues.
- **Comprehensive project execution** – Working with a turnkey contractor across a full suite of services (design-build-operate-maintain contract) and a comprehensive list of decarbonization measures can help to avoid some of the pitfalls and costs associated with piecemeal projects by having the contractor responsible for project performance.
- **Strong decision-making framework** – The case studies showed that the decision-making process greatly affected the outcome of the project. Successful projects integrated an approach that assessed a range of upgrades against decision criteria, including decarbonization targets, tenant benefits, and payback periods. This process enabled project teams to prioritize those measures that would provide the greatest benefit.
- **Economies of scale** – Undertaking conversions in a comprehensive manner can help to reduce costs, noise, and disruption resulting from construction time. Case studies demonstrate the difficulty in achieving the benefits from economies of scale that might be achieved by more streamlined implementation, including reduced design time, construction time, and contractor markups. In large portfolios or across specific building typologies, equipment could be purchased in bulk to create discounts on materials costs and a more streamlined supply chain. Developing implementation packages for certain building typologies can help to create market momentum and reduce these costs for implementers, but they could prevent adaptative approaches and create roadblocks for projects that don’t fit the given typologies.

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Technical Assistance

Challenges & Opportunities

Housing providers rely on technical assistance to complete retrofits, and they have considerable needs for assistance to navigate the financing and incentive landscape, understand technologies and develop project scopes, monitor and distribute project benefits, and more.

- **Long-term strategic planning** – Multi-family buildings vary in their readiness and capacity for deep energy retrofits. Much of Los Angeles's housing stock is comprised of older buildings that have deferred maintenance issues and require upgrades just to ensure livability. In that context, retrofits can become more costly if they are implemented separately or in a piecemeal manner to accommodate other maintenance priorities. Planning for retrofits could help to identify opportunities and to align them with capital funding opportunities and other fiscal timelines. Systematic review of natural gas systems could help to ensure that opportunities for electrification are not missed. Housing providers need support for long-term strategic planning of retrofits, to understand the prioritization of retrofits and upgrades, and require assistance to develop project plans that maximize efficiencies and returns. NRDC and allies could work with housing associations to provide education and assistance to housing providers.
- **Grant funding and incentive scan –** The incentive and grant funding scan provided by Bright Power for Miramar Towers helped to unlock significant funding, identifying the amount of money available to the project. Project scope was then tailored to this funding, thereby ensuring a financially successful project. This first step proved vital to the performance of the project. Technical assistance should provide this service in order to pair up affordable housing developers with the funding sources best suited for their projects.
- **Leveraging partnerships with technical advisors** – Groups like Bright Power, AEA, and National CORE can facilitate successful project outcomes by offering technical support to building owners within their organizational missions. However, capacity of implementers is also limited.
- **Turnkey project delivery** – Consultants can also fulfill housing provider needs for technical assistance, but this can eat away at limited project budgets. Training more energy retrofit providers to provide a full suite of services (design-build-operate-maintain contract), and to navigate both technical and financing complexities, can help to fill this gap in capacity.

Carbon Reduction

Challenges & Barriers

The primary intent of a decarbonization, as the word suggests, is to reduce carbon emissions. Projects striving for decarbonization typically set targets for the level of carbon reduction they aim to achieve. The case studies revealed specific challenges to creating and realizing carbon reduction goals and monitoring performance.

- **Site constraints** – As described in the Policies and Regulation slide, site constraints can hinder the installation of equipment necessary for electrification including heat pumps. Where site constraints get in the way, developers may resort to electric resistance heating, which is a much less efficient technology. Others may forgo electrification all together, instead opting to incorporate energy efficiency measures that preserve the existing gas systems.
- **Electrification and emerging technology** – Case studies also demonstrate the limited application of electrification technologies at the time that these retrofits occurred. Since these case studies were implemented, the movement towards electrification and heat pump technology have advanced. Though we commonly saw application of solar panels and improvements to insulation, two of the five properties incorporated heat pumps. Broader application may come from increased awareness of successful technologies, confidence of operators in using and maintaining them, and workforce capacity to supply and service those technologies.

Carbon Reduction

Opportunities

The case studies identified the following key opportunities to ensure effective decarbonization projects that realizes its goals:

- **Measurement & verification** – Case studies show that there are few instances of monitoring decarbonization performance following retrofits, so carbon reduction benefits are generally not measured or verified. That said, in cases where monitoring took place (e.g., Miramar Towers and Village at Beechwood), energy savings for both gas and electricity were shown to be substantial. Funding should be set aside for monitoring, enhanced commissioning, measurement & verification, etc. to ensure that the implemented measures achieve their designed intent. Funding programs should consider all stages of measuring performance including the planning during design, installation of meters as well as performance testing during construction, and monitoring during occupancy.
- **Sustainability Rating Systems** – Certifications (NZ and IFLI) may be unattractive because they add to the project's timeline and costs. However, certifications can increase the likelihood of the project achieving decarbonization targets. Municipalities could incentivize certifications (NZ, IFLI, etc.) by exempting requirements and expediting permitting or certification processes.
- **Community solar –** Projects with limited roof space or site area should be able to take advantage of community solar in order to meet their decarbonization needs. Community solar has struggled to grow in California due to poor program design. Fortunately, the bill AB 2316 and the Inflation Reduction Act will usher in reform as well as new funding that will make community solar projects much more attractive. To ensure access to community solar, specific solar programs must be established and approved by the California Public Utility Commission (CPUC) that allow community solar in both IOU and municipal utility territories. Moreover, incentives need to be created so that lower-income residents can take advantage of community solar.

Tenant Impacts

Challenges & Barriers

A primary challenge for decarbonization of existing multi-family housing is reducing negative impacts of retrofits on tenants while ensuring their direct and broader social benefits. Based on the interviews conducted, the following represent a few tradeoffs that may arise as a result of deep energy retrofits:

- **Temporary service interruptions** – Depending on the project scope, certain building services may have to be shut off temporary when installing new pieces of equipment. In a couple of the case studies, for example, water was shut off to connect solar hot water panels or plumbing fixtures to the domestic water system. For the most part, these interruptions only lasted for a few hours, usually less than 8 hours, allowing for access during non-construction hours. Service interruptions like this one may be unavoidable with this type of work, as such, should be limited where possible through efficient construction schedules.
- **Temporary relocation** – A few of the case studies required temporary relocation of residents to enable the construction work. Relocations place a large burden on residents, having to pack up belongings, spend nights away from home, etc., and prove costly for housing providers.
- **Eviction** – Though not experienced at any of the case studies, retrofit work in rare cases can result in eviction. During the development of this study, residents at Barrington Plaza in downtown Los Angeles were evicted to enable a sprinkler system upgrade. The eviction was permitted by the Los Angeles Housing Department under the Ellis Act (1985)[8]. Protections need to be put in place to make sure such a thing would not happen due to a decarbonization retrofits.
- **Change in home appliances** – Decarbonization measures such as electrification usually introduce new equipment into residential units such as induction cooktops and/or electric heaters. Tenants may have some difficulty at first learning how to use the equipment. Moreover, induction stoves may require tenants to buy new pots and pans compatible with the induction cooking. Training and supplies should be provided wear possible to ease the transition.

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Tenant Impacts

Opportunities

Aside from the primary benefit of reducing greenhouse gas emissions, decarbonizing the affordable housing stock can provide several benefits directly to the tenants.

- **Indoor air quality** – Electrification projects can dramatically improve indoor air quality inside residents' units by eliminating all harmful pollutants associated with gas combustion. In homes without gas stoves, for example, average CO levels are between 0.5 and 5 parts per million (ppm). Homes with gas stoves that are properly adjusted are often between 5 and 15 ppm whereas levels near poorly adjusted stoves can be twice as high: 30 ppm or higher. Exposure to air pollutants leads to adverse health outcomes including respiratory illnesses. Minimizing exposure thereby can improve overall health and wellbeing.
- **Skills training** – Economic opportunities may stem from decarbonization such as skills training provided to tenants during retrofits—or in preparation for retrofits. Skills training can help to develop the workforce that is required for scaling decarbonization; it can also benefit residents interested to learn more about green construction. There is not data from these case studies on whether skills training has increased job opportunities for residents, but there is anecdotal evidence that trainings on solar installation (e.g., at Village at Beechwood) improved tenant understanding of retrofit benefits. There are also be opportunities for on-the-job skills training for non-tenants.
- **Utility cost savings** – Energy efficiency measures completed within the tenants' units usually result in lowering their utility bills. As discussed in the "Policy and Regulations" section prior, Virtual Net Energy Metering or credit mechanisms also can help to realize tenant utility savings from solar PV.
- **Tenant rent not impacted** – In these case studies, tenants' rent costs were not impacted by the retrofits because most of the properties were deed-restricted, which prohibited rents from increasing. Housers funded retrofits through grant programs, private funding, or other sources to make the project cost effective.

Tenant Impacts

Opportunities

- **Thermal comfort** – The Beechwood case study showed that energy efficiency measures can simultaneously provide a thermal comfort benefits, depending on project scope. In making the air conditioning system more efficient, the project team was also able to improve the effectiveness of HVAC, helping to bring much more cooling into the residents' spaces. In the Urban Soil / Tierra Urbana property, the solar hot water system achieved a similar result, increasing the effectiveness of the domestic hot water heater system by helping to raise and balance the temperature of the hot water.
- **Pride in residence** – Energy retrofits can sometimes lead to a greater sense of satisfaction and pride among tenants for their residence. During the tenant interviews for the Ocean Avenue building, many recognized living in a greener building as an opportunity to contribute to a better, more sustainable world, i.e., living in alignment with their values.

  Improved safety and resilience – Decarbonization retrofits often help to improve safety of buildings. Electrification projects, for example, eliminate gas usage, thereby minimizing both exposure to air pollutions from gas combustion as well as the risk of gas leaks. Weatherization measures, such as adding insulation and replacing windows, can help tenants weather fierce storms and long heat waves, working to preserve comfortable temperatures inside apartment units with less energy consumption.
- Solar PV with battery storage can further enhance energy resilience by providing necessary backup power in the event of an outage. To provide active benefits, however, VNEM needs to become compatible with load-side PV installations. At the same time, utility cost savings from batteries need to be incorporated into either the VNEM tariff or a separate tariff so that usage of the battery can be extended to tenants.

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Conclusion & Next Steps

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Addressing Study Gaps

While this study highlights many key takeaways on decarbonization retrofits, it is limited in scope and examples/data. Subsequent studies could address the limitations and gaps of our study in the following ways:

- **More recent examples —** Interviews for this study were limited in number, and some of them were older studies. It's important to conduct ongoing studies like this, especially as technologies advance and become more common.
- **More electrification examples —** This report only includes one electrification study, and it will be important in future studies to include more studies involving electrification.
- **Building diversity —** All properties reviewed in this report are Section 8 deed-restricted except the Urban Soil / Tierra Urbana Property. It would be helpful to look at other types of affordable housing and income mixes.
- **Data collection —** Monitoring building energy data can help to better understand project economics and performance. As such, building data monitoring should become both a priority of retrofit projects as well as future studies that expand on this one. On the east coast, BrightPower is developing a free, public database that will include information on building details, low-carbon criteria including energy and water usage, demand, and cost data. It would be helpful to the western region to have a similar database on costs and payback to better understand economic feasibility of projects.

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Evolving the Business Case for Retrofits

The study identified the following key opportunities to improve the cost-effectiveness of affordable housing retrofit projects:

- **Reducing upfront capital burden —** For owners, the need for upfront capital is a major roadblock, and grant funding is often essential for project implementation. Improvements can come from expediting the financing process and disbursement of grants, maintaining reasonable application fees, and implementing Tariffed on Bill programs to reduce the need for loans.
- **Capturing Health and Social Benefits —** There is active research in the area of monetizing health and social benefits associated with retrofits, which can help to improve the business case for retrofits and the case for public funding. Decarbonization and energy efficiency programs have focused on carbon and energy savings, but more fully capturing health and social benefits would require additional research. There is significant research demonstrating the connection between electrification and indoor air quality benefits and between air quality improvements and health outcomes.[9] Accounting for health benefits from avoided costs of electrification (e.g., from reductions in hospitalizations, deaths and illnesses) is an ongoing area of research, but there are estimates of health savings associated with electrification in California[10] and the value of electrifying natural-gas combustion buildings in the LA.[11]

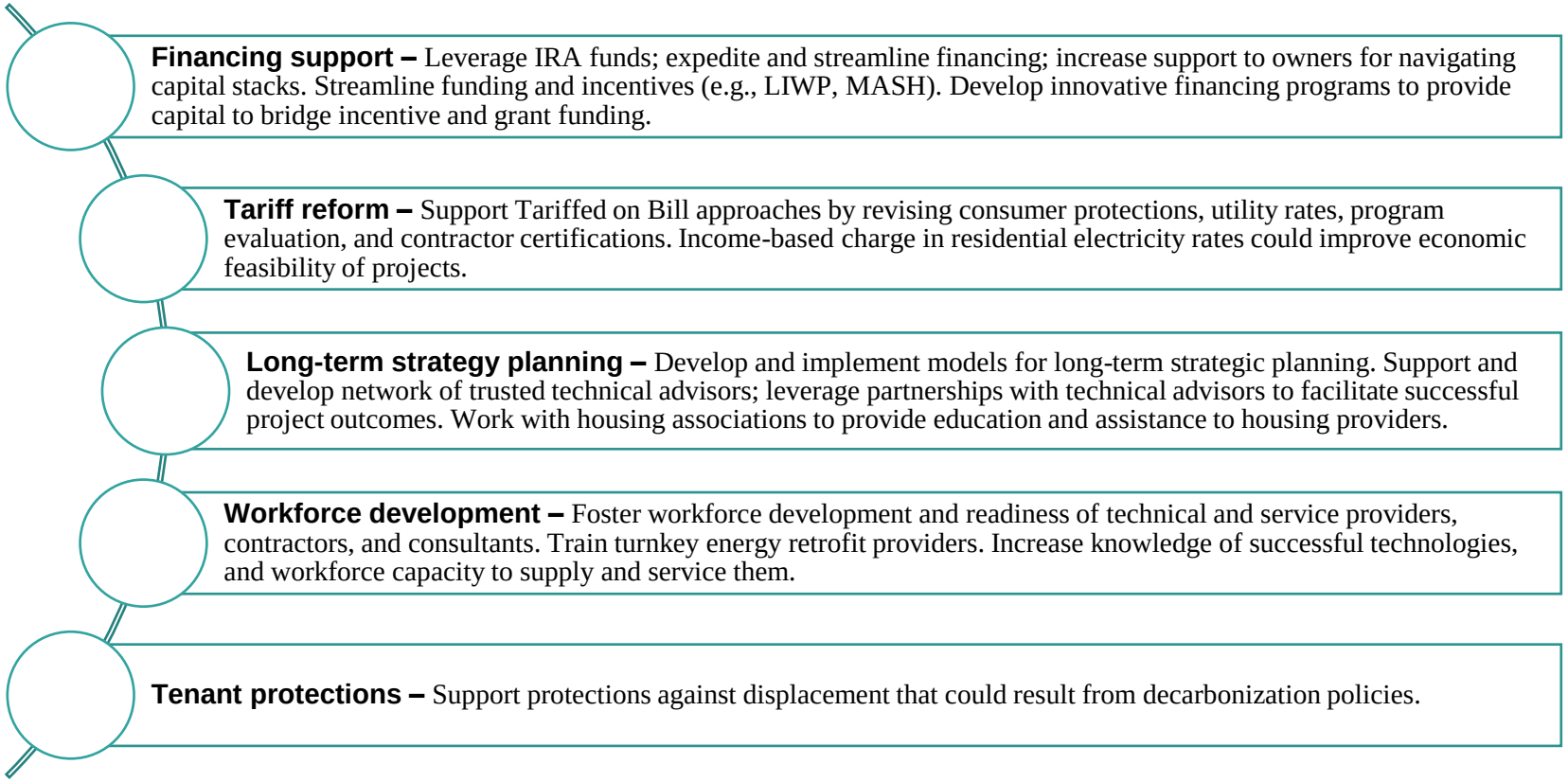
Ongoing Policy/Program Developments

To summarize, the following policies and programs are being advanced by advocates in the space to improve the reach of affordable housing decarbonization. Where possible, these initiatives should be promoted and tracked to ensure they develop in the best way possible to make decarbonization projects easier and more cost-effective:

- **Innovative financing —** The need for reducing upfront capital required for implementation is a major roadblock for decarbonizing affordable housing. Strategies to address this gap include expediting the financing process and disbursement of grants, maintaining reasonable application fees, and implementing programs like Tariffed on Bill that reduce the need for loans.
- **Tariffed on Bill —** Support Tariffed on Bill approaches by revising consumer protections, utility rates, program evaluation, and contractor certifications
- **Utility allowances —** Facilitate utility allowances to help mitigate split incentives
- **Income-based fixed charge** for tariffs could significantly impact the feasibility of projects
- **VNEM —** Facilitate virtual allocations of utility bill savings.
- **Expedite permitting** of decarbonization retrofits by exempting requirements and giving priority to these projects. Establish retrofit permitting pathways for different decarbonization project types.
- **Developing compatible / stackable financing** with congruent timelines. Stacking grants can be complex and may require significant coordination and planning; some groups are working to provide options to bridge these financing stacks with innovative financing approaches that meet project meets and the requirements of each program.
- **Energy monitoring** to accurately measure retrofit benefits and net zero success

Advocacy Pathways

Addressing the challenges identified through the case studies will require changes to policies, programs, technical assistance, and information sharing. The study team identified a few strategic advocacy pathways that can help to advance this transformation while maximizing equitable and resilient outcomes.



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Citations

[1] LA DWP. (n.d). *Virtual Net Metering*. https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-ressolar/r-gg-rs-vnem?_adf.ctrl-state=5ymxyk7db_17&_afrLoop=63886473354049

[2] Canary Media. https://www.canarymedia.com

[3] Southern California Edison. (n.d). *Rates and Reading Your Meter.* https://www.sce.ciom/residential/rates/multi-family

[4] EQ Research. (2023, April 11). *Residential Fixed Charges-Comparisons of California IOU Proposal.* https://eq-research.com/wp-content/uploads/2-23/04/20230411-Residential-Fixed-Charges.pdf

[5] Natural resources Defense Council and The Utility Reform Network. (2023, April 7). *Addressing Options for an Income-graduated Fixed Charge.* https://docs.cpuc.ca.gov/PublishedDocs/SupDoc/R2207005/5897/505727242.pdf

[6] John, J. (2023, May 9). *Income-based electric bills: The newest utility fight in California.* Canary Media. https://www.canarymedia.com/articles/energy-equity/income-based-electric-bills-the-newest-utility-fight-in-california

[7] Environmental Protection Agency. (2023, June 1). *Summary of Inflation Reduction Act provisions related to renewable energy.* https://www.epa.gov/green-power-markets/summary-inflation-reduction-at-provisions-related-renewable-energy

[8] Vincent, R. (2023, May 8). *Fire-plagued apartment complex to remove tenants for sprinkler retrofit.* LA Times. https://www.latimes.com/california/story/2023-05-08/fire-plagues-apartment-complex-to-remove-tenants -for-sprinkler-retrofit

[9] Bistline, J.E.T., Blanford, G., Grant, J. et al. (2022). Economy-wide evaluation of CO2 and air quality impacts of electrification in the United States. *Nature Communications* 13, 6693 https://doi.org/10.1038/s41467-022-33902-9

[10] Machol B, Rizk S. (2013) Economic value of U.S. fossil fuel electricity health impacts. Environ Int. 2013. 10.1016/j.envint.2012.03.003

[11] Mantegna, Gabe. (2021) Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California. Energy and Environmental Economics. Advanced Power & Energy Program, UC Irvine. https://www.ethree.com/wp-content/uploads/2022/01/CPUC-Air-Quality-Report-FINAL.pdf