BayREN

Heat Mitigation Pilot Research Final

Photo sources: https://www.thepoultrysite.com/articles/5-steps-to-preventing-heat-stress-in-layers

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Executive Summary

The Bay Area Regional Energy Network (BayREN) is an organization made up of the nine counties in the San Francisco Bay Area (referred throughout this report as the Bay Area). These local governments are acutely aware of the risks posed to their populations (and especially their vulnerable populations) as temperatures are getting warmer than before and warm temperatures are lasting longer. This study sought to provide information to help BayREN decide whether to move forward with a pilot to mitigate heat in residential buildings.

The Bay Area is getting warmer now and the counties are forecast to experience from 4% to 57% more days over 90° F by 2035. The forecast expects more heat events in 2035-2064 that will last at least 4 days. For example, Solano (one of the hotter counties within BayREN's territory) averaged eight 4-day heat events annually in the past and is forecasted to have an average of 17 events annually in the future. Additionally, heat-events in all counties are expected to have more days within a single heat event (with the number of days in a single heat event having the potential to be close to doubling between 2035 and 2064). Using the Solano example, over a 30 year period, households in Solano have experienced single heat events that average 13 consecutive days above 90° F; however, in the future, an average heat event could last 27 days (almost a full month of consecutive days above 90° F).

> There will be more heat events that last at least 4 days, and all counties will experience more days of high heat within a single heat event.

The Bay Area may have close to 25% of the population especially vulnerable to extreme heat. People who are obese, those over 65 or under 5, or with certain medical conditions (e.g., heart disease) cannot regulate their body temperatures as well as healthy adults and heat can cause asthma flares. These people are at higher risk of health issues when they experience heat that they cannot mitigate. A healthy adult, if they cannot cool their body, can develop heat cramps when the temperature feels like 90°-105° F, heat exhaustion at 105°-130° F, and heat stroke above 130° F. Within the Bay Area, ~23% of adults are obese and 10% are over 65. Being both overweight and over 65 exacerbates heat-related health issues and can cause issues to occur at even lower temperatures. As such, our analysis (that uses 90° F as the threshold for health issues) gives results that are a conservative estimate of the number of people affected by heat.

There are no programs in the Bay Area specifically targeted to heat mitigation, but other related actions are being taken. While many energy efficiency programs offer measures that can support reduction of heat within buildings, our team could find no publicly available details of programs that specifically seek to reduce indoor temperature. However, local governments are very active in helping to ensure their constituents understand heat emergencies. Additionally, California has an Action Plan to build community resilience.[1] Based on that plan, funding will be available in 2024 to public entities, California Native American tribes, community-based organizations, and non-profits that focus on heat mitigation programs.

[1] California Natural Resources Agency (b). 2022. *https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Climate-Resilience/2022-Final-Extreme-Heat-Action-Plan.pdf*

Heat mitigation and energy efficiency can act almost hand-in-hand, demonstrating that reducing the most extreme temperatures in homes can be accomplished, in most cases, with little use of mechanical cooling or fan measures, (although this may not bring the home under 90° F).

The addition of "passive" measures can significantly reduce the hours above 90° F indoors, but not eliminate them.[2] Reducing the heat brought in through existing windows (i.e., creating shade) has the highest influence over indoor temperature followed by changing windows. In single family homes, the cumulative effect of multiple passive measures can reduce the number of hours over 90° F by 95% or more, but not eliminate them altogether. Inclusion of shading, exterior paint, and new windows in multifamily homes can reduce the number of hours over 90° F by close to 99%. This is a positive finding as our data indicates that 56% of households in the Bay Area lack air conditioning.

For several counties, mechanical cooling is required to enable a home to never go above 90° F. For two of the climate zones (CZ 2 and CZ 3 that include most of Sonoma, Napa, Marin San Mateo, San Francisco, and parts of Alameda and Contra Costa Counties), simulations indicate that addition of a whole house fan could successfully cause a home to never experience interior temperatures of 90° F.

Certain measures that mitigate heat are not part of existing energy efficiency programs. While measures like insulation, air sealing, weatherization, and air source heat pumps are generally available through existing efficiency programs, other measures that demonstrate significant impacts to reduce indoor temperatures, like exterior paint, shading, radiant barriers, and whole house fans are not often seen within energy efficiency incentive programs available to BayREN's customers.

BayREN could explore partnering with energy efficiency and repair programs to improve heat mitigation. There are 27 organizations providing 35 energy efficiency programs already being implemented in the Bay Area that may be open to partnering with BayREN to add measures like those noted above. Certain programs (such as the PG&E Energy Savings Assistance Program or the US DOE Weatherization Assistance Program) are only for low-income households. Others (such as the Golden State Rebates or the MCE Single Family program) are not income constrained.

Power outages exacerbate the potential for high heat in a home, but products such as portable or permanent power equipment could help mitigate that heat by running a window air conditioner or the central HVAC system. Portable or permanent power can be stored within a battery or generated by different fuels. Portable generators that use gasoline, diesel, or propane must be run outdoors (for health reasons). Portable batteries must be charged before there is an outage. Portable generators and batteries can be used for items that have a plug. If appropriately sized, a portable generator or battery could be used on a window air conditioner. Additionally, PG&E provides a technology (called a backup power transfer meter) that enables a portable generator to power a home, which would include the HVAC system. If BayREN wants to provide portable or permanent power equipment to help mitigate heat during power outages, more detailed research is needed to determine specifications (e.g., of the portable or permanent power) and then set program requirements. Additionally, BayREN may need to consider that both portable or permanent generators use fuels that emit greenhouse gases and particulates.

The remainder of this report covers:

- Overview (with research objectives and questions)
- Results (based on the research questions)
- Appendices
  - A. Details on Historic and Forecast Weather
  - B. Typical Baseline Home Configuration
  - C. Additional Measure Details
  - D. Simulation Results by Climate Zone
  - E. EE Programs in BayREN area
  - F. Annotated Bibliography

[2] Passive measures are measures that do not use energy. For example, attic insulation is a passive measure.

Overview

Climate change is causing extreme high and low temperatures, and associated weather and wildfire events pose new threats to human health. Within the San Francisco Bay Area, much of the building stock was constructed for a milder climate that did not require both heating and cooling. However, the increase in temperature extremes highlight that past building practices are falling short in their ability to create livable indoor environments for existing buildings (although codes for new construction point to buildings being better able to manage extreme heat).

Research Objective

This study sought to provide information to help BayREN decide whether to move forward with a heat mitigation pilot.

Research Questions

1. Define an extreme heat emergency.
    a. How do governments or health experts define an extreme heat emergency?
    b. What proportion of the population in the Bay Area is especially vulnerable to extreme heat because of underlying health conditions?
2. Identify baseline criteria for protecting occupants from temperature extremes and having a livable indoor environment within residential dwellings.
    a. How is a livable indoor environment defined by medicine and building science?
    b. Define what temperature limits, and other indoor conditions, are required to protect occupant health during an extreme heat emergency across a range of health conditions (from healthy to vulnerable).
3. Describe measures that are needed to ensure livable indoor environments for residential dwellings (single family and multifamily) and how those measures can be quantified.
    a. Define the baseline package of building performance measures that are needed to ensure the indoor temperature remains at a livable, healthy level during extreme high temperature events.
    b. Document how the heat mitigation performance of a set of building performance measures can be quantified. Document the relative heat mitigation benefit on a measure-by-measure basis.
4. Summarize existing California programs, their customers, their services and measures, and the measures they provide that specifically protect occupants from temperature extremes (include both direct install and rebate programs).
    a. Identify additional measures that need to be layered on to existing direct install programs to enable them to deliver adequate protection from temperature extremes.
    b. Identify current energy storage technologies that could support cooling during a Public Safety Power Shutoff (PSPS) if necessary and any California programs currently providing those technologies.
5. Provide examples of heat mitigation programs from other regions.

The research team of Grounded Research and Consulting, LLC and Verdant Associates, LLC used review of Cal-Adapt databases, multiple building simulations of both single family and multifamily buildings, and a literature review to answer these questions. [3]

[3] Details of the Cal-Adapt weather data are in Appendix A. Details of the simulation are described later within this document and in Appendix B and C. The annotated bibliography of the literature review is in Appendix F.

Results

What is an extreme heat emergency?

The Federal Emergency Management Agency (FEMA) "defines an extreme heat event as a long period (2 to 3 days) of high heat and humidity with [outdoor] temperatures above 90 degrees Fahrenheit." According to FEMA, "The increase in frequency and time of these heat events is a major cause for concern as extreme heat is expected to continue threatening the wellbeing of families and vulnerable populations. Extreme heat-related deaths significantly outnumber those caused by any other weather-related disaster. Low-income households are more likely to suffer from extreme heat and other natural disasters, creating financial and health concerns that impact individuals' and families' wellbeing.[4]

Many local governments have information regarding how to "beat the heat", but few indicate outdoor threshold temperatures that designate an extreme heat emergency. A few examples are San Mateo County officials who describe high heat days as anything over 85° F and extreme heat days as 100° F or higher and Sonoma County officials who indicate that extreme heat is an extended period of intense heat and humidity with temperatures above 90° F.

What temperature does an indoor environment need to be livable?

Regardless of whether it is defined as an extreme heat emergency or not, based on how normal people respond to temperatures, a livable indoor environment needs to be under 90° F to prevent health issues. (Table 1)

Table 1. Physical Responses to Specific Temperatures in the "Normal" Person

Temperature "feels like"*	Physical response in "normal" person without taking steps to regulate temperature
90° -105° F	Heat cramps – painful muscle cramps and spasms, heavy sweating
105° -130° F	Heat exhaustion – cold, pale, clammy skin, dizziness, headache, fast, weak pulse
130° + F	Heat stroke – hot, red, dry or damp skin, rapid and strong pulse, fainting – can be fatal

**How the body perceives temperature is based on both the temperature and relative humidity. A temperature combined with high relative humidity can feel much hotter than the actual temperature.*
Source: Pittalwala, Iqbal. 2021.

Throughout this report, we use this threshold, 90° F indoors, to define what temperature limits are required to protect occupant health during an extreme heat emergency across a range of health conditions (from healthy to vulnerable). Note that for people with difficulty regulating their internal body temperatures (e.g., those who are obese, have medical conditions such as heart disease, the young or old), livability temperatures most likely are lower than shown above.

Who is most affected by heat emergencies and how are these people represented in the Bay Area?

People can acclimatize to heat, so heat waves in places such as San Mateo or San Francisco (that are cooler than other counties), are more likely to be deadly than the same conditions in hotter places or later in the summer (when one is more used to the hot). (Bebinger, 2023. Crownhart, 2021.)

People who have difficulty regulating their internal body temperature are most affected by extreme heat conditions. This includes the very young (under 5), the elderly (over 65), those who are obese, and those with certain medical conditions such as kidney disease, or heart disease. Additionally, heat can exacerbate pulmonary diseases such as asthma or chronic obstructive pulmonary disease (COPD). Furthermore, certain medications can impair the body's ability to regulate the internal temperature (e.g., antihistamines, cyclic antidepressants, certain antipsychotics). (Penman, 2022)

[4] https://liheap-and-extreme-heat-hhs-acf.hub.arcgis.com/

In the Bay Area, obesity affects about 23% of the adult population (a little over 1.7 million people). About 10% of the population are elderly, while those under five and all other diseases are ~5% or less of the population. [5] However, with about 7.7 million people in the Bay Area, even 5% is over 400,000 people who are affected by extreme heat (heat emergencies).

Alameda and Santa Clara counties have the highest number of people who would be affected by heat emergencies, but other counties have higher percentages of those who would be affected by heat emergencies. For example, Napa, with only about 140,000 people, is the top county in terms of the percentage of people likely to be affected by heat emergencies. (Table 2)

Table 2. Thousands of People Who Are Especially Vulnerable in Heat Emergencies by County
(two counties with highest number of people for all columns highlighted in green, top two counties with highest percent by column highlighted in light blue)

		Thousands of People						
County	**People**	**Obese**	**Over 65**	**Asthma**	**Heart Disease**	**COPD**	**0-4 years**	**Kidney Disease**
Alameda County	1,657	393	156	96	68	68	64	28
Contra Costa County	1,142	275	107	57	53	53	36	17
Marin County	260	59	38	15	13	13	8	5
Napa County	140	39	25	11	7	8	6	4
San Francisco County	875	140	96	48	35	33	28	14
San Mateo County	767	159	78	40	33	31	28	12
Santa Clara County	1,927	409	161	88	72	71	69	26
Solano County	442	133	44	28	21	23	19	8
Sonoma County	500	132	62	30	25	28	15	8
Total	*7,710*	*1,740*	*768*	*412*	*328*	*327*	*272*	*122*
Percent for all counties		*22.6%*	*10.0%*	*5.3%*	*4.3%*	*4.2%*	*3.5%*	*1.6%*

Source: 2019 Social Determinants of Health; Centers for Disease Control & Prevention

What are historical and future temperatures?

Extreme heat emergencies can occur when the daily outdoor temperature becomes extremely high or when hot temperatures continue for multiple days (i.e., a heat event). In this report, we describe four different ways to consider historical and future temperatures.

- **Highest Temperatures**: The outdoor temperatures where only 2% of hours are hotter (i.e., the 98th percentile of temperatures). – Figure 1
- **Days over 90° F**: The number of days where the maximum outdoor temperature is over 90° F, regardless of whether the days are consecutive or not. We provide the number of days historically and forecast in the future. - Figure 2
- **Number of 4-day long Heat Events**: We use the Cal-Adapt default of 4-days to represent a heat event to indicate the increase in actual events. - Table 3
- **Number of Days in a Single Heat Event**: The number of days in a single heat event. Different from the number of days over 90 ° F, this information provides the maximum number of *consecutive* days above 90 ° F. Also different from the number of heat events data, this is a single event that does not have a minimum of four days. - Table 4

Historic and forecast temperatures are from the Cal-Adapt website. Information in this report uses the "dissimilar" simulation and the RCP 4.5 emissions scenario that are described in the California's Fourth Climate

[5] Totals are by individual issue and the total that are vulnerable are most like less as there can be people who have more than one of the issues (e.g., are over 65 and have heart disease).

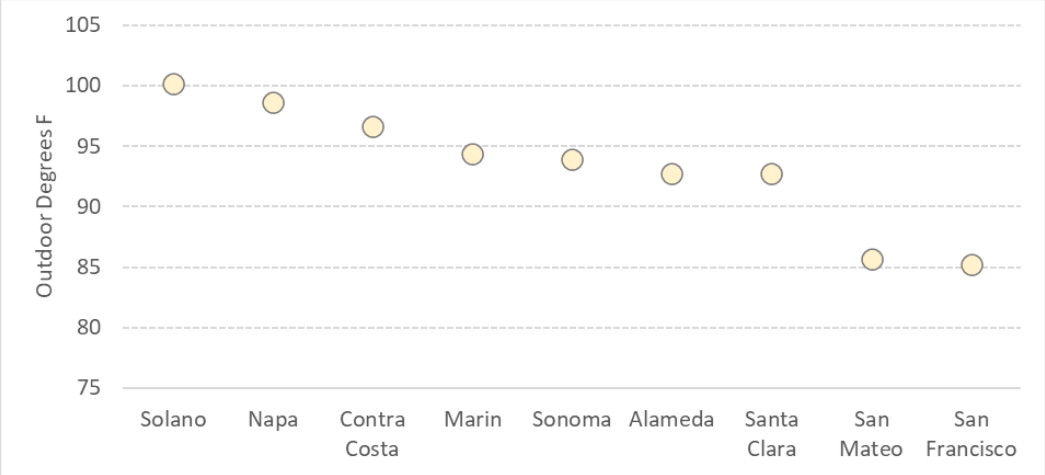
Change Assessment. The temperatures represent maximal coverage (and so a worst case scenario) of future climate conditions while the emissions scenario includes greenhouse gas mitigation efforts. Appendix A provides more details on the Cal-Adapt information.

Figures and tables with these four ways of considering temperatures are next.

Highest Temperatures. The Bay Area has multiple climates and, removing the hottest 2% of temperatures (176 annual hours removed), the highest temperature varies by county with a low of 85° F (San Francisco) to a high of 100° F (Solano). (Figure 1)

Figure 1. Historic 98th Percentile Outdoor Temperature by County

(i.e., from 2011-2020, 2% of all temperatures, 175 annual hours, were hotter than these values)



Source: Cal-Adapt https://cal-adapt.org/tools/extreme-heat

For the 10-year period between 2026 and 2035, the forecast shown in the Cal-Adapt site indicate that most counties expect from 12-16 more days over the values shown in Figure 1.

Days over 90° F. As described above, 90 degrees is the temperature when heat begins to have impacts on health. Absent air conditioning, heat will move into buildings to the point of temperature equilibrium at a rate that depends on the construction of the building shell. As such, when outdoor temperatures are 90° F, a non-air-conditioned building will eventually have an indoor temperatures of 90° F. This is especially true when, across several days, the evening temperatures do not cool down (i.e., during a heat event).

In the figure below, some counties experience many days over 90° F. Between 2011-2020, Napa experienced 60 days per year over 90° F and Solano experienced more than 80 days per year over this temperature. Compared to the 2011-2020 period, in 2026-2035 all counties are forecast to have from 4% (Marin) to 57% (Santa Clara) more days per year with the outdoor temperature over 90 degrees, according to Cal-Adapt. (Figure 2)

Figure 2. Change in Number of Days per Year over 90 degrees by County
(change from annual days in 2011-2020 to annual days in 2026-2035)

Source: Cal-Adapt https://cal-adapt.org/tools/extreme-heat

Number of Heat Events There is no specific definition for how many days are in a heat event. Cal-adapt defines a heat event as "four consecutive extreme heat days or warm nights when the daily maximum temperature is above the extreme heat threshold". Using this definition and a threshold of 90° F outdoors, most counties are forecast to see many more heat events in the future where the top of the range in the future is substantially higher than the baseline values.

For example, in the table below, from 1961-1990 Solano had an average of 8 heat events per year where the temperature remained high (over 90°F) for at least four days, with a range over the same previous thirty-year period of 1 to 16 heat events annually. By mid-century, the forecast is for an average of 17 heat events per year lasting at least four days (up from 8 per year), with a range from 5 to 29 heat events in a year. (Table 3)

Table 3. Four-day Heat Events – Number of Events per Year
(at 90 degrees threshold and RCP 4.5)

County	Baseline Modeled (1961-1990)		Mid-Century (2035-2064)	
	Average # of 4-day events per year	Range of events per year	Average # of 4-day events per year	Range of events per year
Alameda	1	0-3	3	0-9
Contra Costa	3	0-8	9	0-19
Marin	1	0-4	2	0-6
Napa	5	0-12	12	5-22
San Francisco	0	0-0	0	0-1
San Mateo	0	0-1	0	0-3
Santa Clara	1	0-3	3	0-9
Solano	8	1-16	17	5-29
Sonoma	1	0-4	3	0-8

Source: Cal-Adapt https://cal-adapt.org/tools/extreme-heat Baseline range is based on available data.

Number of Days in a Single Heat Event. Additionally, all counties are expected to have more days within a single heat event. By 2035-2064, the number of days in a single heat event has the possibility of being double what it

was in the baseline period. Using the same Solano example, historically, a heat event in Solano averaged 13 consecutive days over 90 F. In the future, the average is expected to be 27 days (almost a full month).(Table 4)

Table 4.Heat Event Duration – Longest Stretch of Days per Heat Event per Year
(at 90 degrees threshold and RCP 4.5)

County	Baseline Modeled (1961-1990)		Mid-Century (2035-2064)	
	Average longest stretch of days in a heat event	Range of days in heat event	Average longest stretch of days in a heat event	Range of days in heat event
Alameda	4	0-10	7	1-20
Contra Costa	7	2-15	14	3-58
Marin	4	0-10	6	1-14
Napa	9	2-21	20	4-62
San Francisco	0	0-3	1	0-5
San Mateo	1	0-4	2	0-13
Santa Clara	4	0-10	7	1-20
Solano	13	4-27	27	8-62
Sonoma	4	0-10	7	1-19

Source: Cal-Adapt https://cal-adapt.org/tools/extreme-heat

During an extreme heat emergency, what does a livable indoor environment look like for a residential home and what is needed to make it livable?

What is needed to make an indoor environment livable?

As discussed above, indoor temperatures above 90°F are the threshold above which people commonly start experiencing physical responses to temperatures. Therefore, keeping a home below 90°F is essential to ensuring a livable indoor environment. To undertake this analysis, our team analyzed the effect of passive and mechanical energy efficiency measures on indoor temperatures.[6] We ran building simulations for both single family and multifamily homes utilizing both NREL's Building Energy Optimization Tool (BeOpt) and OpenStudio software which support whole building energy modeling using EnergyPlus, the Department of Energy's (DOE) flagship simulation engine.

The team first simulated a baseline home,[7] using square footage, occupancy, and building shell data for homes built prior to 1975 from the California 2019 Residential Appliance Saturation Survey (RASS).[8] As we display further in this section, for many homes, creating a livable indoor environment requires air conditioning. However, according to available data, 18% to 91% of households in the Bay Area lack air conditioning, as shown below in Table 5. Therefore, for the purposes of this study, the baseline homes do not have mechanical cooling.

Table 5. Households without Air Conditioning by County

County	Climate Zone	Total Households (HH)	HH without AC	
Alameda	CZ 3, CZ 12	489,913	315,047	64%
Contra Costa	CZ 3, CZ 12	320,347	97,355	30%
Marin	CZ 2, CZ 3	133,955	97,265	73%
Napa	CZ 2	77,893	33,443	43%

[6] Passive measures use no energy. Attic insulation or windows are examples of passive measures.
[7] Baseline home configurations are provided in Appendix B.
[8] 2019 California Residential Appliance Saturation Study, a comprehensive study of residential sector energy use. Completed June 2020. https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study

County	Climate Zone	Total Households (HH)	HH without AC	
San Francisco	CZ 3	406,846	369,389	91%
San Mateo	CZ 3	272,989	213,158	78%
Santa Clara	CZ 4	537,467	190,429	35%
Solano	CZ 12	185,061	32,514	18%
Sonoma	CZ 1, CZ 2	203,520	131,260	64%
Total		2,627,990	1,479,861	56%

Source: BRACE_Air Conditioning_727_CO_RE_CA.xlsx, https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx

More detailed information about the typical home configurations for both single family and multifamily dwellings can be found in Appendix B.

Table 6 below highlights energy efficiency measures that were simulated to understand the effect they had on indoor environments. A description of each measure is provided below the table.

Table 6. Simulated Measures by Home Type

	Single Family	Multifamily
Shading	✓	✓
Exterior Paint	✓	✓
Radiant Barrier	✓	Not simulated
Attic Insulation	✓	Not simulated
Attic Ventilation	✓	Not simulated
Cool Roof	✓	Not simulated
Windows	✓	✓
Wall Insulation	✓	✓
Air Sealing	✓	Not simulated
Ceiling Fan	Not simulated	✓
Whole House Fan	✓	Not simulated
Heat Pump Space Heating	✓	✓

- **Shading:** Shading measures can be represented by either interior shades or exterior awnings. Shades work by reducing the amount of solar heat gain that enters the home. The single family simulations model a shading coefficient (SC) of 0.25, reflecting a reduction in solar heat gain of 75%. Shading devices are independently rated by the Attachments Energy Rating Council (AERC) and provide Solar Heat Gain Coefficients (SHGC) for both interior and exterior shading devices.[9] An attachment with a SHGC rating of 0.22 would give an SC of approximately 0.25, like the Alustra Duette Honeycomb Light Filtering cellular shades by Hunter Douglas. Other possible shading options can be found on the AERC product search website, with additional details provided in Appendix C. [10]
- **Exterior Paint:** Exterior paint with lower solar absorption ratings (or high solar reflectance ratings) are designed to reflect sunlight away from exterior walls before it can be absorbed. The simulation models a solar absorption of 0.5. (White paint almost always has a solar absorption under 0.5, but some colored paints can also have a solar absorption of 0.5). More details can be found about exterior paint in Appendix C.

[9] The SC and SHGC are similar concepts. The SHGC represents the heat gain from the entire window (glass and frame) while the SC calculates heat gain from only the glass portion, excluding the frame. The SC is often approximated as SHGC ÷ 0.87.
[10] https://aercenergyrating.org/product-search/residential-product-search/

- **Radiant Barrier:** Like exterior paint, radiant barriers (generally installed in attics) reflect heat away, preventing heat transfer from one side of the barrier to another and keeping the space cooler.
- **Attic Insulation:** Attic insulation measures provide resistance to heat flow (i.e., it takes longer for heat or cold to make it to the interior space). The simulation models a cellulose, blow-in attic insulation rated as R-49. (R-49 is about 14" of insulation.)
- **Attic Ventilation:** Attic ventilation is important, as natural air flow in a well-ventilated attic helps to remove super-heated air. Older homes were typically built with a specific leakage area (SLA) of about 1:300 (1 ft^2 of ventilation for each 300 ft^2 of attic space). The simulation models the Title 24 requirements of an SLA of 1:150, a value that provides twice as much attic ventilation as many older homes.
- **Cool Roof:** Cool roofs are characterized by two parameters, solar reflectance (how much sun is reflected off the roof initially) and thermal emittance (how much heat a surface can release after heat is absorbed). High values for both solar reflectance and thermal emittance increases the ability of a roof to reduce heat gain in a building. The simulation models a cool roof with a solar reflectance (SR) of 0.5 and a thermal emittance (TE) of 0.9. While cool roofs may bring about images of white roofs, the Cool Roof Rating Council (CRRC) has rated many roofing products with an SR of about 0.5 and a TE about 0.9 in a variety of colors.[11]
- **Windows:** Windows reduce the amount of heat entering the house both by providing resistance to heat (designated by a U-value where a lower number is better) and by reflecting heat away from the window (the solar heat gain coefficient (SHGC), where a lower number is better). The model simulates a low-emissivity double paned window filled with argon gas, with a U-value of 0.34 and a SHGC of 0.3. (The 2022 Title 24 requirements for residential homes currently require windows with a maximum U-value of 0.45.)
- **Wall Insulation:** Like attic insulation, wall insulation provides resistance to heat flow. The simulation models an R-13 rated fiberglass batt wall insulation, the level of insulation that can be put into a typical wall with 2x4 studs.
- **Air Sealing:** Air sealing reduces the amount of air that leaks in and out of the home, and typically involves caulking and installing weatherstripping. Air sealing is often measured using a blower door test, specified as air changes per hour at 50 Pascals of pressure (ACH50). The simulation models a home with 5 ACH50, which is comparable to a "tight" home with a low level of air changes per hour. Further discussion about air sealing measure benefits can be found in Appendix C.
- **Whole House Fan:** A whole house fan is used when the temperature outside is less than the temperature inside and brings in cool fresh air from outside through open windows while pushing hot air outside through the attic. These large fans are typically only used for short periods in the evening or nighttime. The simulation models a 350W fan capable of moving 4,200 cubic feet of air per minute (CFM). More about whole house fans compared to other ventilation and attic fans can be found in Appendix C.
- **Heat Pump:** Heat pumps provide both heating and cooling in a single integrated system. Our single family simulations model 3-ton central air source heat pumps (i.e., the heat pump has ducting to bring cooling and heat to all rooms in the home) with a SEER2 rating of 15.2 and an HSPF2 rating of 7.6. Multifamily simulations model a 2-ton mini split heat pump (i.e., the heat pump does not have ducting and cooling and heating are provided directly into the space from the air handler in the space.) with a SEER2 rating of 18 and an HSPF2 rating of 8.6.[12]

The following sections discuss the effect that each of these measures individually has on the indoor environments and quantify the cumulative effect that these measures have on indoor environments (based on how each measure is added to the model). The results below are shown for Climate Zone (CZ) 3 and CZ 12,

[11] https://coolroofs.org/directory/roof

[12] SEER2 is a rating that indicates cooling efficiency while HSPF2 is a rating that indicates heating efficiency. Higher values for both show higher efficiency. In California, the SEER2 minimum is 14.3 and the HSPF2 minimum is 8.2.

which are the two BayREN climate zones with the most contrasting temperatures. The results for the remaining climate zones can be found in Appendix D.

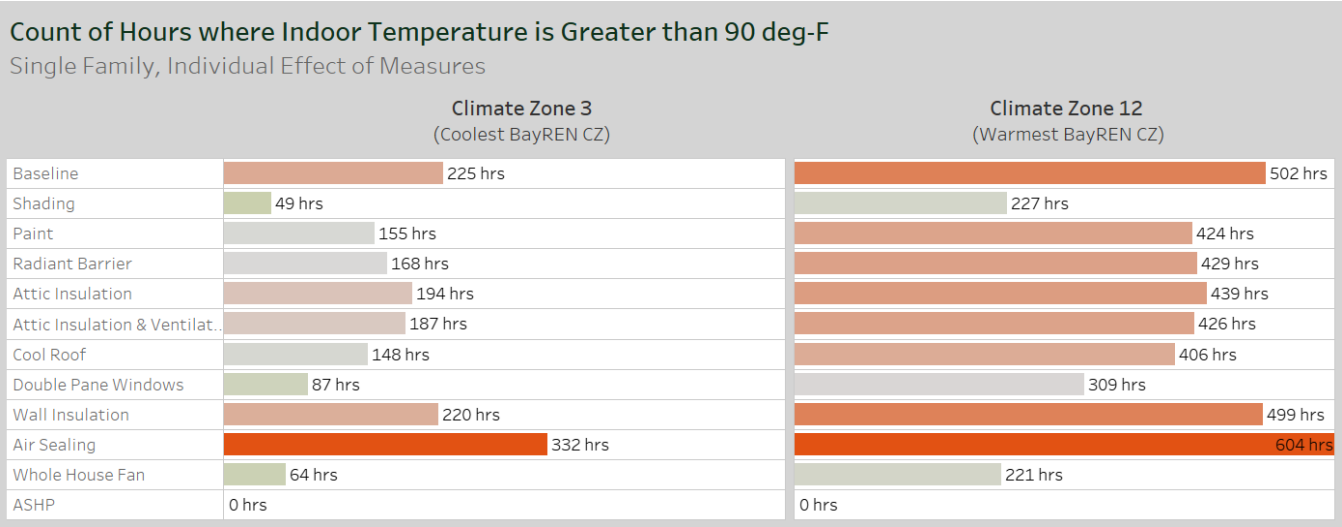
Single Family Homes

The individual effect of each of the 9 measures (shown in Table 6) simulated on a single-family baseline home is displayed below in Figure 3, for the two BayREN climate zones with the most contrasting temperatures. San Mateo San Francisco, and portions of Marin, Alameda, and Contra Costa Counties are represented by CZ 3, and reflect the milder of BayREN's climate zones. Solano County and portions of Contra Costa and Alameda Counties are in CZ 12, on the hotter end of BayREN's climate zones. Most of the simulated measures contributed to a substantial reduction in the number of hours where the indoor temperature was over 90°F.

The one exception was for air sealing as a single measure which was found to increase the indoor air temperature for a baseline unconditioned home. Air sealing is generally looked at as a package with other building shell and ventilation measures, which was not analyzed in this report. More information is in Appendix C.

The two individual measures that contributed to the largest reduction in the number of high-temperature hours were shading and whole house fans. As shown below, in CZ 3 (the coolest BayREN climate zone), the baseline single family home has 225 hours over 90° F and adding shading reduced that to 49 hours. In CZ 12 (the warmest BayREN climate zone), the baseline home had double the number of hours over 90° F (at 502 hours). In CZ 12, adding in shading or whole house fans reduced that to more than half the baseline hours (at 227 and 221 hours, respectively). In both climate zones, the addition of double pane windows also significantly reduced the number of hours over 90° F.

Figure 3. Individual Effect of Measures for Single Family Simulations in Two Climate Zones
(Count of Hours where Indoor Temperature is Greater than 90°F)



*Note: The color scheme ranges from the maximum number of hours in a year above 90°F **(orange)** to the minimum number of hours in a year above 90°F **(green)**. The color range is based on the maximum and minimum count of hours for each specific model and climate zone (in the CZ 3 model, the maximum and minimum counts range from 332 hours down to 0 hours, whereas in the CZ 12 model, the maximum count is 604 hours). This color scheme continues in similar figures throughout the report.*

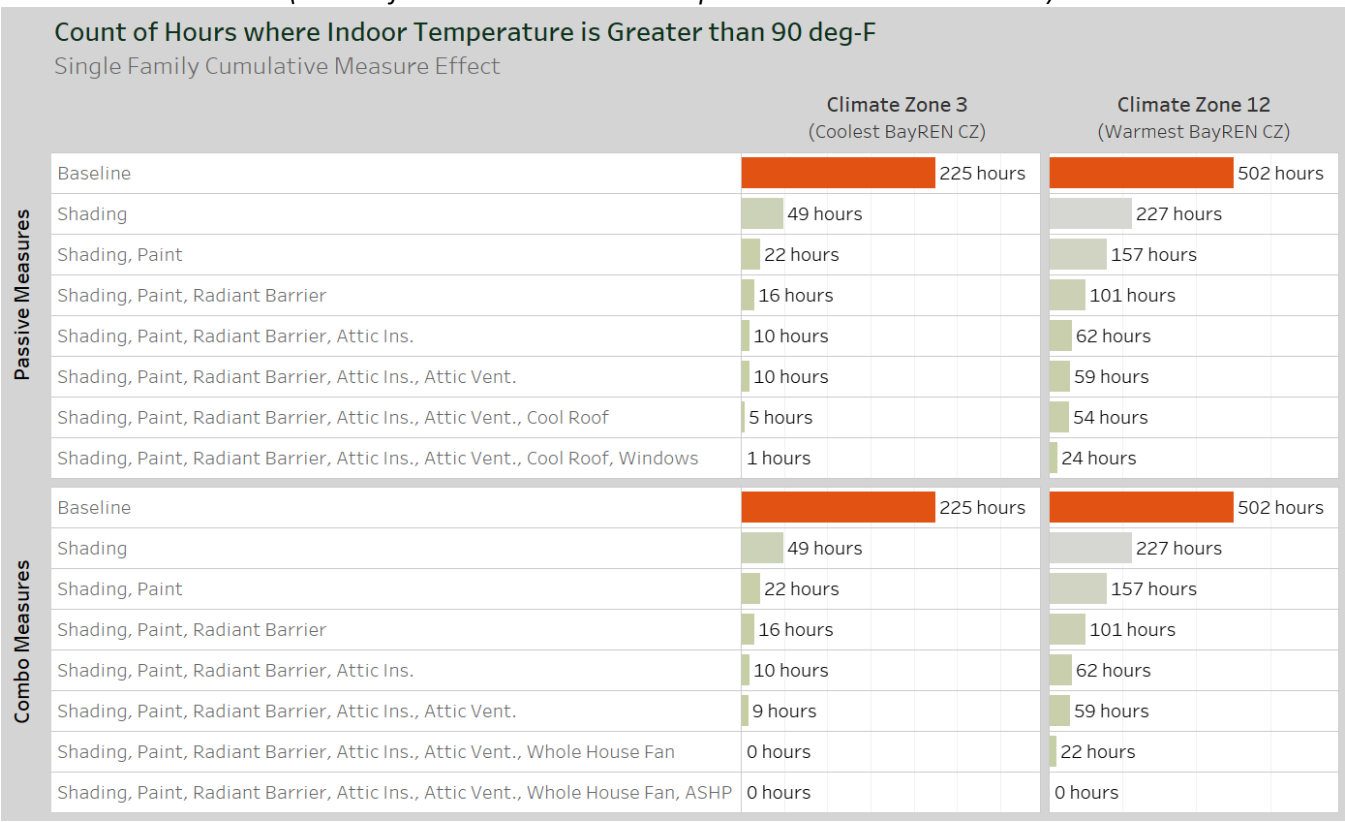
Based on the individual measure effects on indoor temperatures, the team selected several measures to model cumulative effects for a set of passive measures and a combination set of measures (both passive measures and mechanical measures). The purpose of the **passive-only simulation** was to determine if it would be possible to reach an indoor livable environment without the addition of energy load from a fan or a heat pump. The **combination simulation** included whole house fans or heat pumps and the passive measures that may be more economical, realizing that cool roofs and windows replacements may be quite costly.

The cumulative simulation results are displayed below in Figure 4 for the same two climate zones presented for the individual measure analysis. In the milder CZ 3, the passive measure simulation results suggest that without the use of air conditioning, a typical single family home can achieve an indoor livable environment without the use of mechanical cooling measures for all but one hour in a year. However, the passive measure simulation results for the hotter CZ 12 show that the home's residents may see 24 hours in a year above 90°F. Removing the most expensive measures like windows, and cool roofs, and replacing them with mechanical whole house fans (the combination simulation), provides similar results to the passive measure simulations. That is, the combination simulation with the whole house fan maintains the home's temperature below 90°F for single family homes in CZ 3 while estimating that homes in the hotter CZ 12 will annually experience 22 hours above 90°F. To ensure that a home in CZ 12 remains below 90°F, air conditioning is required (modeled here as an air source heat pump).

As noted above, the combination simulation includes a whole house fan and a heat pump to ensure a livable indoor temperature below 90°F. Whole house fans were found to increase energy usage between 120 and 180 kWh across the four different climate zones, while air source heat pumps were found to add an additional 190 to 680 kWh. The annual energy consumption for the different cumulative measures can be found in Figure 14 in Appendix D.

Figure 4. Cumulative Measure Effect for Single Family

(Count of Hours where Indoor Temperature is Greater than 90°F)



While this analysis has shown that each measure, installed individually, may have a measurable impact on the indoor temperature, understanding the stacked effect of multiple measures provides insights into measures whose cumulative impact may not be as substantial.

The combination of measures that had the most substantial effect on reducing indoor air temperature for both passive-only measures and combination measures are shown below in Table 7.

Table 7. Single Family Cumulative Measures with the Greatest Impact on Indoor Environment

	Passive-Only	Combination
Shading	✓	✓
Exterior Paint	✓	✓
Radiant Barrier	✓	✓
Attic Insulation	✓	✓
Attic Ventilation	×	×
Cool Roof	×	Not simulated
Windows	✓	Not simulated
Whole House Fan	Not simulated	✓
Air Source Heat Pump	Not simulated	✓

For example, Figure 4 above shows that combining Attic Insulation, Attic Ventilation, and Cool Roofs does not provide substantially more reduction in indoor temperature than can be achieved with only one of these three measures. A well-insulated attic should significantly slow down the rate of heat transfer from a hot attic into the conditioned space below. Cool roofs and increased attic ventilation should cool down an attic itself, but if an attic is well insulated, the effect of cool roofs and increased attic ventilation are reduced. For single family homes, multiple measures are needed to significantly reduce indoor air temperatures in the home.

Multifamily Homes

Based on our knowledge of the differences seen by where a unit is located, the team simulated two multifamily units – (1) a ground floor, middle unit has a slab floor and shares both side walls with neighboring units; and (2) a mid-floor corner unit which only shares the one side wall with a neighboring unit. Corner units receive more solar heat gain due to the additional exterior walls than middle units, and therefore see significantly higher indoor air temperatures. Ground floor units also receive a higher rate of temperature transfer through the slab, helping them to stay cooler than mid-floor units. These two multifamily scenarios, therefore, show substantial differences in indoor temperatures, with the ground floor, middle units seeing only a fraction of the hours above 90°F that mid-floor corner units experience (see Figure 6). Multifamily homes are modeled as individual units (not the entire building), so we did not include attic and roof-related measures in the analysis.

The individual effect of each measure, simulated on a baseline multifamily middle unit home is displayed below in Figure 6, for the two climate zones with the most contrasting temperatures among the BayREN counties. Many of the simulated measures provided a substantial reduction in the home's annual hours over 90°F. Wall insulation and ceiling fan measures, however, were ineffective at reducing indoor temperatures. A detailed description of the impact of wall insulation measures can be found in the sidebar. Ceiling fans help to circulate air throughout a room, causing a draft. They can improve occupant comfort because they increase the rate of evaporation of sweat from a body. However, from the perspective of indoor air temperatures, a ceiling fan will add energy into the room, thereby increasing the indoor air temperature.

Wall Insulation Measures and Heat Gain in Multifamily Units

Wall insulation provides resistance to heat flow, increasing the length of time it takes for solar radiation to penetrate the home and increase the temperature of the home. However, insulation works in reverse as well. When the home is warmer on the inside than the exterior temperature, insulation traps heat inside and slows the time for that heat to move outside. The simulation shows a slight increase in nighttime temperatures due to the additional wall insulation because heat inside the home takes longer to escape. This is displayed in Figure 5 below, which highlights the indoor temperature of the simulated baseline home (**in black**) and the home with wall insulation measures (**in orange**) for three summer days. The highlighted bars show the nighttime hours when the difference between the wall insulation simulation and the baseline simulation is noticeable.

Figure 5. Baseline vs. Wall Insulation Measure Simulated Indoor Temperatures

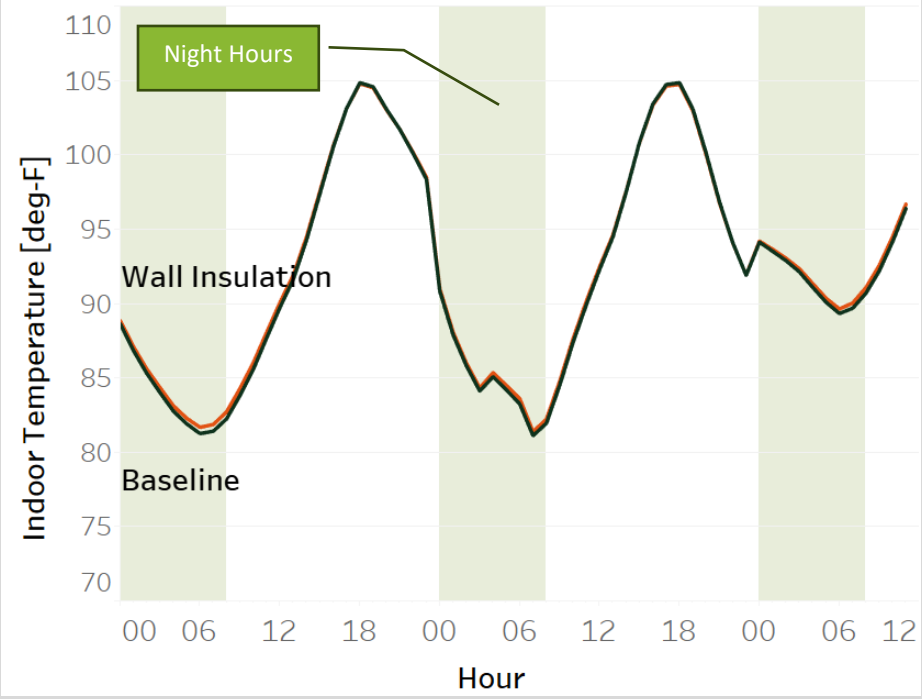
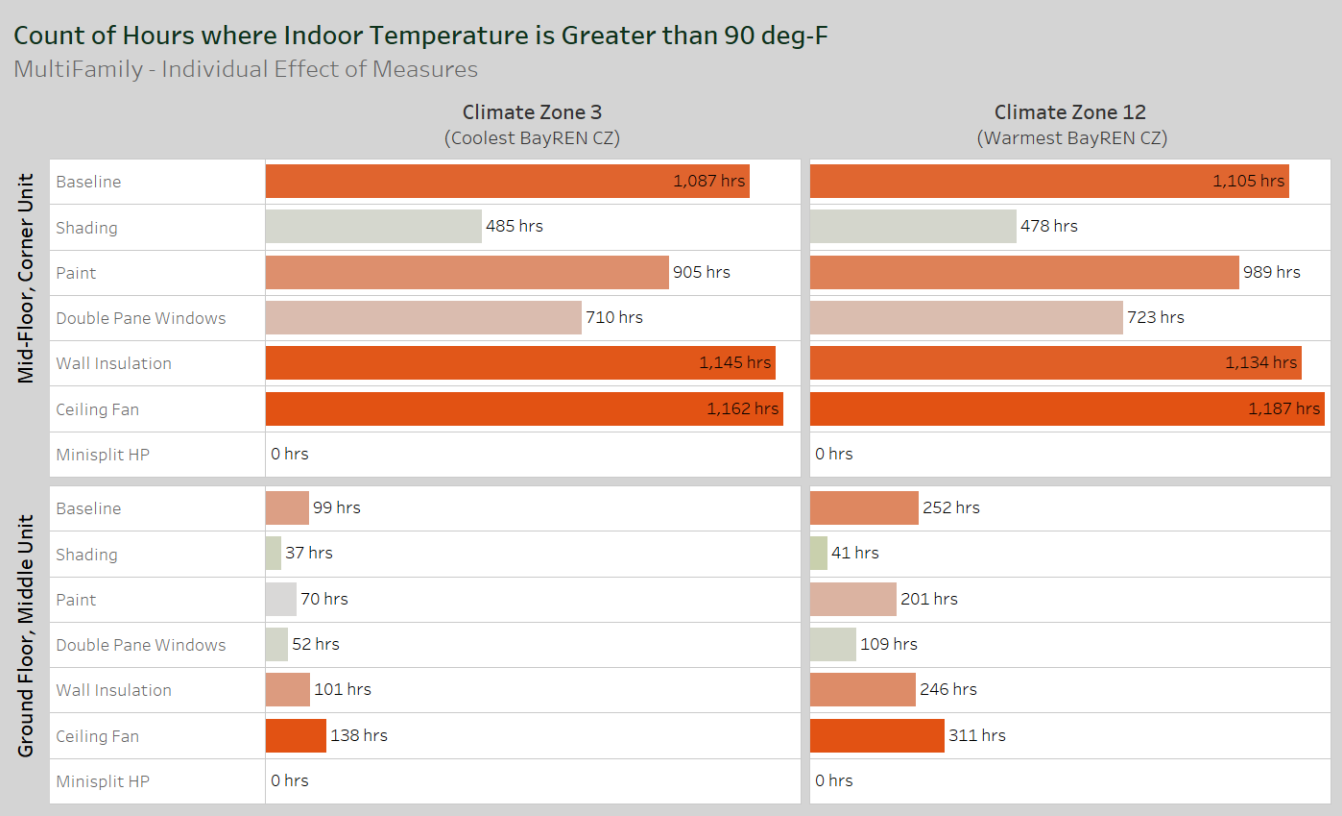


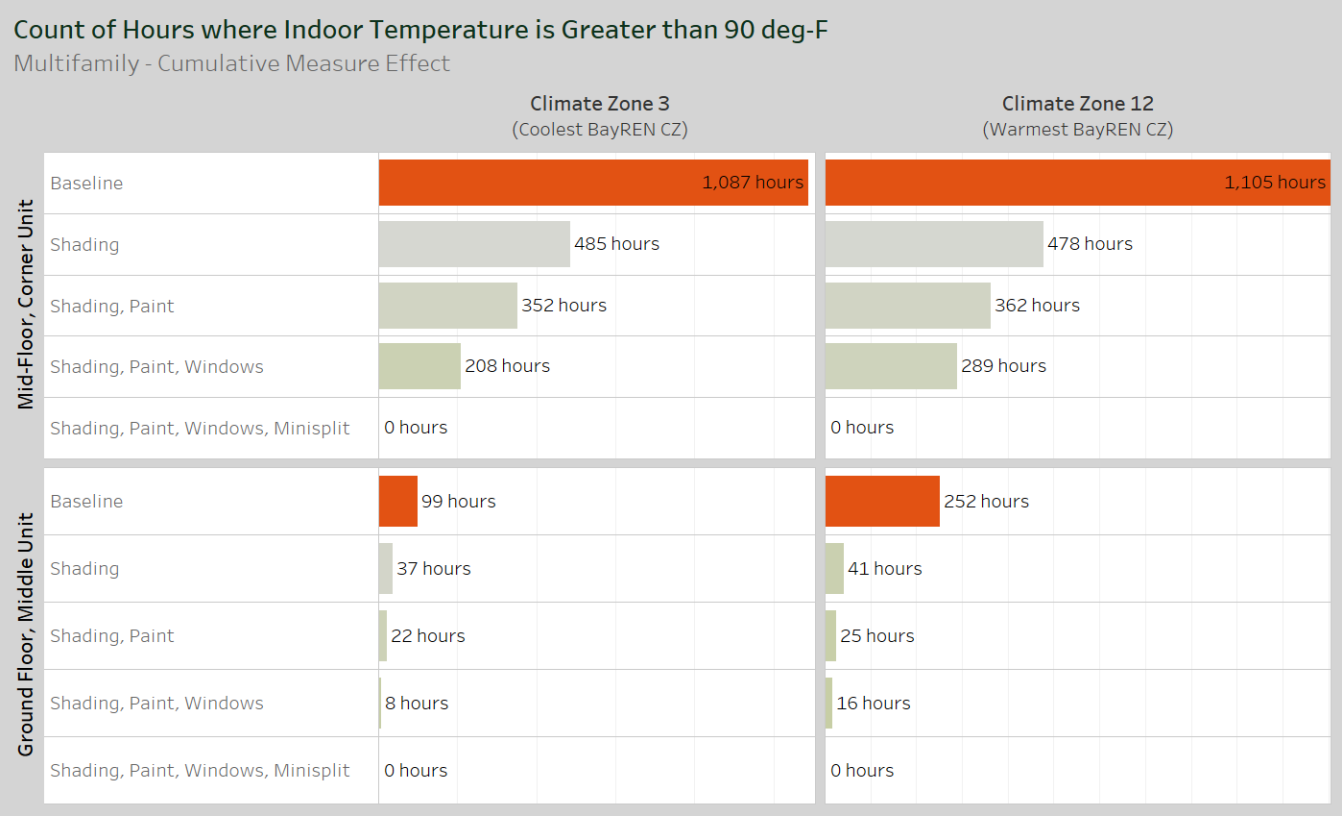
Figure 6. Individual Effect of Measures for Multifamily Simulations
(Count of Hours where Indoor Temperature is Greater than 90°F)



The cumulative simulation results of these measures are displayed below (in Figure 7) for the same two climate zones. The mid-floor, corner units have a much harder time rejecting heat and see a much higher share of solar radiation than the ground-floor middle units, therefore the simulations show a substantial number of hours above 90°F without the use of mechanical cooling (mini split heat pumps in this analysis). The ground-floor middle units, on the other hand, start out with a much smaller number of hours above 90°, and are estimated to have 8 to 16 hours per year above 90°F with only passive measures in both the milder CZ 3 and the hotter CZ 12, respectively. The use of mini split heat pumps to reduce the indoor temperature to 90° increases the energy usage of the house between 20 and 50 kWh.

As described above, for multi-family units, the location of the unit matters when considering heat issues. Because many programs seek to serve the entire building, and not just specific units within a building, it may be crucial to ensure that air conditioning is included in any intervention so that heat mitigation can occur regardless of location within the building.

Figure 7. Cumulative Measure Effect for Multifamily Simulations
(Count of Hours where Indoor Temperature is Greater than 90°F)



What programs are already helping create livable indoor environments for residential homes?

Much of the literature on heat mitigation describes local government actions that support society as a whole more than individual households. For example, local government heat mitigation strategies often revolve around reducing the effects of urban heat islands through tree planting, cool roofs, cool pavements, and built shade structures. (US EPA, 2023) While these can eventually help with the interior temperatures of homes, they are not directly serving households like the typical energy efficiency program (except for cool roofs).

However, we did find that California local governments are very active in helping to ensure their constituents understand heat emergencies. Multiple websites we reviewed included information to recognize when one is beginning to have physical signs due to heat as well as tips to reduce the likelihood of harm due to extreme heat.

Additionally, California has an action plan to build community resilience (California Natural Resources Agency(b). 2022) with four specific areas of focus:

- Build Public Awareness and Notification
- Strengthen Community Services and Response
- Increase Resilience of Our Built Environment
- Utilize Nature-Based Solutions

Based on this action plan, funding will be available in 2024 to public entities, California Native American tribes, community-based organizations, and non-profits to focus on heat mitigation programs. (Governor's Office of Planning and Research, 2023 and https://arccacalifornia.org/grant-tracker/).

California Programs Available to Households in BayREN Service Territory

Our research found no programs in the BayREN territory that specifically targeted heat mitigation or indoor environments.[13] However, there are 27 organizations offering 35 energy efficiency programs that may be available to households within BayREN service territory that include measures that can be utilized to mitigate heat in residential dwellings. Table 8 below highlights the number of programs, by measure and incentive types, which may be available to customers in BayREN territory, separated out by statewide programs vs those that are only available in local jurisdictions. A full list of the programs can be found in Appendix E, again separated out by statewide and local programs.

Many energy efficiency programs emphasize weatherization, building envelope improvements, and cooling-related measures.[14] Notably, only one program available to homeowners in BayREN's territory was geared towards planting trees for home shading. In addition to energy efficiency programs the team also reviewed home repair programs that may be available to BayREN's customers. While these programs were not focused on heat mitigation or energy efficiency measures, some incorporated elements related to "health and safety," with a few including windows, roofs, and exterior paint, the implementation of which could potentially enhance indoor environments and address heat mitigation.

The energy efficiency initiatives primarily offered instant rebates (coupons enabling customers to buy measures online at a reduced cost) or mail-in rebates, which are either sent directly to the customer or to the contractor. Grant programs were exclusively income-eligible (low income) repair programs, typically funded by state or local governments. In addition, some programs provided services like weatherization, enhancing the building envelope, installing smart thermostats, and upgrading HVAC systems. Several programs offered loans for energy efficiency enhancements, while some federal programs provided incentives in the form of tax credits. Table 8 below highlights the count of programs both by the end uses they offer and by the incentive types they offer. Many programs offer incentives for multiple end uses, and several programs offer multiple incentive types.

Table 8. Count of Potential Programs Available to BayREN Customers, Statewide vs. Local

	Statewide	Local
Count of Programs by End Use ***(one program may offer multiple end uses)***		
Cooling (HVAC)	5	9
Insulation	5	6
Repairs	2	7
Thermostats	2	2
Weatherization	3	5
Whole House	5	1
Other	1	2
Count of Programs by Incentive Type ***(one program may offer multiple incentive types)***		
Rebate	5	9
Grants	1	2
Free Measures	3	3
Financing	4	9
Tax Credit	1	0

[13] There may be a Heat Resiliency Pilot Program in Redwood City, San Mateo County, but no public information about the program could be tracked down.

[14] Examples of these include air sealing, caulking, attic insulation, HVAC measures, etc.

The team also examined the target audience of the programs, categorized by housing type (single family or multifamily) and income status (inclusion of an income-eligible segment). Most programs primarily cater to single-family homes. However, there were 11 distinct programs that were exclusively designed for multifamily properties or included a component tailored to multifamily property owners or tenants. Additionally, there are 6 programs for multifamily income-eligible customers and 19 programs for single family income-eligible customers that were either exclusively available or featured a component providing extra rebates to such customers. Table 9 provides an overview of the number of programs categorized by end-use and their availability to various customer and dwelling types.

Table 9. Count of Potential Programs with Incentives Available to BayREN Customers
(one program may offer multiple end uses)

	Single Family		Multifamily	
End Use	**Incentives for any Income**	**Income Eligible Incentives**	**Incentives for any Income**	**Income Eligible Incentives**
Cooling (HVAC)	12	5	6	3
Insulation	8	5	5	4
Repairs	9	9	0	0
Thermostats	4	1	1	0
Weatherization	6	2	3	1
Whole House	4	3	5	2
Other	3	1	0	0

Many of the measures identified as effective heat mitigation measures were largely missing from energy efficiency-programs. Only a single program, the PACE Home Run Financing program, specifically offered roofing as a qualified measure, and although several repair programs highlighted roofing as a potential measure, it is unclear whether cool roof rated projects would be eligible for incentives. No programs were identified in BayREN's territory that specifically offered incentives for whole-house fans, interior or exterior shading devices, radiant barriers, or exterior paint. In California, incentives for whole house fans and exterior window solar screens were found in energy efficiency programs in Southern California, but these incentives are inaccessible to residents within the BayREN service territory. (See Appendix E for links to Southern California programs with exterior solar screens or whole house fans.)

The identified home repair programs were typically geared towards income-eligible and senior residents and often included aspects of roofing repair, HVAC replacement, building envelope, and other measures emphasizing health and safety of occupants. Some of these programs offered grants, most offered low interest or no-interest loans, and there was one organization, Rebuilding Together, that provides direct repair assistance to bring homes up to safe and healthy living conditions.

Programs Outside of California

Cool roof programs were put in place several years ago in Chicago, Pennsylvania, Houston, and Austin, but are no longer being implemented. (US EPA, 2008).

Phoenix, however, has two current programs related to heat mitigation. According to a 2019 article in Scientific American, "Phoenix has launched two revolutionary initiatives: HeatReady—the nation's first program of its kind—treats heat readiness like hurricane readiness and heat waves like temperature tsunamis. It will alert residents with text notifications and offer emergency cooling centers. Another project, Nature's Cooling Systems, is redesigning those low-income neighborhoods hit hardest by heat to remove some of the sting." (Cornelius, 2019)

The Phoenix HeatReady plan includes a multi-prong set of 31 programs, six of which support "cool and safe home environments". (City of Phoenix, 2023) Two of these six programs are likely to create a livable indoor environment:

- Programs *likely* to create livable indoor environments
    - Cooling ordinances to require rental housing units with maximum temperatures (i.e., 86 F if cooled using evaporative cooling and 82 F if using regular air conditioning).
    - Housing repair and weatherization program.
- Broad programs that *could* support livable indoor environments
    - Landlord tenant program to spread the word on tenant rights, including those related to cooling.
    - Emergency utility assistance to help with utility costs.

Outside of the Phoenix programs, and not specific to buildings, another Arizona program is Nature's Cooling Systems (NCS). NCS is a partnership between The Nature Conservancy, Arizona State University, and the Maricopa County Department of Health. NCS seeks to green areas to mitigate heat with plants and has created a Virtual Urban Heat Leadership Academy to "equip community residents in Greater Phoenix with the knowledge, resources and skills to mobilize their communities and advocate for greener, cooler, and healthier neighborhoods." (The Nature Conservancy of Arizona, 2022)

Boston has created a set of strategies of heat reliance solutions (Boston, 2022), five of which are specific to buildings. Two of these five strategies appear to be up and running. The first is their partnership with Mass Save (the state of Massachusetts energy efficiency programs) where they are seeking to achieve 600 heat reliance related projects per year in environmental justice communities (these communities are specific areas described in the Boston strategies document).[15] The second is the Cool Schools strategy which aims to integrate appropriate resilience investments into City-owned buildings with the Renew Boston Trust (RBT). RBT is an existing initiative that conducts energy audits and installs energy conservation measures in municipal buildings. As of April 2023, RBT was installing lighting and HVAC in nine schools, one police station, and City Hall as well as new solar arrays.

While not a specific program (and regardless of location), for any building that is attempting LEED certification (new or existing), the U.S. Green Building Council seeks to keep buildings survivable during power outages. As contractors pursue LEED building certification, they can earn two pilot credits for application of specific options around safe thermal conditions during extended power outages. [16]

Power Outages, Portable and Permanent Power, Available Power Programs

Power outages during times of high heat are difficult for any household and even worse for vulnerable populations noted above in Table 2. Weather events spurred by long durations of high temperature, with low humidity and gusting winds, can lead to power outages due to wildfire risk within California. These conditions pose a threat, not only to the electricity transmission and distribution system but, more critically, to vulnerable communities and populations experiencing the high heat in wildfire prone areas. In 2018, the California Public Utilities Commission (CPUC), in collaboration with CAL FIRE and other public safety authorities, established a High Fire-Threat map to pinpoint areas at extreme or elevated risk of wildfires. The CPUC also expanded on earlier regulations by granting electric utility companies the authority to shut down portions of the electric grid in response to wildfire threats, in what is called Public Safety Power Shutoff (PSPS) events to mitigate potential wildfires caused by electrical infrastructure.

In the period spanning from September to December of 2020, wildfire threats materialized, resulting in extended power outages from PSPS for hundreds of thousands of electric customers, at times lasting for days. Most BayREN counties contain segments designated as Tier 1 High Hazard Zones and many customers likely experienced a wildfire mitigation outage or PSPS event from 2019-2021. Luckily, milder temperatures and above

[15] The Mass Save program projects will emphasize participation by renters, low-to-moderate income, English-isolated residents, and small businesses. Additionally, Boston expects to use existing data under the Building Energy Reduction and Disclosure Ordinance to identify and engage with large multi-family affordable residential buildings with higher energy use.
[16] LEED buildings have compliance paths to meet two options and obtain points. Option 1: Provide for Passive Survivability (thermal safety). Option 2: Provide backup power for critical loads.

average rainfalls have contributed to fewer PSPS events being called in the last two years (e.g., PG&E experienced no PSPS outages in 2022). However, the risk remains because climate change and naturally occurring weather events like La Niña (which bring about very dry conditions) will require continued wildfire mitigation as well as adaptation to challenges. In addition, California could face power outages after an earthquake.

Passive building measures such as shading and cool roofs would continue to function during a power outage, and as described above, for some housing types in some climate zones, these could be enough to prevent high indoor temperatures. For other types of housing and other climate zones, however, mechanical cooling is needed. To keep those functioning during a power outage, portable or permanent power would be needed.[17]

Portable and Permanent Power

To overcome a loss of power during PSPS or other during events where the grid is not available, households can use electricity that comes from portable or permanent power to continue to use a window air conditioner or a central air conditioner. Portable or permanent power can be stored within a battery or generated by a different fuel. (Table 10)

Table 10. Categories of Residential Electricity Back-up

Category	Description
Portable Power	Portable power is accessed typically by other equipment through plugging into the portable power equipment (also see battery transfer meter information below under PG&E programs). It is smaller, moveable equipment that either depends on the grid or photovoltaic system at some point or uses a different fuel to create power. • Battery based (storage)- typically lithium ion batteries that must be charged from the grid or a small photovoltaic system before use • Generator based - gasoline/diesel/propane is used within the equipment to create power when needed
Permanent Power	Permanent power is tied directly into the home electric panel. It is larger, non-moveable equipment that either depends on the grid at some point or uses a different fuel to create power. • Battery based (storage) - typically lithium ion batteries that must be charged from the grid or a photovoltaic system before use • Generator based – natural gas/diesel/propane is used within the equipment to create power when needed

There are pros and cons to each category of back-up power, especially when considering their use to mitigate heat within a home. (Table 11)

Table 11. Pros and Cons of Residential Electricity Back-up Categories and Use to Mitigate Heat

Category, Pro/Con	Battery Storage	Generator
Portable Power		
Pro	• No emissions • Silent • Can be used inside • Relatively low cost	• Unlimited time that can be used if have appropriate fuel to power the generator • Relatively low cost • A window air conditioner could be plugged into an appropriately sized generator

[17] Households that have solar generation tied to the grid typically cannot use the power from the solar when the grid is offline (due to safety issues when the grid resumes power). When the grid is offline, a household with solar and battery back-up, if configured appropriately, could use the solar system to charge the battery and use power from the battery.

Category, Pro/Con	Battery Storage	Generator
	• A window air conditioner could be plugged into an appropriately sized battery	• Could run a house (and so an HVAC system) if the home has a PG&E transfer meter (discussed further below the table under PG&E programs)
Con	• Must be charged before use, so may not be available if the outage is sudden and the battery has not been kept charged • Limited hours that the battery can be used before needing to be recharged (time is dependent on the equipment that is plugged into the battery)	• Must be used outside • Has emissions when in use • Can be noisy • There may be local or state ordinances regarding emission or sound levels • Must have a place to store fuel when not in use • Difficult for some households as one should locate the generator at least 25 feet from a home for safety (per PG&E website) and not all have the space (e.g., could be an apartment on the third floor) • Extension cord must be able to be brought into the home, leaving a gap where heat can enter
Permanent Power		
Pro	• No emissions • Is generally ready when needed • Relatively silent (may have slight noise, e.g., the Tesla Powerwall has noise from a pump and small fan that keep the battery cool) • Dependent on how the battery system is set up. Could run the entire panel (and so the entire house) or could run only certain circuits that may or may not include the HVAC system.	• Unlimited time that can be used • Can run the whole house. If appropriately sized, will run any window air conditioner or HVAC system. For example, a 26 kW natural gas generator (~34 brake horsepower, BHP) can provide electricity for a home that includes a 5-ton central air conditioner.
Con	• May require initial building permit, which adds cost and time to install • Dependent on the battery and HVAC system specifications, the battery may not be able to run the HVAC system (insufficient power from the battery to manage power requirements from the HVAC) • Limited hours that the battery can be used before needing to be recharged (time is dependent on the household electrical draw from the battery) • High cost	• May require initial building permit, which adds cost and time to install • If equal to or over a certain size (50 BHP), the Bay Area Air Quality Management District requires permits, which adds cost and would need to be renewed annually.[18] • Has emissions when in use (e.g., greenhouse gases and particulates) • Can be noisy • High cost

Available Programs for Portable or Permanent Power

Bay Area customers have a few programs that could help with the costs of portable or permanent power systems.

[18] https://www.baaqmd.gov/permits/apply-for-a-permit/engine-permits/psps

Batteries and SGIP. The CPUC's Self-Generation Incentive Program (SGIP) is designed to incentivize and support various distributed energy resources, both existing and emerging. In recent years, the program has primarily focused on providing incentives for residential and non-residential permanent battery storage technologies[19]. In September 2019, the CPUC issued Decision 19-09-027, which introduced an SGIP equity resiliency budget to address the urgent needs stemming from wildfire risks in the state. This allocation of funds is specifically designated to assist vulnerable households located in Tier 2 and Tier 3 high fire threat districts. In 2020, energy storage systems paired with on-site solar PV were particularly effective at providing long duration customer resiliency.[20]

Customers may be able to access a statewide program to help offset costs associated with permanent battery back-up power that uses the grid or solar to charge the battery. SGIP has decreasing incentives as the program steps through available funds. As of December 2023, PG&E customers were at Step 7 with $0.15/kWh incentive for small residential storage systems and ~$2 million in available funds. Additionally, $0.85/kWh is available for small residential storage in equity areas[21] and ~$18 million available in funds.[22]

PG&E Programs. PG&E also offers two energy storage incentive programs and a power transfer meter program.[23] The "Permanent Battery Storage Rebate" program provides incentives to eligible customers for battery storage, and the "Residential Storage Initiative" offers free permanent battery storage systems to individuals most vulnerable in high-risk areas. PG&E also has a "Backup Power Transfer Meter Program" where eligible PG&E customers can receive a free backup power transfer meter. A transfer meter includes additional technology that allows an appropriate generator to be plugged directly into the panel to energize the home when the grid is down. Eligibility is based on location (live in a certain area that has high fire threat)[24] and/or by powerline capabilities (e.g., the powerline to the home can be shut off within 0.1 seconds). The meter must a specific type of meter (a 2S-socket meter)[25] and the site must have access to a specific generator as well.[26]

The PG&E website indicates that the "Backup Power Transfer Meter Program" was fully subscribed for 2023, but they will open the program again in 2024.

Other Opportunities. The Investment Tax Credit recently created a qualifying category for energy storage systems that did not have to be paired with solar. Additionally, Bay Area SunShares (administered by the Business Council on Climate Change) is available to all Bay Area residents and offers a discount on solar and

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[19] While battery storage technologies are the primary method of energy storage, thermal energy storage systems are also available in both residential and non-residential applications and are available for SGIP incentives. However, these products are generally designed to shift traditional peak loads like cooling into off-peak periods, and still require energy to operate.

[20] In 2020, 21 percent of SGIP participants in the Pacific Gas and Electric (PG&E) service territory experienced a PSPS events. The average duration of these outages was approximately 35 hours (equivalent to 1.5 days), with the lengthiest event in September that lasted 115 hours (nearly 5 days).

[21] Residential customers must be in a high fire area, have experienced >=2 PSPS events and be eligible for the equity budget through several options (e.g., certain income, medical needs, etc.). All requirements are outlined in the Residential Equity Resiliency Eligibility Matrix document here: https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpucwebsite/content/news_room/newsupdates/2020/attachment-a-sgip-equity-resiliency-eligibility-matrix-for-residential-customers-version-3.pdf

[22] Incentives and funds available in PG&E service area as of 12/14/23 at this site: https://www.selfgenca.com/home/program_metrics/

[23] https://www.pge.com/en/outages-and-safety/outage-preparedness-and-support/general-outage-resources/generator-and-battery-rebate-program.html.html and https://www.pge.com/en/outages-and-safety/outage-preparedness-and-support/general-outage-resources/residential-storage-initiative.html#tabs-eaa85f7c5f-item-779fcb001d-tab

[24] There are many areas within the nine Bay Area counties that are in Tier 2 or Tier 3 high fire threat districts.

[25] We could find no data on how many residential meters already include this type of meter.

[26] A 30 amp, 120V/240V with a standard National Electrical Manufactures Associated L14-30P plug portable generator with overcurrent protection.

storage options.[27] Discounts are offered in the fall of each year and for 2023, are no longer available (discounts were offered September 1 – November 15, 2023).

There are other offers within limited geographic areas:

- Medical baseline customers in Alameda County served by Ava Community Energy (Ava, previously East Bay Community Energy) can receive up to $1,000 for a portable backup battery. Ava has a fully enrolled resilient home program (i.e., they are no longer taking applications) that combined solar and battery storage.
- While not specific to outages, MCE provides a credit of up to $20/month for customers with solar and permanent batteries that discharge the battery from 4-9 pm daily.
- Silicon Valley Independent Living Center is coordinating various programs for those who depend on power for durable medical equipment or for their livelihood and has a program that provides access to backup portable batteries.[28]
- Silicon Valley Power is offering a pilot program to provide rebates for permanent battery storage systems. Batteries must be integrated with a solar photovoltaic (PV) system and must be installed through the Bay Area SunShares program (see above).[29]

If BayREN wants to provide back-up systems to help mitigate heat during power outages, more detailed research may be needed to determine specifications that may meet a program's requirements (e.g., size of battery storage or generator, electric capabilities such as amperage).

Conclusions

While extreme heat is a major topic of conversation within California, we could find no publicly published details on heat mitigation programs within BayREN's territory. Many of the available energy efficiency and home repair programs push for electrification or improvements in health and safety. The lack of programs explicitly focused on heat mitigation is startling given that close to at least 1.7 million Bay Area residents are at risk for heat emergencies and highlights a need for specific types of intervention within the Bay Area.

Our research found that heat mitigation and energy efficiency can act almost hand-in-hand, demonstrating that reducing the most extreme temperatures in homes can be accomplished, in most cases, with little use of mechanical cooling or fan measures. Installing passive heat mitigation and energy efficiency measures can help to achieve livable indoor temperatures while reducing the need for mechanical cooling. Passive measures will also help to maintain or reduce energy bills for California's most at-risk population while limiting grid stresses.

While measures like insulation, weatherization, and air source heat pumps are generally available through existing efficiency programs, other measures that demonstrate significant impacts to reduce indoor temperatures, like exterior paint, shading, radiant barriers, and whole house fans are not often seen within energy efficiency incentive programs available to BayREN's customers. Energy efficiency programs in areas that are traditionally hotter, like Southern California, do offer some of these types of measures. As the temperatures in Northern California rise, the need for heat mitigation and these measures will also increase.

The CPUC and local governments are taking actions to provide portable back-up batteries for use when the power goes out. At this point, the local government programs generally focus on customers that use electric devices for medical reasons. In at least one case, a community based organization is the conduit for such a program and begins to show the possibilities of how to move information and products into the homes of those most vulnerable to extreme heat.

[27] https://www.bayareasunshares.org/
[28] https://svilc.org/ddar-information-resources/
[29] https://www.siliconvalleypower.com/residents/rebates-6214

If BayREN chooses to move forward with a heat mitigation pilot, they will need to gather additional information to help design such a pilot and understand various opportunities. Potential additional design information includes:

- Modeling details of the interactions of energy use, heat mitigation, and packages of measures. This study focused on indoor air temperature only and did not simulate energy savings to provide information about both energy savings and heat mitigation for various (or combination of) measures.[30]
- Closely related to the bullet above, BayREN would most likely want to know specifics about energy savings measures and whether they could "claim" energy savings using the various platforms available (i.e., deemed or custom measures, Normalized Metered Energy Consumption approach) or if savings from products like windows may not be able to be claimed.
- More detailed information about possible portable or permanent back up power. This study provides high level information but including back up power within a program would need further research.

The study highlighted a few opportunities that BayREN may want to explore as well.

- Exploring partnership with other energy efficiency programs to bring heat mitigation efforts that BayREN could support into other programs.
- Pursuing grants such as those provided by California's Climate Resilience Package (application launch for $25 million in grants expected sometime from January to March 2024).
- Supporting local ordinances that set maximum temperatures within rentals.
- Steering customers towards back up power programs such as PG&E programs or SGIP, if not a part of a BayREN program.

[30] We specifically recommend investigating the relationship of energy and indoor temperature for air sealing combined with other measures when there is an existing HVAC system. We did not include air sealing measure in our analysis due to the results of increased indoor air temperatures when there was no mechanical cooling in the home.

Appendix A – Details on Historic and Forecast Weather Temperatures and in our Simulations

The research team made choices, in consultation with the BayREN project team, on which model to use when forecasting temperatures and which emissions scenario to use. This appendix details the specific choices and highlights which model/emissions scenario was chosen.

All temperature data are from the California website Cal-Adapt. (https://cal-adapt.org/) The data on the site are from Global Climate Model research developed for California's Fourth Climate Change Assessment.

Global Climate Model (GCMs)

- A global climate model (GCM) is a mathematical model that represents the processes and interactions that drive the Earth's climate. General circulation models incorporate the atmosphere, oceans, lands, and ice cover. Thirty-two global climate model simulations produced by institutions across the world served as a basis for California's climate projections for California's Fourth Climate Change Assessment, and thus for the data available on Cal-Adapt. (A Fifth Climate Change Assessment is underway with reports due anywhere from 2024 to 2026.)
- The GCMs projections hosted on Cal-Adapt were generated for the periods 2006 to 2100 (future climate) and 1950 to 2005 (modeled historical climate).
- The California Department of Water Resources' Climate Change Technical Advisory Group reduced the larger ensemble of 32 GCMs to a more manageable set of 10 GCMs as being most suitable for California water resource climate change studies. For some study teams and users of California's Fourth Climate Change Assessment data, even the previously identified set of 10 GCMs was too much data. Accordingly, 4 of those 10 GCMs were identified whose project future climate can be described as producing:
    - A "warmer/drier" simulation (HadGEM2-ES)
    - An "average" simulation (CanESM2)
    - A "cooler/wetter" simulation (CNRM-CM5)
    - A "dissimilar" simulation that is most unlike the other three, to produce maximal coverage of possible future climate conditions (MIROC5) ←**-Chosen Simulation**

Additionally, the simulations have two different emission scenarios, described next.

Emissions Scenario

An emissions scenario is a representation of future greenhouse gas emissions and resulting atmospheric concentrations through time. An emissions scenario illustrates a plausible future so that climate projections for that emissions scenario can be generated, used to inform analysis and decision-making, and compared to other scenarios.

Changes in global and California temperatures depend on the accumulation of carbon dioxide and other heat-trapping gases emitted from human activities in the atmosphere. Future emissions and resulting accumulation of greenhouse gases (GHGs) could take a range of pathways depending on the success of international and local efforts to reduce GHG emissions and sequester GHGs.

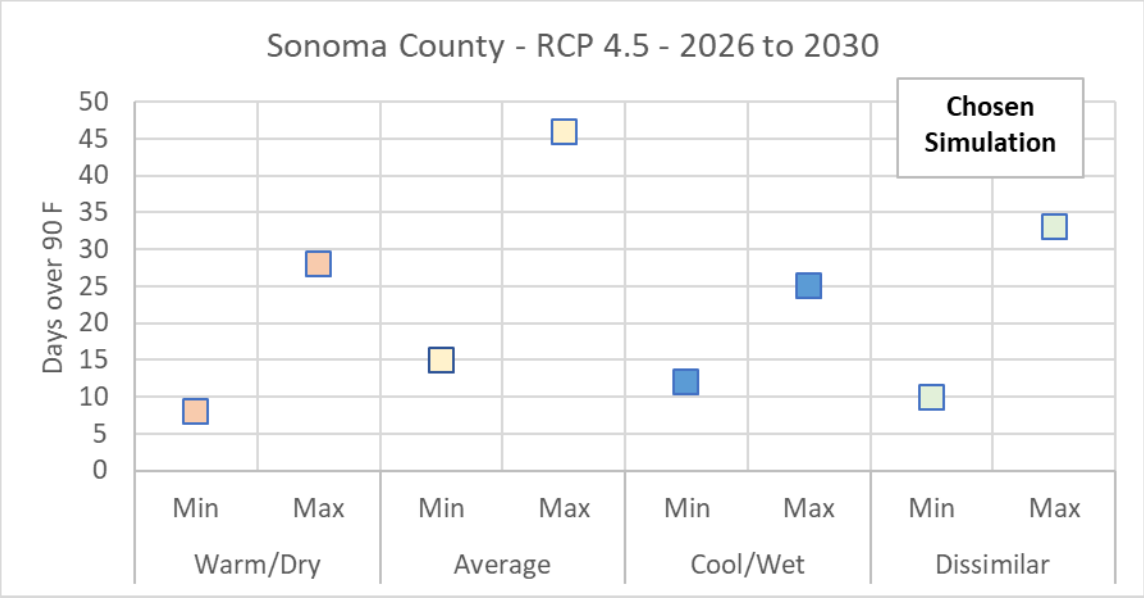
Warming and other climatological changes experienced under different plausible future conditions are projected using representative concentration pathways (RCPs). RCPs are defined in terms of their total radiative forcing by 2100 (i.e., the net balance of radiation into and out of Earth's surface due to human emissions of GHGs from all sources, measured in watts per square meter of Earth's surface). In other words, each RCP represents a standardized set of assumptions about the human influenced GHG trajectory in the coming years. RCPs do not represent a specific policy, demographic, or economic future.

California's Fourth Climate Change Assessment uses two RCPs from the Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment Report on Climate Change:

- RCP 4.5 (medium emissions scenario): a mitigation scenario where GHG emissions peak by 2040 and then decline. In California, annual average temperatures under this scenario are projected to increase 2°C – 4°C by the end of this century, depending on the location. **←-Chosen Emissions Scenario**
- RCP 8.5 (high emissions scenario): a no-mitigation scenario where global GHG emissions continue to rise throughout the 21st century. In California, annual average temperatures under this scenario are projected to increase 4°C – 7°C by the end of this century.

Here is an example for Sonoma County of the variations between the four types of simulations and for the RCP 4.5 (medium emissions scenario). The chosen simulation of "dissimilar" is slightly conservative compared to the average scenario for Sonoma but was chosen based on the description provided by Cal-Adapt, which was to produce maximal coverage of possible future climate conditions and so represent a worst-case scenario for the Bay Area.

Figure 8. Example of Simulation Results – min/max # of extreme heat days per year – Sonoma County



Weather Data in Simulations that Determined Hours over 90° F

The simulations performed by the team to determine the number of hours a home was over 90° F used data weather data from Calmac (https://www.calmac.org/weather.asp) . Specifically, the CZ2022 typical year files that span 1998 through 2017 (a 20 year period of record) that the California Energy Commission adopted for Title 24 Version 2022.

Appendix B – Typical Baseline Home Configurations

To quantify the impact on indoor temperatures for both individual and cumulative installation of measures on a home, a baseline home prototype had to be developed. To develop the baseline home, our team used the most recent, 2019 California Residential Appliance Saturation Survey (RASS) to gather data such as square footage, occupancy, window types, and insulation levels. Information on air leakage was leveraged from an LBNL Residential Diagnostics Database (RDD), [31] and other remaining information leveraged BeOpt standard assumptions. The details that went into these models can be found below in Table 12 and Table 13.

The data was based on an average single family or multifamily homes in Climate Zones 2, 3, 4, and 12 that were built prior to 1975.

Table 12. Single Family Baseline Prototype

Parameter	Source
Building Direction: South	
Number of Occupants: 3	**RASS:** average 3.1
Square Footage: 1,680 ft^2	**RASS:** 1,685 ft^2
Wall Insulation: R-10	**RASS:** 46% Have Ext. Wall Insulation*
Attic Insulation: R-13 Fiberglass Batt	**RASS:** 18% 4-6" Attic Insulation
Attic Ventilation: Specific Leakage Area 1:300	BeOpt Standard
Radiant Barrier: None	BeOpt Standard
Roof: Asphalt Shingles (Medium Color)	BeOpt Standard
Exterior Paint: Vinyl Exterior (Medium/Dark)	BeOpt Standard
Windows: Double Pane, Vinyl Frames	**RASS:** 40% Double Pane, Vinyl Frames
Interior Shading: Summer Shading Coefficient 0.7	BeOpt Standard
Air Sealing: 10 ACH50	**LBNL RDD:** 75th percentile
Ceiling Fan: No ceiling fan	BeOpt Standard
Mechanical Cooling: No Interior Cooling/AC	

** The first iteration of Title 24 was put in place in 1978, which required walls to have an R-value of 12.5. Based on that information and knowing that 46% of these homes claimed to have wall insulation, we assumed that a baseline home would have a wall insulation R-value of R-10.*

Table 13.Multifamily Baseline Prototype

Parameter	Source
Building Direction: South	
Number of Occupants: 2	**RASS:** average 1.8
Square Footage: 756 ft^2	**RASS:** 753 ft^2
Wall Insulation: R-10	Same as Single Family
Exterior Paint: Vinyl Exterior (Medium/Dark)	BeOpt Standard
Windows: Single Pane, Metal Frames	**RASS:** 27% Single Pane, Metal Frames
Interior Shading: Summer Shading Coefficient 0.7	BeOpt Standard
Air Sealing: 10 ACH50	Same as Single Family
Ceiling Fan: No ceiling fan	BeOpt Standard
Mechanical Cooling: No Interior Cooling/AC	

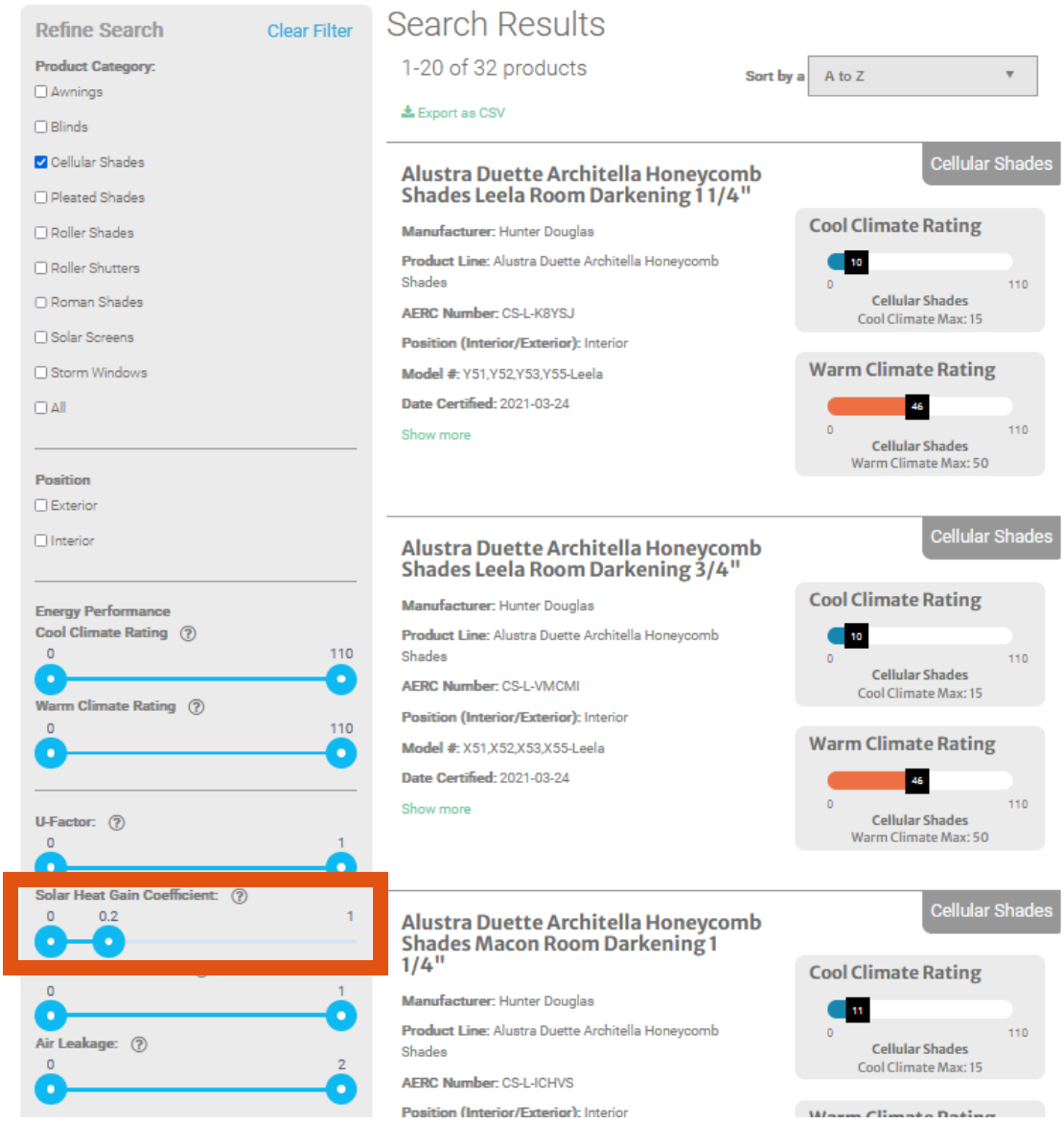
[31] LBNL. Residential Diagnostics Database – California specific Envelope Leakage Model. https://resdb.lbl.gov/

Appendix C – Additional Measure Details

Shading Measures

A number of different shading types are rated by the AERC; exterior awnings, blinds, a number of different shades, solar screens, and even storm windows. Each of these have a cool climate rating, warm climate rating, u-factor, solar heat gain coefficient (SHGC), visual transmittance, and air leakage rating. This research focused on interior shades SHGC ratings, but many different products rated by AERC would achieve a similar reduction in interior temperatures that are modeled in this study.

Figure 9: AERC Product Search



The research modeled an interior cellular shade with a SHGC of 0.22. AERC currently has 32 different cellular shade products with an SHGC 0.20 or less. These, and other similar products, can be found by visiting their website.[32]

A screenshot from this page is shown in Figure 9 The left side of the page can select the filtering options while the right side shows the results. At the top of the results pane, the user can also choose to export the list of products to a csv. The filtering options include the product category, as well as the range of different metrics. Down towards the bottom of the list, can be found the Solar Heat Gain Coefficient.

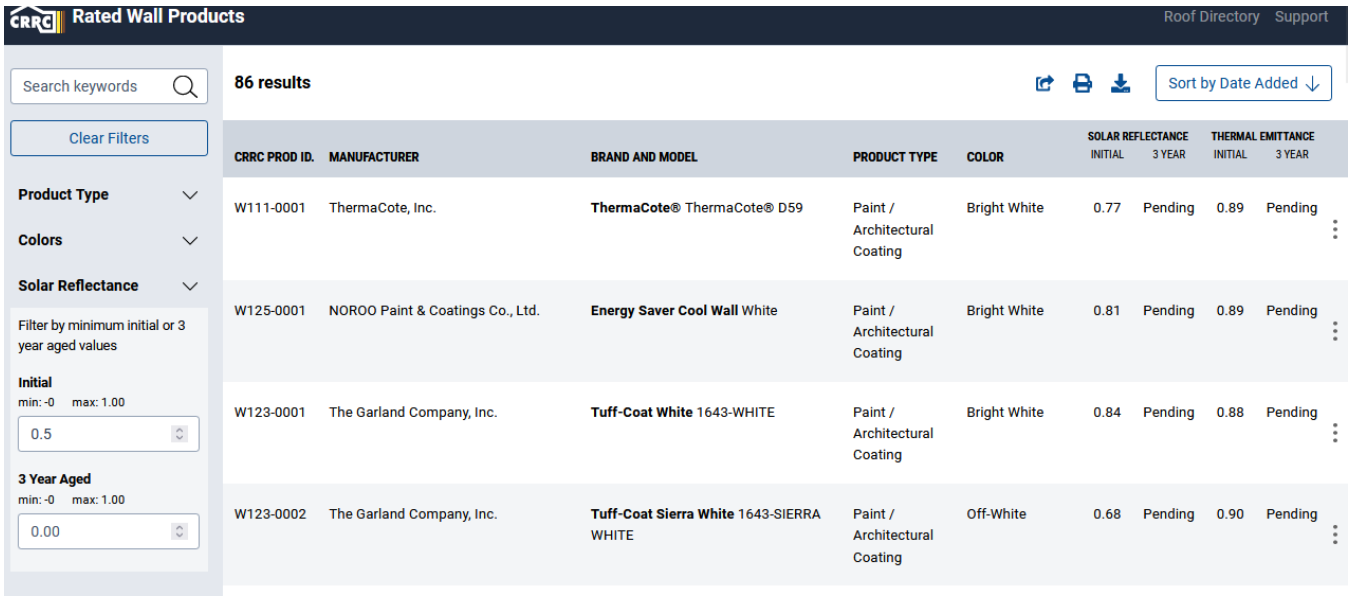
[32] https://aercenergyrating.org/product-search/residential-product-search/

Exterior Paint

Exterior paint with high solar reflectance ratings can be used to lower heat gain in buildings and reduce energy costs. The U.S. Green Building Council (USGBC) has also recognized "cool walls" as an option to reduce urban heat island effects,[33] and designed a pilot to provide LEED credits for cool-wall materials. In January 2022, the Cool Roof Rating Council (CRRC) began to offer product ratings for wall products. There are currently 89 products, across five manufacturers, however, a product's rating does not necessarily indicate that the product is considered 'cool'. In addition to this resource, Lawrence Berkely National Laboratory has developed a tool called the Cool Surfaces Savings Explorer, which is designed to calculate potential savings from increasing wall solar reflectance.[34]

The research modeled exterior paint with a solar absorptivity (equal to 1-solar reflectance) of 0.5. There are 86 of the products that have a solar reflectance value 0.5 or greater in the CRRC directory.

Figure 10: CRRC Cool Wall Product Rating Directory



Whole House Fans

Whole house fans are large fans designed to quickly exchange air throughout the house by venting the warm indoor air out of the attic and roof while sucking in cooler air through open windows. These use less energy than an air conditioner and are also only designed to be used in the evenings or nighttime when the temperatures outside are cooler than the temperatures inside.

Several different types of whole house fans are available:

- **Traditional:** These systems are mounted in the ceiling and pull air directly upward from the living space into the attic.
- **Insulated Joist-Mount:** Similar to traditional systems, yet these are designed to fit in-between joists and include insulated dampers which reduce heat loss.
- **Ducted:** Typically hung from roof framing to reduce vibration, these short-ducted systems reduce noise into the living area.

[33] The increased heat, energy costs, air pollution levels, and heat-related illnesses that comes with replacing natural land cover with dense concentrations of pavements and buildings, as often seen in cities.
[34] https://basc.pnnl.gov/library/cool-surfaces-savings-explorer

- **Roof Mounted:** These modified ducted designs mount the fan to the roof and have a curved duct directly into the conditioned space, reducing transmission of noise into the living area.

Whole house fans do come with several risks including home depressurization, humidity issues, and winter heat loss, so ensuring proper usage and installation is crucial. More information about whole house fans can be found on the Pacific Northwest National Laboratory website.[35]

Attic Ventilation Fans

Attic ventilation fans are designed to only pull outside air into the attic through intake vents, and exhaust through the fan to the outside. This mechanical ventilation can save energy by exhausting heat from the attic and can prevent mold by exhausting moisture from the attic. However, the Pacific Northwest National Laboratory notes that these purposes can be achieved with passive ventilation systems also, and the cooling effect on the living space may be much less than expected. Homes with poorly shaded roofs and attics with little insulation and no radiant barriers typically will see the greatest benefit from attic fans. However, attic fans are not recommended by the ENERGY STAR program due to potential risks like:

- Potential to use more electricity for powering the fan than they save in A/C consumption.
- Condensation and moisture issues occurring on poorly insulated and sealed A/C ductwork or attic-based air handlers.
- Exacerbation of house fires by increasing air flow to flames.
- Potential to suck in wildfire embers.

Additional information about the Pros and Cons of attic fans can be found on the Pacific Northwest National Laboratory website.[36]

Air Sealing

Air sealing is the act of reducing the amount of air that leaks into and out of a home, generally through caulking openings between stationary home components and weather stripping doors and operable windows. While air sealing measures have not been recommended as part of this heat mitigation research, air sealing is a crucial tool to ensure a healthy home. A leaky house may suffer from moisture problems as well as poor indoor air quality. The likelihood of outside noise, pollutants like dust and pollen, as well as insects and pests increase with a poorly sealed home. According to Energy Star, adding up all the leaks in a home is equivalent to having a window open all year long.[37]

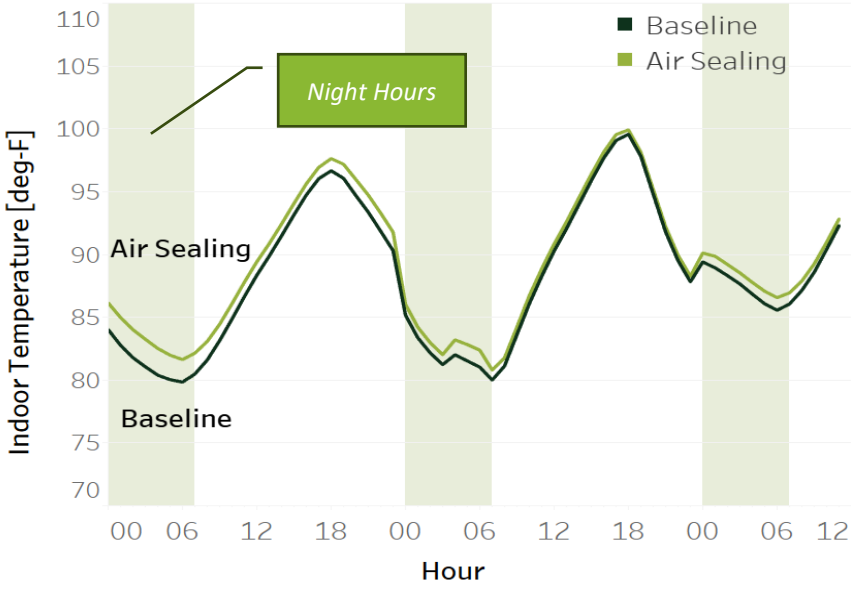
Additionally, when air sealing is combined with other building shell improvements, a home with mechanical cooling will use less energy. However, our analysis did not include impacts of single or combined measures on the energy use of a home nor look at air quality issues (that air sealing can affect). If the analysis had been broader and included homes with mechanical cooling, including air sealing as a measure would have made a difference in the eventual energy use.

More information about air sealing measures and their relationship with indoor air temperatures based on our modeling, can be found in figure below that demonstrates results for three random days (and so starts “hotter” because the heat from the prior day takes longer to escape in the home with air sealing). The baseline home is able to shed its heat quicker than the 'air sealed' home.[38] The model simulates that unconditioned homes see an increase in temperature due to air sealing because heat inside the home is slower to escape, especially at night when the temperature outside drops. This is displayed in Figure 11 below, which highlights the indoor

[35] https://basc.pnnl.gov/resource-guides/whole-house-fans
[36] https://basc.pnnl.gov/information/attic-ventilation-fans
[37] https://www.energystar.gov/saveathome/seal_insulate/why_seal_and_insulate
[38] Because of the increase in temperatures from air sealing, we did not include it in simulations that estimate cumulative reduction in hours over 90° F but show it as an individual measure. If a home were already tightly sealed, we expect that an air source heat pump would be required to keep a home under 90° F.

temperature of the simulated baseline home (**in black**) and the home with air sealing measures (**in green**) for three summer days. The highlighted bars show the nighttime hours, when the difference between the air sealing simulation and the baseline simulation is the largest.

Figure 11. Baseline vs. Air Sealing Measure Simulated Indoor Temperatures



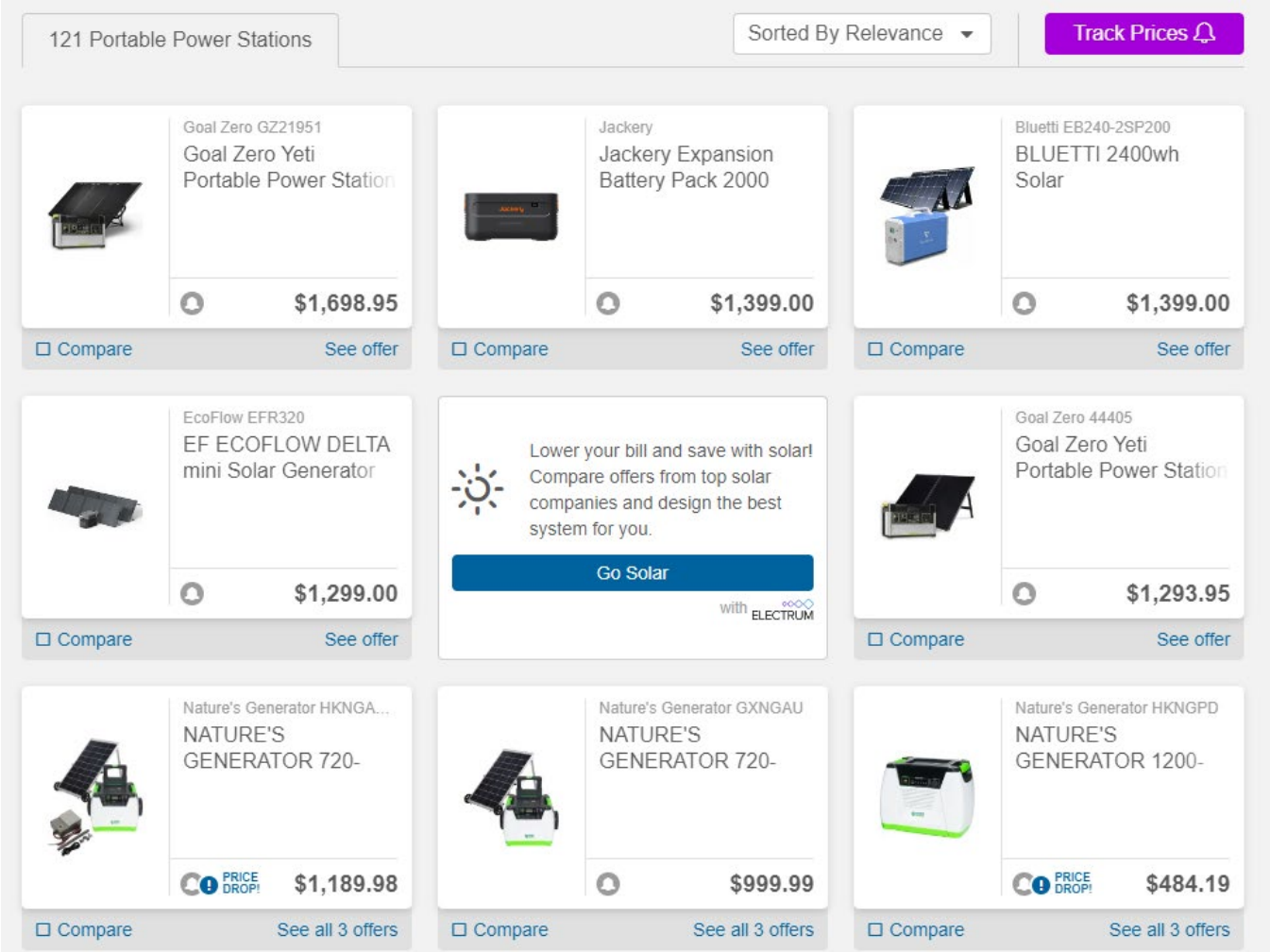
Source: Modeling within this analysis

Portable and Permanent Power

High level information on some portable and permanent power systems are available from the Enervee website that they operate for Los Angeles Department of Water and Power (LADWP). This site had details about each as well as the ability to compare products. Prices are also included so the website is a good source for information on the available products. We provide examples of portable power (battery and generators) and permanent power (battery and generators).

Example of Portable Power (Battery Storage)

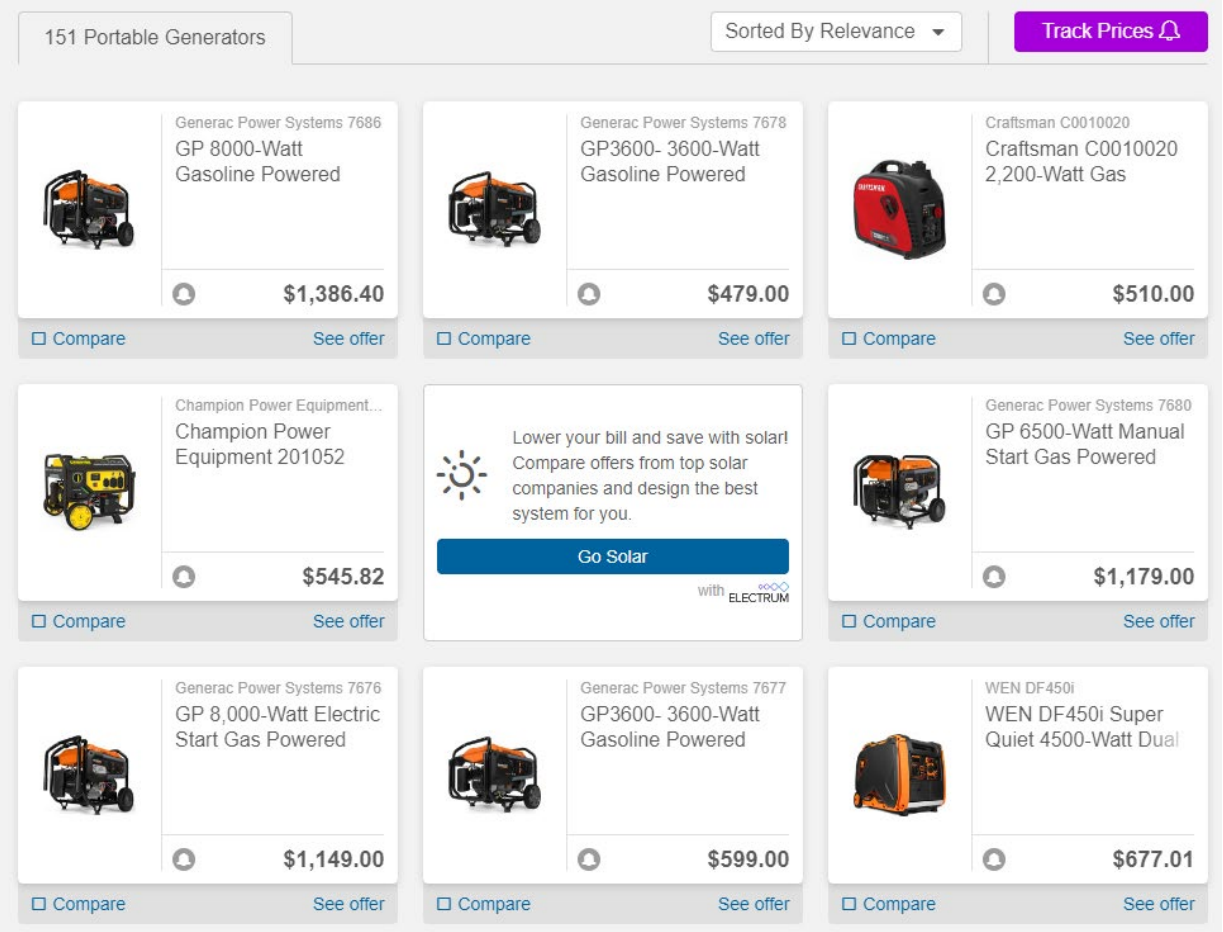
At the time we accessed the website, the examples shown below of these products range in price from $484 (for a battery storage system) to $1,698 (for a battery and solar panel system). Below are examples (in no particular order).



Source: *https://marketplace.ladwp.com/portable-power-stations/*

Example of Portable Power (Generator)

At the time we accessed the website, examples shown below of these products range in price from $479 (for a 3.6 kWh gasoline generator) to $2,618 (for a 15 kW gasoline generator). Below are examples (in no particular order.)



Source: https://marketplace.ladwp.com/portable-generators/

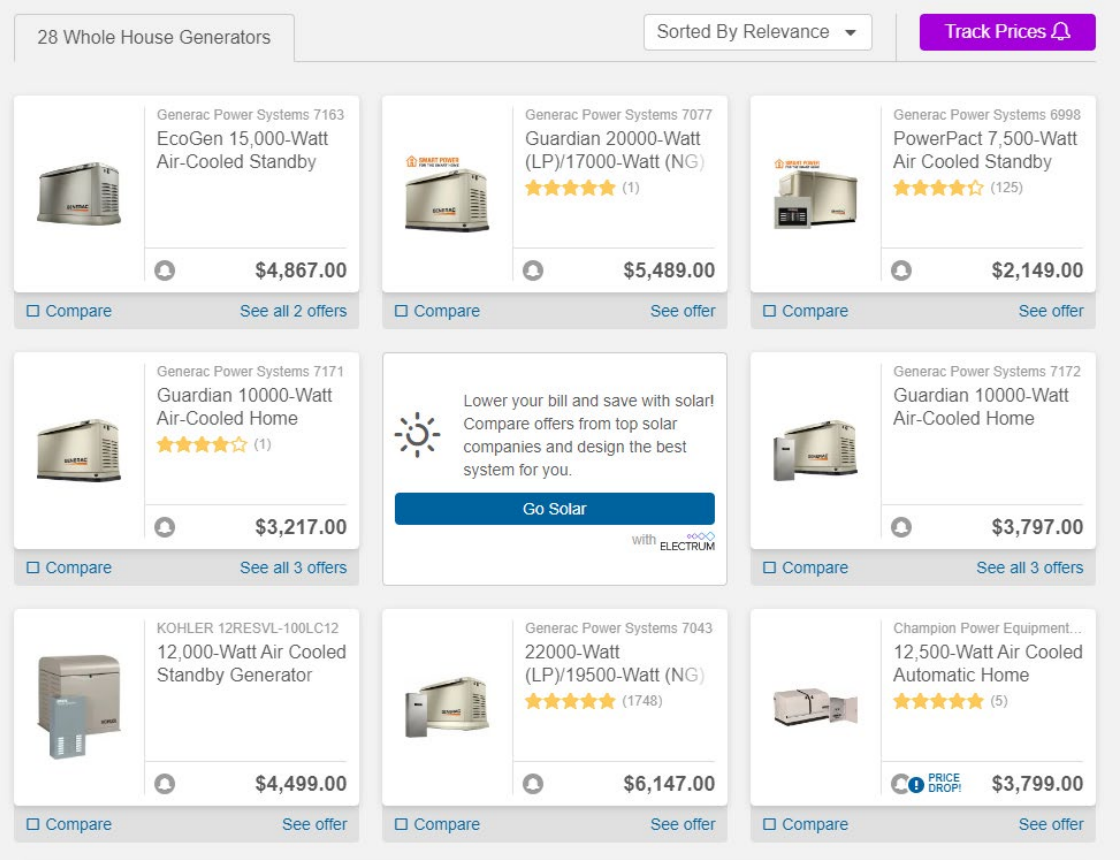
Example of Permanent Power (Battery Storage)

The LADWP Marketplace did not include a listing of whole house battery storage. However, examples of these are the Tesla Power Walls (https://www.tesla.com/powerwall), LG Batteries (https://www.lgessbattery.com/us/home-battery/intro.lg), and Sonnenusa (https://sonnenusa.com/en/sonnen-ecolinx/).

Example of Permanent Power (Whole House Generators)

Most whole house generators use natural gas, but some also use gasoline or propane.

At the time we accessed the website, examples of these products range in price from $2,149 (for a 7.5 kW system that operates on natural gas or propane) to $11,400 (for a 25 kW system that operates on gasoline). Below are examples (in no particular order). The prices do not include installation and connection costs.

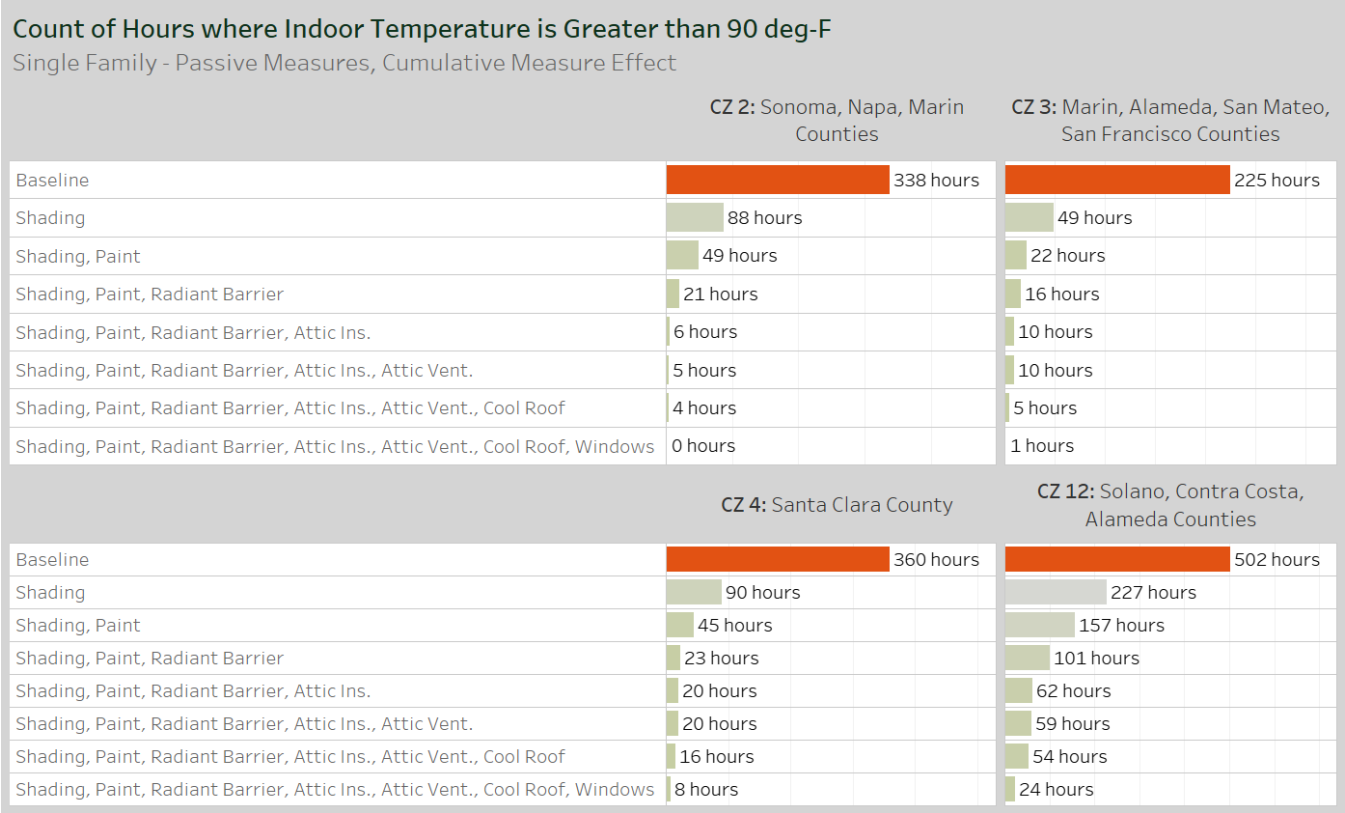


Source: https://marketplace.ladwp.com/whole-house-generators/

Appendix D – Results by Climate Zone

Single Family Passive Measure Simulation

Figure 12. Cumulative Measure Effect for Single Family Passive Measures
(Count of Hours where Indoor Temperature is Greater than 90°F)



Single Family Combination Measure Simulation

When adding in the whole house fan or air source heat pump, the simulation is only running the equipment for the remaining hours to bring the home back to under 90° F. As such, there is a relatively minimal increase in energy use.

Figure 13. Cumulative Measure Effect for Single Family Combination Measures

(Count of Hours where Indoor Temperature is Greater than 90°F)

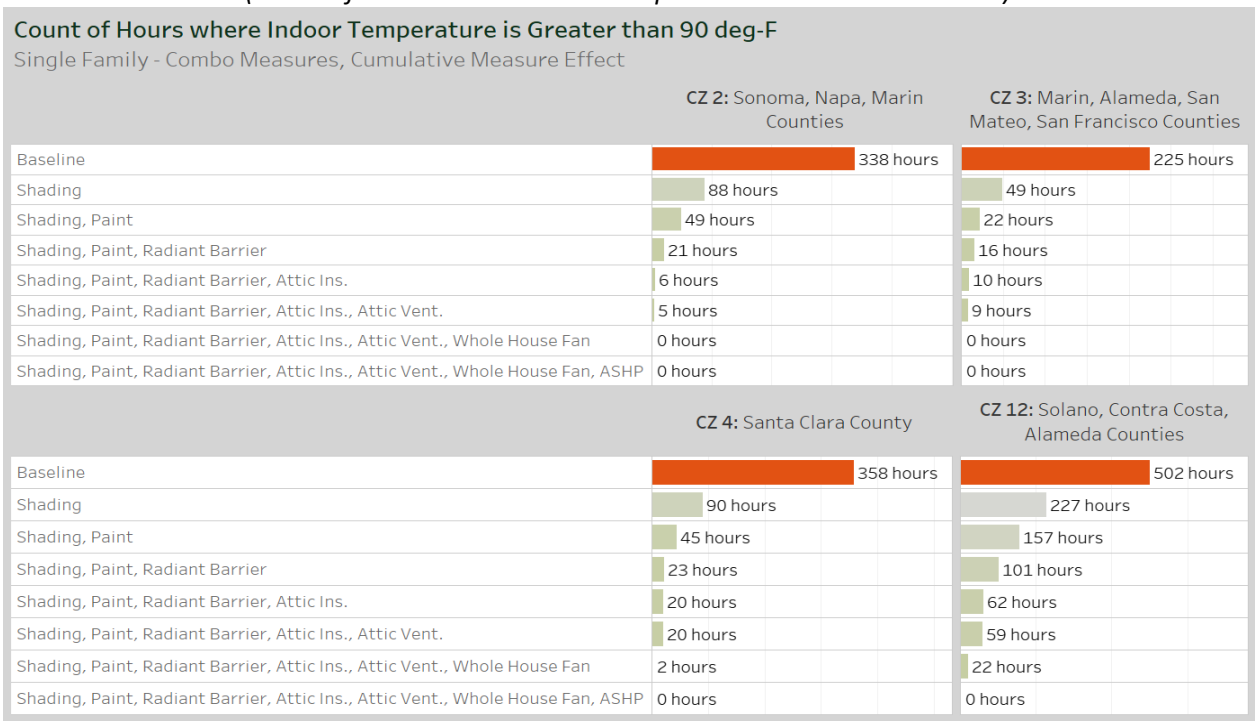
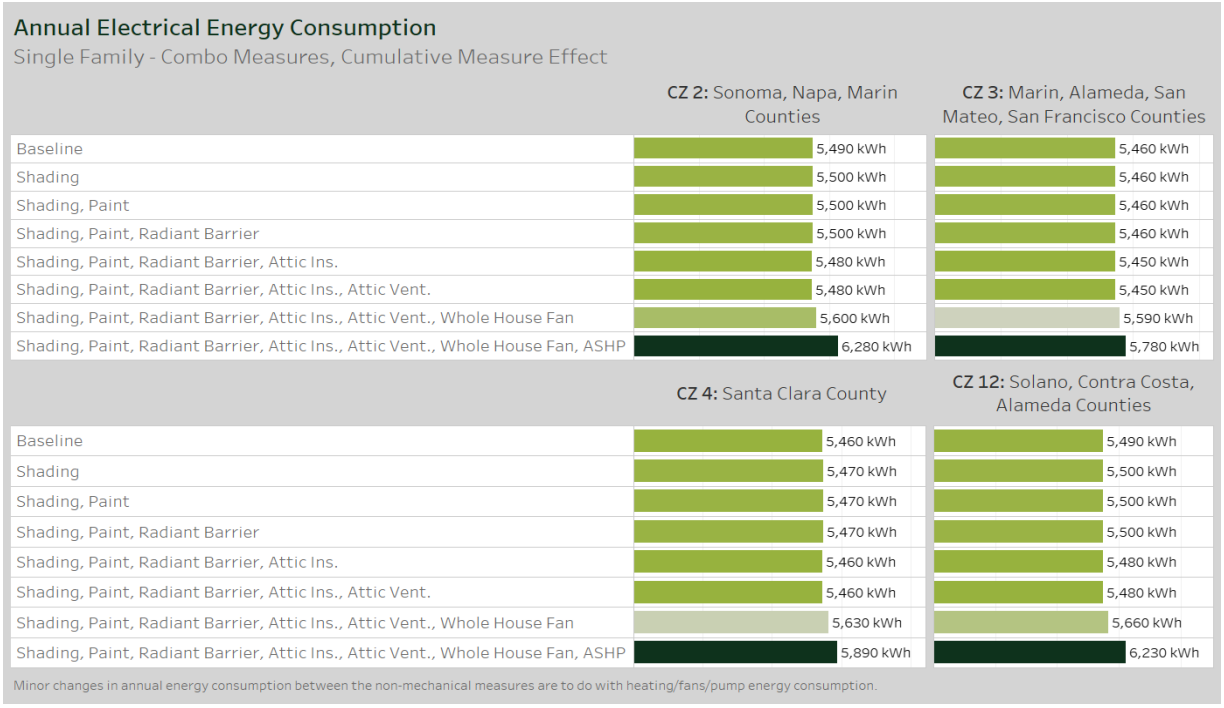


Figure 14. Cumulative Measure Effect for Single Family Combination Measures

(Annual Energy Consumption)



Multifamily Ground Floor, Middle Unit Measure Simulation

When the mini-split heat pump is added to the simulations, it only picks up the few hours left to enable bringing the apartment down to 90° F. As such, there is little additional energy use within the simulation.

Figure 15. Cumulative Measure Effect for Multifamily Ground Floor, Middle Unit Measures
(Count of Hours where Indoor Temperature is Greater than 90°F)

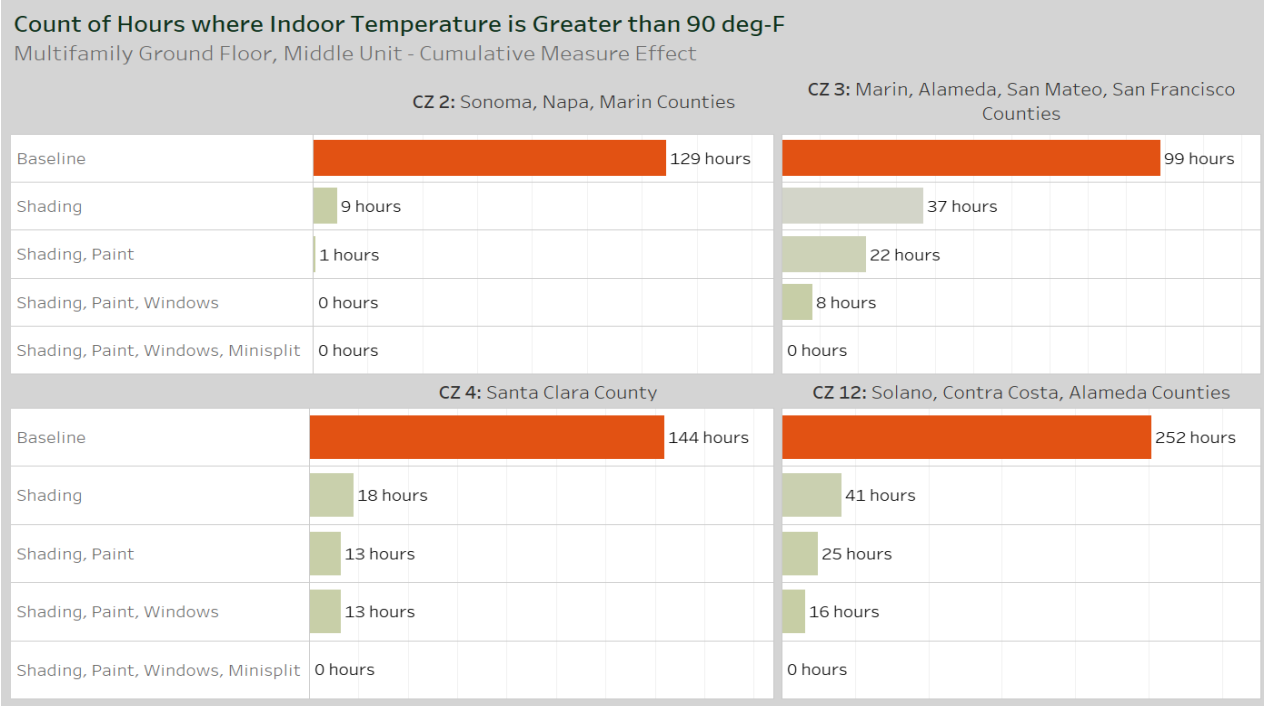
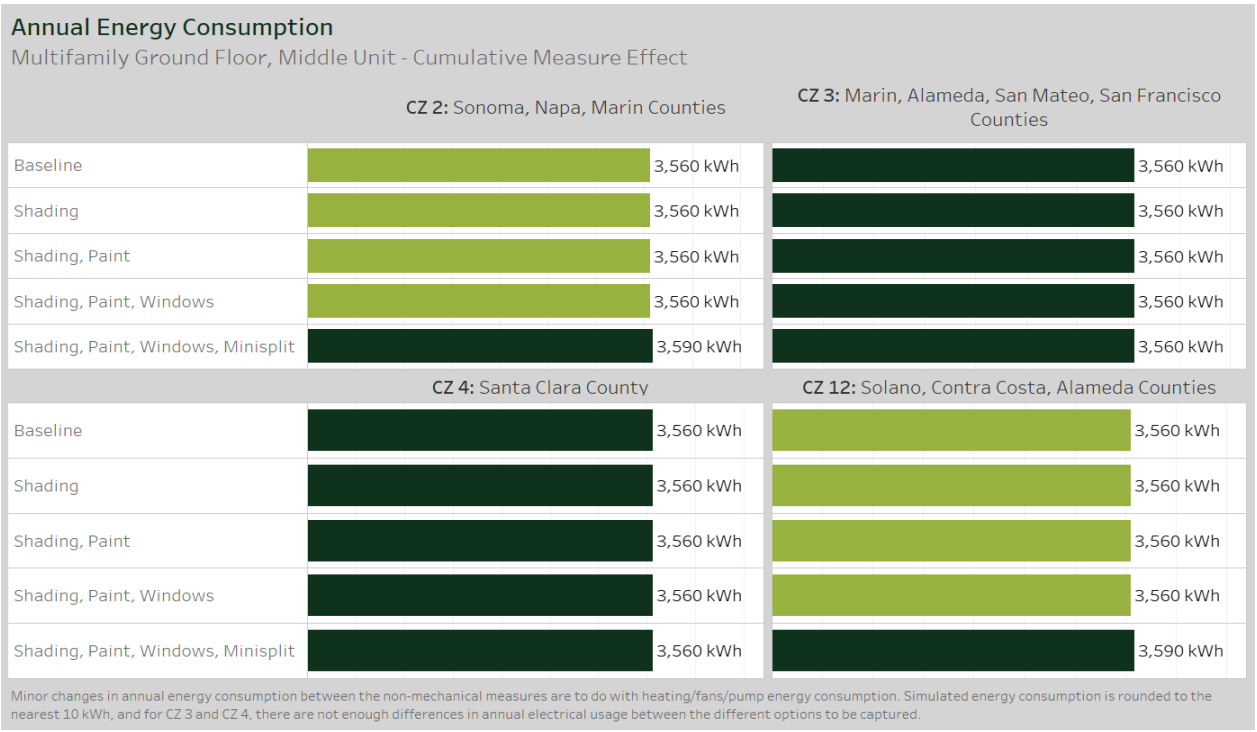


Figure 16. Cumulative Measure Effect for Multifamily Ground Floor, Middle Unit Measures
(Count of Hours where Indoor Temperature is Greater than 90°F)



Multifamily Mid-Floor, Corner Unit Measure Simulation

Figure 17. Cumulative Measure Effect for Multifamily Mid-Floor, Corner Unit Measures
(Count of Hours where Indoor Temperature is Greater than 90°F)

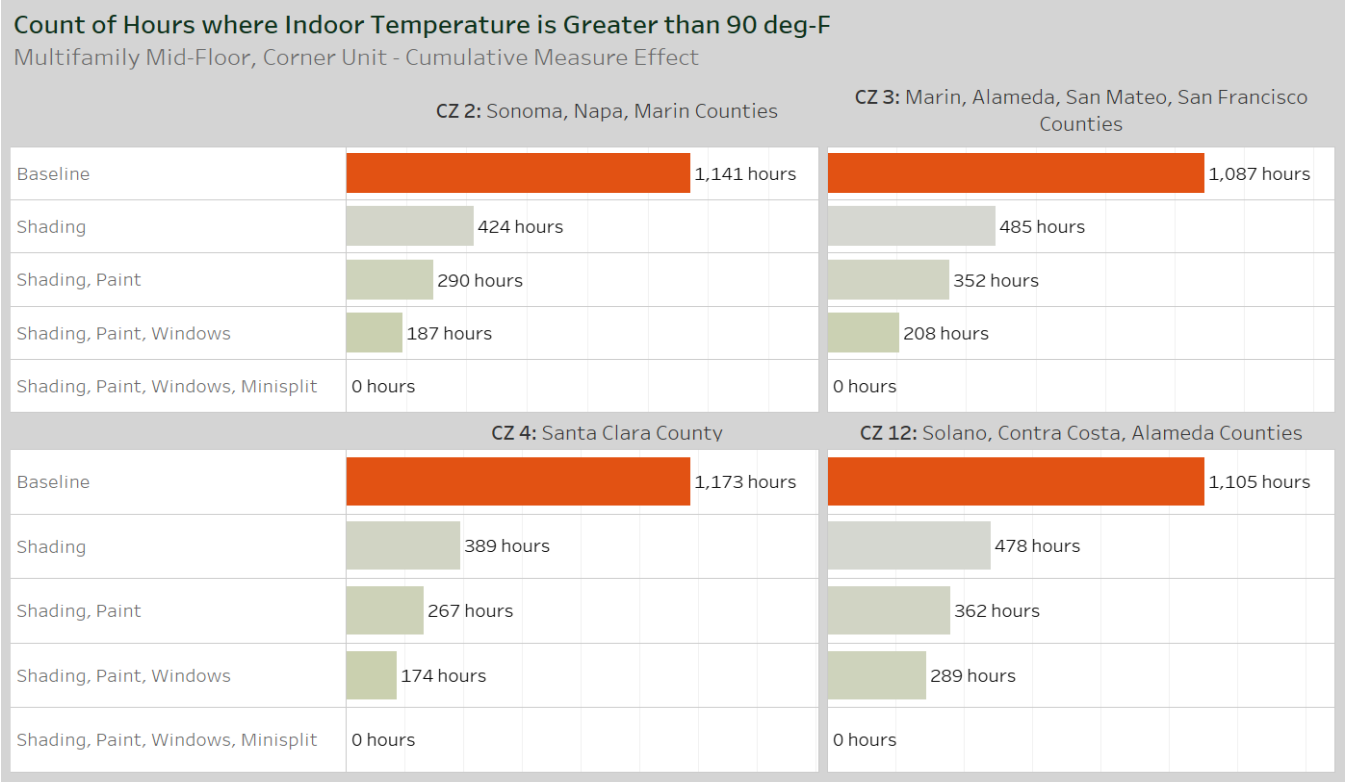
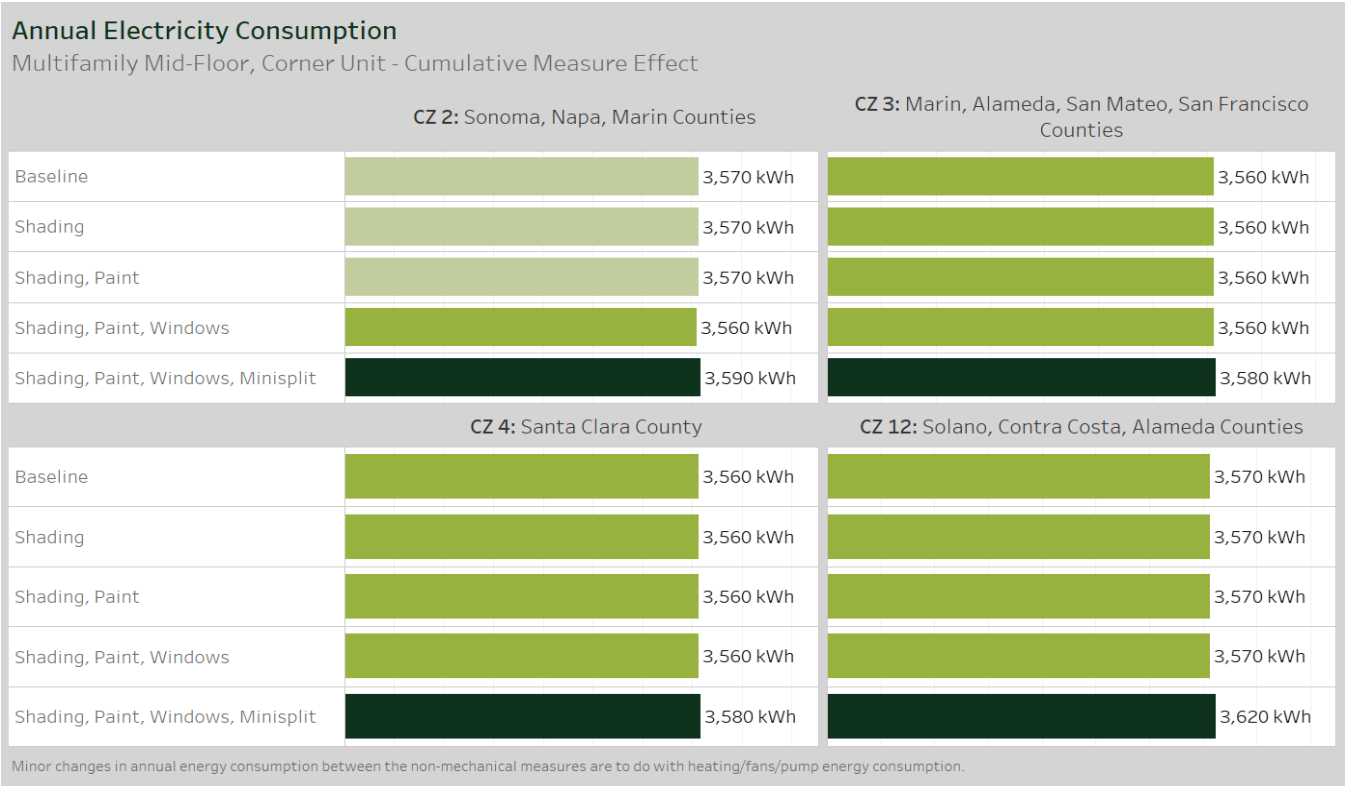


Figure 18. Cumulative Measure Effect for Multifamily Mid-Floor, Corner Unit Measures
(Annual Energy Consumption)



Appendix E – BayREN Service Territory Energy Efficiency Programs

The table below highlights 35 different programs available to residents within BayREN's service territory. The field *Multifamily* refers to whether the full program or a portion of the program is specifically geared towards multifamily residents. Similarly, the field *Income Eligible* refers to whether the program or a portion of the program has incentives specifically for income eligible residents. Some programs specifically called out an *education* or *audit* aspect to their program.

Table 14.Programs Available Statewide (or at least within all the Bay Area)

Program Administrator	Program	Climate Zones	Single Family		Multifamily		Program type	Services provided	Program financials	Measures offered
			Income Eligible	Any Income	Income Eligible	Any Income				
CA Energy Smart Homes		CZ 2, CZ 3, CZ 4, CZ 12	No	No	No	Yes	Unknown	Unknown	Rebate	Whole House
CAEATFA	Go Green Financing	CZ 2, CZ 3, CZ 4, CZ 12	No	Yes	No	No	Contractor, DIY	Unknown	Financing	Building Envelope, HVAC
California Department of Community Services & Development	US DOE Weatherization Assistance Program (WAP)	CZ 2, CZ 3, CZ 4, CZ 12	Yes	Yes	No	No	Contractor	Audit	Free Measures	Whole House, Weatherization, Building Envelope
	US DOE Low-Income Home Energy Assistance Program (LIHEAP)	CZ 2, CZ 3, CZ 4, CZ 12	Yes	Yes	No	No	Contractor, DIY, Direct Install	Audit	Rebate	Whole House/weatherization
	CA Low-Income Weatherization Program (LIWP)	CZ 2, CZ 3, CZ 4, CZ 12	Yes	Yes	Yes	Yes	Contractor	Audit	Unknown	Whole House/weatherization
Fannie Mae	Green rewards	CZ 2, CZ 3, CZ 4, CZ 12	No	No	No	Yes	Unknown	Audit	Financing	Whole house
Golden State Rebates		CZ 2, CZ 3, CZ 4, CZ 12	No	Yes	No	Yes	DIY	N/A	Instant Rebate	Smart Thermostats, Room Air Conditioning
Inflation Reduction Act	Federal Tax Credit	CZ 2, CZ 3, CZ 4, CZ 12	No	Yes	No	Yes	Unknown	N/A	Federal Tax Credit	Heat Pump HVAC, Air Sealing, Ducts, Weatherization, Windows
Multiple PAs	PACE - Home Run Financing	CZ 2, CZ 3, CZ 4, CZ 12	No	Yes	No	No	Unknown	Unknown	Financing	Roofing & HVAC
PG&E	SmartAC Thermostats	CZ 2, CZ 3, CZ 4, CZ 12	No	Yes	No	No	DIY	N/A	Instant Rebate	Smart Thermostats
	Energy Savings Assistance Program	CZ 2, CZ 3, CZ 4, CZ 12	Yes	Yes	Yes	Yes	Contractor	Audit	Free Measures	Whole house - Insulation, Weatherproofing
Rebuilding Together Peninsula		CZ 2, CZ 3, CZ 4, CZ 12	Yes	Yes	No	No	Unknown	Unknown	Free Repairs	Repairs

Program Administrator	Program	Climate Zones	Single Family		Multifamily		Program type	Services provided	Program financials	Measures offered
			Income Eligible	Any Income	Income Eligible	Any Income				
TECH Clean California		CZ 2, CZ 3, CZ 4, CZ 12	Yes	Yes	Yes	Yes	Unknown	Unknown	Rebate	Heat Pump HVAC
USDA	Single Family Housing Repair Loans & Grants	CZ 2, CZ 3, CZ 4, CZ 12	Yes	Yes	No	No	Unknown	Unknown	Grants, Financing	Repairs

Table 15.Programs Available Locally (not across all the Bay Area)

Program Administrator	Program	Climate Zones	Income Eligible	Any Income	Income Eligible	Any Income	Program type	Services provided	Program financials	Measures offered
Alameda Municipal Power		CZ 3, CZ 12	No	Yes	No	No	Contractor, DIY	N/A	Rebate	Heat pump HVAC, Smart Thermostats
BayREN	Home +	CZ 2, CZ 3, CZ 4, CZ 12	No	Yes	No	No	Contractor	N/A	Rebate	Insulation, Air Sealing, Heat Pump HVAC
	Multifamily Property Owners	CZ 2, CZ 3, CZ 4, CZ 12	No	No	No	Yes	Contractor	Education	Rebate, Financing	Cooling, Weatherization, Building Shell, etc.
City of Alameda	Housing Rehabilitation Program	CZ 3, CZ 12	Yes	Yes	No	No	Unknown	Unknown	Financing	Repairs
	Minor Home Repair Program	CZ 3, CZ 12	Yes	Yes	No	No	Unknown	Unknown	Grants	Repairs
City of Berkeley	Senior and Disabled Home Rehab Loans	CZ 3, CZ 12	Yes	Yes	No	No	Unknown	Unknown	Financing	Repairs
City of Healdsburg		CZ 2	No	Yes	No	No	Unknown	Unknown	Rebate	Insulation, Windows
City of Palo Alto	Multifamily Plus Program	CZ 4	No	No	Yes	No	Unknown	Unknown	Free Measures	Weatherization
City of San Mateo	Housing Rehabilitation Loan Program	CZ 3	Yes	Yes	No	No	Unknown	Unknown	Financing	Repairs
Contra Costa Conservation & Development	Neighborhood Preservation Program	CZ 12	Yes	Yes	No	No	Contractor	Unknown	Grants, Financing	Repairs
County of Marin	Electrify Marin - Natural Gas Appliance Replacement Rebate Program	CZ 2, CZ 3	Yes	Yes	No	No	Unknown	Unknown	Rebate	Heat Pump HVAC
County of Sonoma	Sonoma County Energy Independence Program	CZ 2	No	Yes	No	Yes	Unknown	Unknown	Financing	Whole house
	Housing Rehabilitation Loan Program	CZ 2	Yes	Yes	No	No	Unknown	Unknown	Financing	Repairs

Program Administrator	Program	Climate Zones	Income Eligible	Any Income	Income Eligible	Any Income	Program type	Services provided	Program financials	Measures offered
Marin County Energy (MCE)	Single Family Energy Upgrades	CZ 2	Yes	Yes	No	No	Unknown	Audit	Free Measures	Weatherization, Smart Thermostat
	Multifamily Energy Efficiency Rebates	CZ 2	No	No	Yes	Yes	Unknown	Audit	Rebate	Weatherization, HVAC, Building Shell
Peninsula Clean Energy	Zero Percent Loans	CZ 3	No	Yes	No	No	Unknown	Unknown	Financing	Heat Pump HVAC
	Home Upgrade Program	CZ 3	Yes	Yes	No	No	Contractor	Audit	Free Measures	Building Envelope, HVAC
San Francisco	Senior Home Repair Program (SHRP)	CZ 3	Yes	Yes	No	No	Unknown	Unknown	Financing	Repairs
Silicon Valley Clean Energy	FutureFit Homes Program	CZ 4	Yes	Yes	Yes	Yes	Contractor, DIY	N/A	Rebate	Heat Pump HVAC
Sonoma Clean Power	Advanced Energy Center	CZ 2	Yes	Yes	No	No	Contractor, DIY	N/A	Rebate	Heat Pump HVAC, HRV
Vacaville	Treebate Program	CZ 12	No	Yes	No	No	DIY	N/A	Rebate	Shading Tree

Besides these Bay Area programs, the report had mentioned programs in Southern California specific to exterior solar screens and whole house fans. Links to those programs are bulleted below.

Exterior Solar Screens:

- Imperial Irrigation District (https://www.iid.com/customer-service/save-energy-and-money/your-home/residential-rebates)
- Turlock (https://www.tid.org/customer-service/save-energy-money/rebates/)

Whole House Fans:

- City of Lodi (https://www.lodi.gov/909/Residential-Rebates)
- SCE Summer Reliability Program (https://www.sce.com/business/savings-incentives/summer-reliability-program)
- LADWP (https://www.ladwp.com/ladwp/faces/wcnav_externalId/hta-cons-reb-program?_adf.ctrl-state=10kzheclka_4&_afrLoop=490764736195372)
- Turlock (https://www.tid.org/customer-service/save-energy-money/rebates/)

Appendix F – Annotated Bibliography

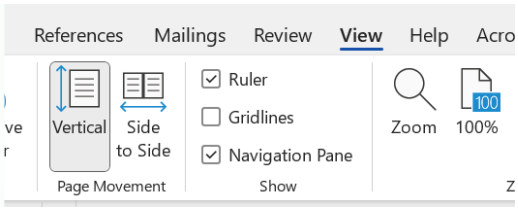
This annotated bibliography provides the results of Grounded Research's literature review, which focused on exploring heat emergencies and determining what livable indoor environments may look like. We used some, but not all, of the information from the entries listed herein in the report. Additionally, while this bibliography lists the information we reviewed, we do not call out each within the report.

The entries herein are in alphabetic order. Each entry has four headers in **bold**:

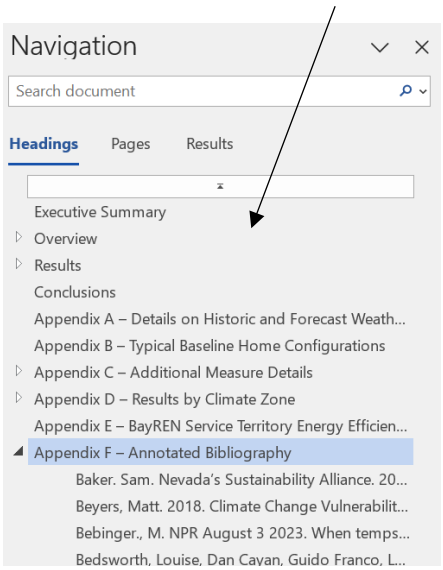
- The specific research question (**RQ**) that the entry supported.
  - RQ1 - Define an extreme heat emergency
  - RQ2 - Identify baseline criteria for protecting occupants from temperature extremes and having a livable indoor environment within residential dwellings
  - RQ3 - Describe measures that are needed to ensure livable indoor environments for residential dwellings (single family and multifamily) and how those measures can be quantified
  - RQ4 - Summarize existing California programs, their customers, their services and measures, and the measures they provide that specifically protect occupants from temperature extremes (include both direct install and rebate programs). *While this bibliography includes RQ4 entries, information related to this RQ is provided within the body of the report and Appendix D, not in this bibliography.*
  - RQ5 - Provide examples of heat mitigation programs from other regions. *Information for this RQ is also provided in the body of the report, although the information herein has a few more details than in the report.*
- The **main point** in the document
- **How we used the information**
- **Details** to describe relevant information.

The bibliographic entry is formatted as a header, so can be seen when using the Navigation pane within Word.

Turn on the Navigation Pane in Word here -→



Graphic showing the Navigation Pane



Baker. Sam. Nevada's Sustainability Alliance. 2022. *Clark County on Extreme Heat: Taking Action Today.* https://impact-nv.org/community/clark-county-on-extreme-heat-taking-action-today

RQ1

Main Point – Described specific actions a Nevada county is taking to help mitigate heat.

How we used the information – Explored to learn about what local governments are doing to mitigate heat.

Details:

- *All-In Clark County* is the comprehensive effort to prepare Southern Nevada for a changing climate and create a sustainable future for all. This involves multiple planning efforts, beginning with a Sustainability and Climate Action Plan for County Operations. The idea here is for the County to lead by example, modeling climate change mitigation and adaptation for the community. Every *All-In Clark County* initiative is being led by four guiding principles: greenhouse gas emissions reductions, transparency, equity, and resiliency for social, economic, and environmental indicators.
- Expanding urban tree canopy is identified in *All-In* as an effective, nature based, and adaptive method for creating heat resilience.
- Ariel (the Urban Heat Fellow working with Clark County) is working to identify what combination of heat mitigation techniques such as cool roofs, cool pavements, and built shade structures, will be most effective across the county.

Beyers, Matt. 2018. Climate Change Vulnerability in Alameda County: A Look at Extreme Heat. **https://www.acgov.org/cda/planning/sustainability/documents/CAP-vulnerability-april-2018.pdf**

RQ1

Main Point – Provides information on who is vulnerable to extreme heat within Alameda County.

How we used the information – Explored to learn how counties are already categorizing those who are vulnerable to extreme heat.

Details:

- Shows slides by percentage of people within a census tract with biological, socioeconomic, social exclusion, and living condition factors that make up vulnerable populations. Data from ACS 2015-5 year file
    - Biological – under 5 year, over 65 years, disability
    - Socioeconomic - <200% poverty, living alone, without a HS degree, unemployed
    - Social exclusion – citizenship (not a citizen), limited English speaking HH, mobility
    - Living conditions – zero-vehicle HH, no tree cover, impervious surface, HH without AC, Ozone levels
- They created three levels of vulnerability to climate change/extreme heat (low, medium, high) by combining the above factors.
    - The document includes a map and a table (by geography) that could be recreated for all counties (Contra Costa already did so).

Bebinger., M. NPR August 3 2023. *When temps rise, so do medical risks. Should doctors and nurses talk more about heat?* **https://www.npr.org/sections/health-shots/2023/08/04/1191342356/when-temps-rise-so-do-medical-risks-should-doctors-and-nurses-talk-more-about-he**

RQ1

Main Point – Hot, but relatively low temperatures (i.e., into the 80s), coming early in a season could drive up heat-related hospital visits and deaths.

How we used the information – Explored to learn about a specific temperature can affect humans.

Details:

- Described that even without official heat warnings, people have heat risks (supported by research).

- A primary care physician in Boston indicated that "People are quite vulnerable because their bodies haven't yet adjusted to heat."
- The non-profit Climate Central and Harvard University's Center for Climate, Health and Global Change is running a pilot to provide emails to doctors and nurses in 12 community-based clinics in seven states (CA, MA, NC, OR, PA, TX, and WI).
    - The first email alerts go out when local temperatures reach the 90th percentile.
    - The second email alerts go out when forecasts indicate that the temperature would reach the 95th percentile.
    - These alerts remind the doctors/nurses to talk about heat with their patients.

Bedsworth, Louise, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. *Statewide Summary Report. California's Fourth Climate Change Assessment*. Publication number: SUMCCCA4-2018-013.
https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf
RQ1

Main Point - This is the statewide summary report for California's Fourth Climate Change Assessment.

How we used the information - We used this to determine how the state is considering temperature and that led to looking into the more detailed report on GCMs (Pierce, et. al).

Details:

- None

Bick, I. A., Santiago Tate, A. F., Serafin, K. A., Miltenberger, A., Anyansi, I., Evans, M., et al. 2021. *Rising seas, rising inequity? Communities at risk in the San Francisco Bay Area and implications for adaptation policy*. https://doi.org/10.1029/2020EF001963
RQ1

Main Point – This article has nothing to do with heat mitigation but is a good reminder that heat mitigation is just one of many risks that people face that local governments are trying to mitigate.

How we used the information – Kept ensuring that we have a literature source that indicates the various hazards faced by residents in the Bay area.

Details:

- The impact of coastal flooding on communities hinges not only on the cost, but on the ability of households to pay for the damages. Here, they show that future coastal flooding could financially destabilize a substantial number of households by burdening them with flood damage costs that exceed discretionary funds that households have left over after covering costs of living. They compute the percentage of households without discretionary income, before and after projected coastal flooding costs. They demonstrate that this percentage is larger than 50% for several communities in San Mateo County, highlighting the need for immediate policy intervention that targets existing, socially produced risk rather than waiting for potentially elusive certainty in sea level rise projections. Across all flood-affected census block groups in the County, they project increases in financial instability by an average of 17% from 2020 to 2060. According to the authors, this methodology is transferable to other urban centers and can help identify the specific challenges that different communities face and inform appropriate adaptation interventions.

Boston, City of. 2022. *Heat Resilience Solutions for Boston.* ***https://www.boston.gov/sites/default/files/file/2022/04/04212022_Boston%20Heat%20Resilience%20Plan_highres-with%20Appendix%20%281%29.pdf***

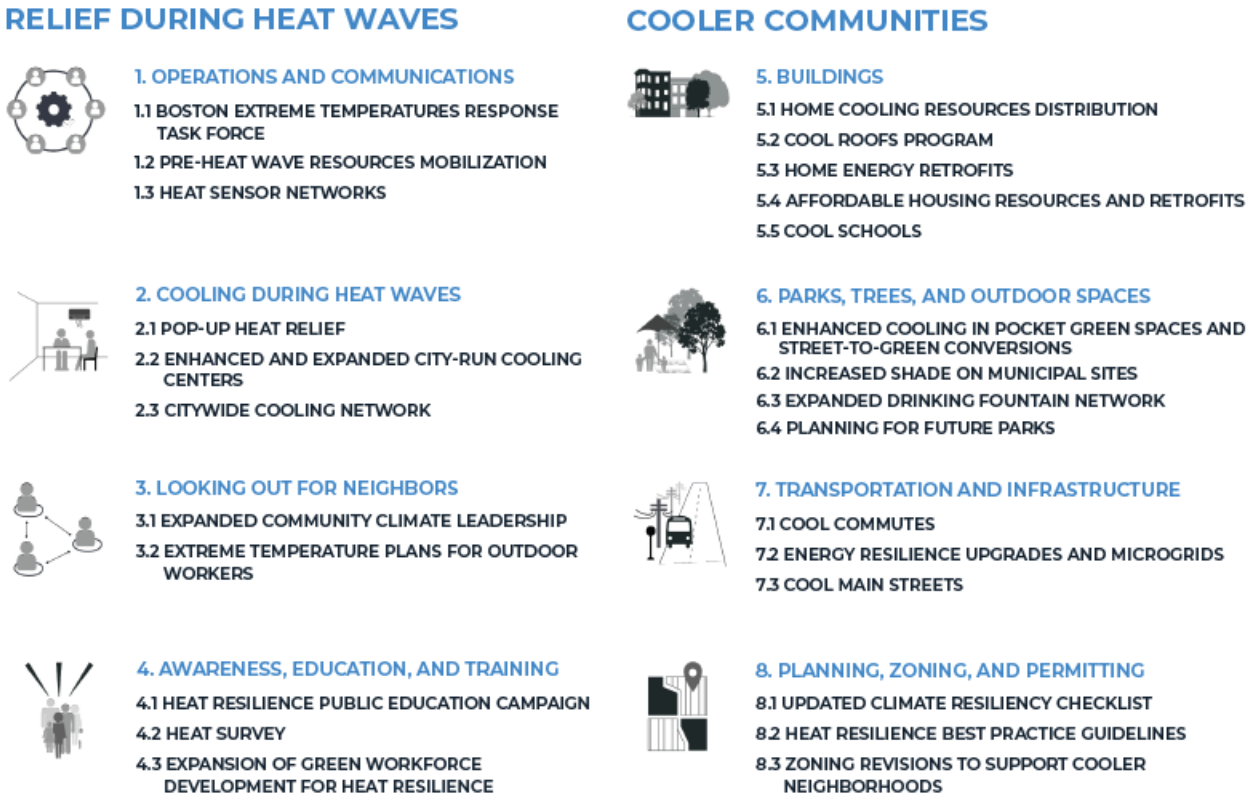
RQ5

Main Point – A roadmap for navigating extreme heat in Boston

How we used the information – Exploration of programs outside of California.

Details:

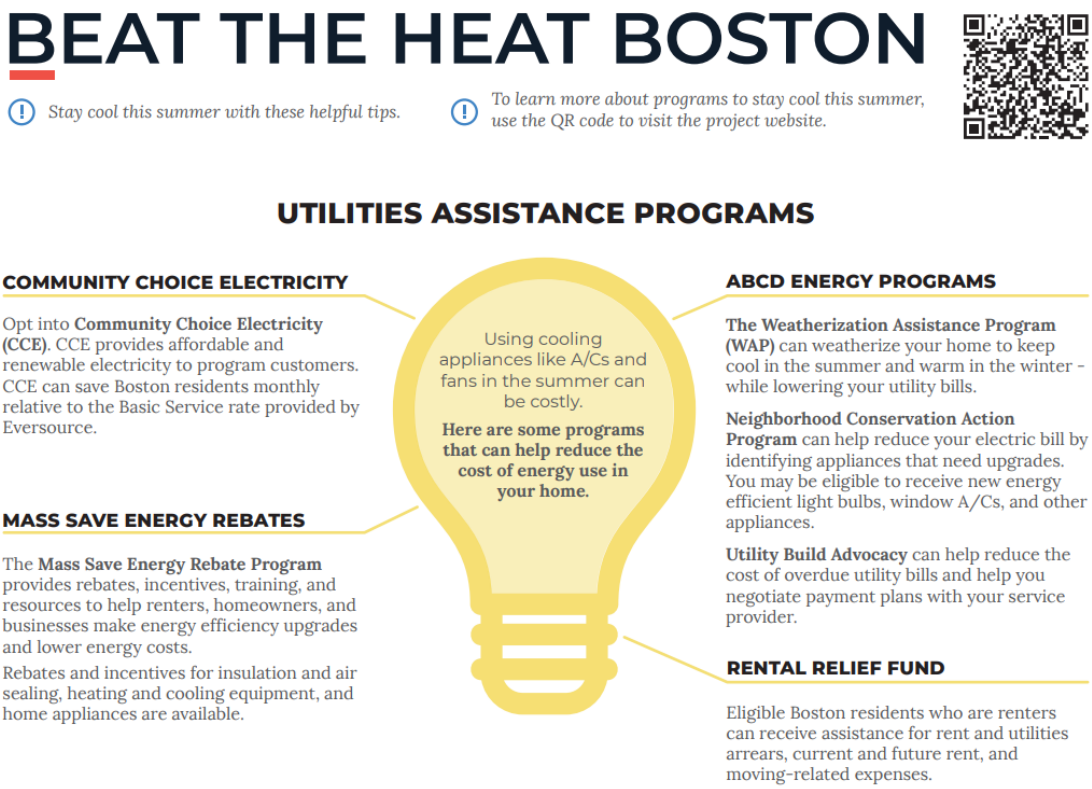
- The document had wide participation – a 12-person steering committee, a 15-person community advisory board, and with special thanks to 5 people or organizations. Additionally, there were close to two pages of additional "Special Thanks".
- The process started in the summer of 2021 and with a report in winter 2022.
- The document put forward solutions to "build a more just, equitable, and resilient Boston"
- Many nice graphics describing the factors associated with how heat is experienced. This is not specific to indoors, but the physical conditions outside (e.g., trees, transportation infrastructure).
- Graphics show where the public cooling centers were located and where official cooling center gaps existed. Additionally, graphics indicate heat levels in redlined areas (compared to other areas)
- The document called out five different neighborhoods and provided details on each (i.e., neighborhood context, heat analysis, community heat experiences and cooling ideas, and heat resilience opportunities).
- The heat resilience strategies were broken into "Relief during Heat Waves" and "Cooler Communities"



- There were five strategies for Cooler Communities – Buildings. As of October 2023, the implementation of the strategies appears to be occurring in 2 or 3 of them.
    - Home Cooling Resources Distribution – relies on the formation of the Boston Extreme Temperatures Response Task Force (Strategy 1) to distribution resources in support of cooler homes – *A May 2023 document on line (https://www.abettercity.org/docs-*

new/extreme%20heat%20primer%2051123.pdf) indicates that hoe to partner with the "anticipated" Task Force. As such, the task force is either newly formed or not yet formed as of October 2023.

- Cool Roofs Program – *City was to launch a cool roofs program with grants to a nonprofit organization to complete cool roof installations on eligible properties. Could not find that this was in place as of October 2023*



- Home Energy Retrofits – City is partnering with Mass Save through their Community First Partnership with a goal to achieve 600 projects per year in environmental justice communities in four of the neighborhoods described in the document. – *Noted within the online resource guide*
- Affordable Housing Resources and Retrofits – continue sharing information on existing resources for affordable housing owners and renters, exploring heat resilience metrics and best practices in planned redevelopment and renovation projects.
- Cool Schools – Identify opportunities to integrate appropriate resilience investments into City-owned buildings with the Renew Boston Trust (RBT). RBT is an existing initiative that conducts energy audits and installed energy conservation measures in municipal buildings. *Phase 3 describes installation of lighting and HVAC in 9 schools, 1 police station, and City Hall as well as new solar arrays. The project began in December 2021 and Implementation construction began in April 2023.*

Cal-Adapt. Accessed June-October 2023. ***https://cal-adapt.org/tools/extreme-heat***

RQ1

Main Point -Data on the temperature and heat waves.

How we used the information – We used this information to determine the various temperature data in the Bay area presented in the report.

Details:

- Modeled information on baseline (1961-1990) and forecast projections (2035-2064 and 2070-2099) by county, census tract, watershed (HUC10), census places (incorporated and census designated 2015) or Congressional districts across California.
- See appendices in the report for more details on choices made regarding the temperature models.

CalBRACE. Accessed June 2023. ***https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx***

RQ1

Main Point -Data on the percent of California households without air conditioning.

How we used the information – We used this information to count the households in the Bay area that do not have air conditioning.

Details:

- CalBRACE stands for California Building Resilience Against Climate Effect.
- There are multiple files of data on this site, categorized by three domains (environmental exposures, population sensitivity, and adaptive capacity). The adaptive capacity domain has four files - air conditioning, tree canopy, impervious surfaces, and public transit access.
- The webpage link above was last updated July 27, 2023. However, the data files are all noted to be from 2016 to 2019.
- The data in the Air Conditioning file (the file we used) was created at the end of 2016.
- This air conditioning data has a crosswalk from Adaptation Impact Region to County with data by county and region.
- The air conditioning data is old as it is based on the 2009 Residential Appliance Saturation Study (RASS). We explored the more recent 2019 RASS, but it did not support determining counts by county (which we needed for this analysis) and so we are using CalBRACE data instead.

California Assembly Bill 209. 2022. *Energy and Climate Change.* ***https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB209***

RQ4

Main Point – Brings forward specific policies to be created by January 1, 2025, and brought to the California legislature regarding recommended maximum safe indoor air temperatures (Section 31 (a))

How we used the information – **–** Explored to learn about what governments are doing to mitigate heat.

Details:

- The law was approved by the Governor and Filed with the Secretary of State on September 6, 2022.
- Section 31 (a) of the law says "On or before January 1, 2025, the Department of Housing and Community Development shall submit policy recommendations to the Legislature that are designed to ensure that residential dwelling units can maintain the recommended maximum safe indoor air temperature. The recommendations shall take into account state climate goals, the extreme heat plan, regional temperature differences, and various methods for reducing indoor air temperatures, including, but not limited to, technical feasibility, building and site electrical system limitations, cost barriers, electric utility capacity limitations, state and federal statutory requirements, and other relevant factors.
- Section 31 (b) says "In developing the recommended maximum safe indoor air temperature and policy recommendations, the Department of Housing and Community Development shall consult with stakeholders, including, but not limited to, the State Air Resources Board, the State Energy Resources Conservation and Development Commission, the Office of Planning and Research, the California Building Standards Commission, the Office of the State Fire Marshal, the State Department of Public Health, local building officials, local code enforcement officers, and community-based organizations, including those working in the areas of housing and health, tenant rights, and environmental justice."

- The California Department of Housing and Community Development (https://www.hcd.ca.gov/) has many activities. Their policies are in response to California's current housing challenges, including: 1) not enough housing being built, 2) increased inequality and lack of opportunities in housing, 3) too much of people's incomes going towards rent, 4) fewer people becoming homeowners, 5) disproportionate number of Californian's experiencing homelessness, and 6) many barriers beyond just cost in trying to find an affordable place to live.

California Department of Public Health. Accessed 2023. *Climate Change and Health Equity.*
https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx
RQ1

Main Point -Describes the website for Climate Change and Health Vulnerability Indicators (CCHVI) that is noted in a different reference here (Governor's Office of Planning and Research 2018).

How we used the information – Exploration of available data. We did not use the data from this source.

Details:

- The site includes links to the raw data behind the indicators (e.g., projected number of heat days as of 2018, palmer drought severity index, etc.) for the same three domains as described in the Regional Transportation Commission of Southern Nevada. 2023 document.

California Department of Public Health (CDPHa). 2023.
https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx
RQ1

Main Point -- This is a PDF of web pages that lists three domains and the indicators within each that define health vulnerability.

How we used the information - We used this to familiarize ourselves with different domains that are in use by others when considering health.

Details from the document:

- Environmental Exposures Domain (to focus where to best market and implement the pilot)
- Population Sensitivity Domain (to focus where to best market and implement the pilot)
- Adaptive Conditioning Domain (to focus on one potential measure to include in the pilot)
- One or more of the indicators within each domain could be useful for a heat mitigation pilot that focuses on the built environment.

The indicators are organized into **Environmental Exposures**, **Population Sensitivity**, and **Adaptive Capacity**

ENVIRONMENTAL EXPOSURES	Extreme Heat Days	Projected number of extreme heat days[1]
	Air Quality ($PM_{2.5}$)	Three-year annual mean concentration of particulate matter ($PM_{2.5}$)[3, 6]
	Air Quality (ozone)	Three-year ozone concentration exceedance above state standard[3, 6]
	Wildfires	Percent of population currently living in high risk fire hazard zone*[4, 6]
	Sea Level Rise (in coastal areas)	Percent of population living in 100-year flood zone and 55 inches of sea level rise*[2, 6]
POPULATION SENSITIVITY	Children	Percent of population aged less than 5 years[7]
	Elderly	Percent of population aged 65 years or older[7]
	Poverty	Percent of population whose income in the past year was below poverty level*[7]
	Education	Percent of population aged ≥ 25 years with less than high school educational attainment*[7]
	Outdoor Workers	Percent of population employed and aged ≥ 16 years working outdoors*[7]
	Vehicle Ownership	Percent of occupied households with no vehicle ownership*[7]
	Linguistic Isolation	Percent of households with no one aged ≥ 14 years speaking English*[7]
	Physical Disability	Percent of population with physical disability (ambulatory disability)*[7]
	Mental Disability	Percent of population with mental disability (cognitive disability)*[7]
	Health Insurance	Percent of population without health insurance[7]
	Violent Crime Rate	Number of violent crimes per 1,000 residents[8]
ADAPTIVE CAPACITY	Air Conditioning	Percent of households without air conditioning*[9, 6]
	Tree Canopy	Percent of area not covered by tree canopy*[10, 6]
	Impervious Surfaces	Percent of area covered by impervious surfaces*[10, 6]

**Indicator is weighted by population, which means the value of the indicator will be higher or lower depending on population density in the locality.*

Data Sources:

1: CalAdapt (projected to 2100), accessed 10/2018
2: CalAdapt; Pacific Institute; U.S. Geological Survey (USGS) accessed 12/2016
3: California Air Resources Board (2009-2011); CalEnviroScreen 3.0 (2012-2014)
4: California Department of Forestry and Fire (CAL FIRE) (2007)
6: U.S. Decennial Census by U.S. Census Bureau (2010)
7: American Community Survey (ACS) by U.S. Census Bureau (2011-2015)
8: Uniform Crime Reports from U.S. Federal Bureau of Investigation (2013)
9: Residential Appliance Saturation Survey (RASS) (2009)
10: National Land Cover Database (NLCD) (2011, 2016)

California Department of Public Health (CDPHb). 2023 **https://skylab.cdph.ca.gov/CCHVIz/**

RQ1

Main Point - This is a website that has census level data for multiple indicators shown in the CDPH domains above (CDPHa).

How we used the information – Exploration of available data. We did not use the data from this source.

Details:

- Some of the data sources are a little old (e.g., 2010 census or 2011-2015 ACS

California Natural Resources Agency(a). 2022. California Extreme Heat Symposium Synopsis. **https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Climate-Resilience/SAS2021/20221212-Extreme_Heat_Symposium_Synopsis.pdf**

RQ4

Main Point – Synopsis captures key highlights of the State's first Extreme Heat Symposium.

How we used the information – Explored to learn about what California and other local governments are doing to mitigate heat.

Details:

- in October, the California Natural Resources Agency (CNRA) and Governor's Office of Planning and Research (OPR) hosted the State's first Extreme Heat Symposium with the aim of informing heat adaptation decision-making and actions across sectors and regions, including the implementation of California's Extreme Heat Action Plan and OPR's recently established Extreme Heat and Community Resilience Program. The event harnessed the collective power of community leaders, State policymakers, scientists, and members of the public, and set the stage for extreme heat action in California in the coming years.
- There were four main takeaways:
  - Building a reliable and safe energy system for the future
  - Re-imagining communication to reach all
  - Addressing historical and racial inequities to address extreme heat
  - Scaling innovative solutions to yield real progress

- Many links are provided that we did not move over to this document, but others can go to the main link above to use the other links.
- To learn more about what was discussed during the Symposium, you can access the full recording of the event, a list of tools, data, and reports shared during the event, and selected speakers' contact information below:
    - Symposium Recording
- Reports, data, tools shared and referenced throughout the symposium:
    - UCLA Heat Maps website
    - Sonoma Water – Carbon Free Water
    - Sonoma Water – Climate Adaptation Plan
    - CDFA Office of Farm to Fork newsletter
    - CDFA Office of Farm to Fork survey
    - CAL FIRE Urban and Community Forestry Program website
    - Public Health Institute's State of Equity
    - Cool Roof Rating Council

California Natural Resources Agency(b). 2022. *Protecting Californians from Extreme Heat: A State Action Plan to Build Community Resilience*. ***https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Climate-Resilience/2022-Final-Extreme-Heat-Action-Plan.pdf***

RQ3

Main Point – Provides information on who is vulnerable to extreme heat and gives suggested actions to protect Californians from extreme heat using energy efficiency funds.

How we used the information – Explored to learn what others recommend occurring to see if we need to include certain measures in our modeling effort. Also explored data sources described in the document, although ultimately, we did not use those sources.

Details:

- The actions have four tracks:
    - Build Public Awareness and Notification
    - Strengthen Community Services and Response
    - Increase Resilience of Our Build Environment
    - Utilize Nature-Based Solutions
- "Extreme heat refers to temperatures that are well above normal conditions, and extreme heat events are consecutive unusually hot days and nights for a given area."
- According to the authors, *Climate vulnerable communities* will experience the worst of these effects, as heat risk is associated and correlated with physical, social, political, and economic factors. Older populations, infants and children, pregnant people, and people with chronic illness can be especially sensitive to heat exposure. Combining these characteristics and existing health inequities with additional factors, such as poverty, linguistic isolation, housing insecurity, and the legacy of racist redlining policies, can put individuals at disproportionately high risk of heat-related illness and death.
- Department of Public Health's *Climate Change and Health Vulnerability Indicators for California and their visualization platform* estimate vulnerability by census tract or smallest scale available for every county in California, including population sensitivity and adaptive capacity indicators related to extreme heat.
- The IOU Energy Savings Assistance Programs (ESAP) are noted here as a strategy for energy strategies to provide heat protection for vulnerable populations (and air pollution).
- Besides the known Codes, LIWP, and ESAP, "The Energy Commission's Research and Development programs fund several active projects that focus on improving building envelope performance in

both new constructions and retrofit situations. The envelope improvements could reduce heating and air condition use in homes. The projects build on completed research projects that promote cool surfaces and technologies, focus on reducing actions that increase heat risk and reduce indoor heat exposure, increase load flexible buildings to mitigate extreme heat (EPC-19-043, Advanced Energy-efficient and Fire-resistive Envelope Systems Utilizing Vacuum Insulation for Manufactured Homes. EPC-19-033, Demonstrating Benefits of Highly Insulating Thin-Triple Window Retrofits in California. PIR-18-007, Phase Change Material-Enhanced Insulation for Residential Exterior Wall Retrofits. EPC-19-035, Advancing Energy Efficiency in Manufactured Homes Through High Performance Envelope. "

- The document indicates a path for using EE funds -- TRACK C - GOAL 2, R8: Support installation of insulation, heat pump HVAC equipment, and facility-level clean backup generation (e.g., microgrid) at designated heat shelter facilities in tribal communities and communities most vulnerable to extreme heat events.
- Support communities in expanding energy assurance. Current energy assurance programs and resources administered by the state include:
    - The *Low-Income Weatherization Program* invests in low-income households to provide weatherization services that can protect from extreme heat, and energy efficiency services to enable more affordable and effective cooling (including HVAC, heat pumps, and solar photovoltaic system upgrades). The *Energy Efficiency and Demand Response programs* integrate the energy efficiency and demand response functions of smart thermostats to address summer peak load and keep customers comfortable. Several programs provide incentives for smart thermostats and the Public Utilities Commission is also investigating smart demand response programs in the Extreme Weather rulemaking.
    - The *Self-Generation Incentive Program*, the Disadvantaged Communities – Single-family Solar Homes program, and the *Solar on Multifamily Affordable Housing Program* focus on low-income energy resource distribution. These programs provide incentives for the installation of solar and storage on a variety of low-income housing types.
    - The *Low-Income Home Energy Assistance Program* provides low-income households financial assistance to meet immediate residential heating and/or cooling needs. The program also provides HVAC repair and replacement, and weatherization services that address energy efficiency, health, and safety.
    - The *Weatherization Assistance Program* helps reduce energy usage and costs by providing services intended to improve energy efficiency in the homes of eligible low-income households.
    - The *California Conservation Energy Corps Program* provides free energy surveys and retrofits for schools and public agencies, including ventilation and air conditioning.
    - The 2013 Report recommended the expansion of the California Local Energy Assurance Planning Program. The implementation of this action has not been completed, as the Program was discontinued.

- TRACK C - GOAL 3, R4: Provide funding for external awnings, in coordination with the Electric Program Investment Charge and Emerging Technology Programs.
    - Awnings can reduce heat impacts at a relatively low cost, reducing indoor air temperatures and facilitating less space cooling. These benefits deliver reduced GHG emissions and peak demand caused by air conditioning load spikes.

- TRACK C - GOAL 3, R6: Streamline the permitting, inspection, and approval processes for the installation of high-efficiency heat pump HVAC equipment across the State.

- This action can be advanced through grants and incentives to local building departments who can speed the approval of permits and inspections for high efficiency heat pump HVAC equipment in existing buildings.

Centers for Disease Control and Prevention. 2023. **https://gis.cdc.gov/grasp/diabetes/diabetesatlas-surveillance.html#**

RQ1

Main Point - This website provides county level prevalence of diabetes (percentage for adults 20+)

How we used the information – Exploration of available data. We did not use the data from this source

Details:

- The site includes tables and graphics by state or county of those diagnosed with diabetes.

City and County of San Francisco. 2020. *Hazards and Climate Resilience Plan.*
https://onesanfrancisco.org/sites/default/files/inline-files/HCR-SummaryReport_210126_comp2.pdf

RQ3, RQ4

Main Point – This report describes San Francisco's (city and county) latest understanding of how hazards are intensifying due to the climate crisis and what they can expect in the years to come. It presents a strategy for how San Francisco will become a safer and more resilient place by mitigating the impacts of seismic and climate hazards to our communities, buildings, and infrastructure, and adapting to what we cannot mitigate.

How we used the information – Explored to learn about what local governments are doing to mitigate heat and determine if there are any measures that we should consider for the modeling effort.

Details:

- Describes how they gathered data to create the report, their assessment process, guiding principles, and strategies. Includes information on hazards faced by San Francisco residents.
- The strategies fall into four domains with 14 key issue areas. For this lit review, four are most relevant
  - Communities domain
    - **Housing:** Build more and safer affordable housing (mainly describing earthquake issues, not heat)
    - **Vulnerable populations:** Help our most vulnerable communities prepare to stay strong in San Francisco
  - Buildings Domain
    - **Private buildings:** Promote and incentivize building retrofits (mainly for earthquake or stormwater issues)
    - **New development:** Design new buildings to better withstand hazards (includes extreme heat in this strategy)

City of Phoenix 2023 Heat Response Plan
https://www.phoenix.gov/heatsite/Documents/Heat%20Response%20Plan%202023%20-%20For%20Gen%20Info%20Packet%20Apr19.pdf

RQ5

Main Point – This document provides information on what Phoenix is doing to mitigate heat.

How we used the information - We used this report to describe other programs outside of California.

Details:

- Includes 31 different "programs" to respond to the heat and keep citizens safe
- The programs have six different focus areas, one of which is Supporting cool and safe home environments. This focus area includes six different approaches

FOCUS AREA 4. Supporting cool and safe home environments			
4.1 Cooling ordinance	RENTERS	NSD	CONTINUED
4.2 Landlord tenant program	CITYWIDE	HSD	CONTINUED
4.3 Housing repair programs and weatherization	LOW-MODERATE INCOME	NSD	CONTINUED
4.4 Emergency utility assistance	LOW INCOME	HSD	CONTINUED
4.5 Suspension of water shutoffs	LOW INCOME	WATER	CONTINUED
4.6 Navigating utility disconnection rules	LOW INCOME	OHRM	CONTINUED

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- FOCUS AREA 4. Supporting cool and safe home environments
    - 4.1 Cooling ordinance The Neighborhood Services Department enforces the City's cooling ordinance, which sets minimum temperature requirements for cooling systems in all single and multifamily rental housing units. Every rental housing unit must be capable of safely cooling all habitable rooms to 86°F if cooled by evaporative cooling and 82°F if cooled by air conditioning. City of Phoenix 2023 Heat Response Plan 22
    - 4.2 Landlord Tenant program The Human Services Department operates a Landlord Tenant program that provides educational services and information to landlords and tenants on their rights under the Arizona Residential Landlord and Tenant Act, including those related to cooling.
    - 4.3 Housing repair programs and weatherization The Neighborhood Services Department operates housing repair programs for the City, including the Home Weatherization Program. Home repair and weatherization investments can dramatically improve residents' ability to have adequately cooled indoor environments. In 2022, City Council allocated American Rescue Plan Act funding to augment the City's weatherization efforts.
    - 4.4 Emergency utility assistance The Human Services Department helps provide utility assistance for Phoenix residents through Family Service Centers. The utility assistance program has been significantly expanded in recent years with the availability of federal Covid relief funding.
    - 4.5 Suspension of water shutoffs The City will continue to operate an innovative low-flow water service program to accommodate customers having difficulty paying their water bills for a period of up to three months. This program allows residents to continue to receive water for basic needs including hydration while resolving challenges with bill payment. Customers will be directed to phoenix.gov/resources for assistance with their bill.
    - 4.6 Navigating utility disconnection rules The Arizona Corporation Commission adopted new policies in 2021 concerning utility disconnection among regulated providers in Arizona. In the City of Phoenix, electricity service is provided by both Arizona Public Service (APS) and Salt River Project (SRP), each of whom have different disconnection rules. Staff will continue to work across departments and with the 3-1-1 call center to ensure clear communication with residents about what the rules are and how to work with utilities to avoid disconnection where possible.

Chu, H., Adams, J., Li, J., Goldmuntz, S. 2021. *Equity-Focused Heat Adaptation Strategies for Los Angeles County.* **https://innovation.luskin.ucla.edu/wp-content/uploads/2021/06/Equity-Focused-Heat-Adaptation-Strategies-for-LA-County.pdf**

RQ4

Main Point – This report leverages existing literature on alternatives to Cooling Centers, spatial analysis, and expert interviews to inform which policy alternatives would best serve Los Angeles County's residents most impacted by extreme heat.

How we used the information – Explored to learn about what local governments are doing to mitigate heat.

Details:

- According to the authors, given heat adaptation's complexity, it is difficult to compare interventions that have dissimilar aims and impact heat adaptation at different timescales. Thus, this report highlights the need for policies that address different aspects of adaptation planning to address extreme heat in a holistic manner.
- This report analyzed 26 policies based on four main Policy Classification Areas and on their timeline for effectuating change. Policies were analyzed based on their alignment with the Los Angeles Countywide Sustainability Plan, Feasibility, and Efficacy. Based on these considerations, the research recommends seven primary policies.
- A substantial level of useful policy information is in this document. However, not included as bullet points since it was tangential to the purpose of this lit review.

Clark, Jordan and Ward, Ashley. 2023. *Defining Extreme Heat as a Hazard. A review of Current State Hazard Mitigation Plans*. **https://nicholasinstitute.duke.edu/sites/default/files/publications/defining-extreme-heat-hazard-review-current-state-hazard-mitigation-plans_0.pdf**

RQ5

Main Point – US states must have a Federal Emergency Management Agency–approved state hazard mitigation plan (SHMP) to apply for certain nonemergency disaster funds and funding for mitigation projects. SHMPs identify the hazards that may impact a state and detail corresponding mitigation strategies. This report assesses the treatment and definition of heat as a hazard in each state's most recent plan.

How we used the information – Explored to learn about what federal governments are doing to mitigate heat.

Details:

- The importance of extreme heat—the leading cause of weather-related death in the United States—is often understated because it does not fit easily into current SHMP guidelines. The authors provide recommendations to help states adequately evaluate the threat of extreme heat as they update their SHMPs.
- Nice report but did not review much beyond what is included in this write up since this is at the state level and specifically to help ensure that states can obtain FEMA nonemergency disaster funds.
- Out of all states, California had the second highest score when this group looked at hazard mitigation plans for extreme heat (14.5 out of 18), so already understands this issue.

Contra Costa Health Services. 2015. *2015 Climate Change Vulnerability in Contra Costa County: A Focus on Heat* ***https://cchealth.org/health-data/pdf/2015-climate-change.pdf***

RQ1

Main Point – This report describes the vulnerability of different communities in Contra Costa County to the health impacts of climate change, with a focus on extreme heat events, or heat waves.

How we used the information – Explored to learn how counties are already categorizing those who are vulnerable to extreme heat.

Details:

- Extreme heat can result in heat exhaustion and heat stroke and can worsen cardiovascular (heart and blood circulation) and respiratory (breathing) problems. Extreme heat can increase the risk of stroke, heart attack and asthma attacks.
- CDC defines extreme heat as "summertime temperatures that are substantially hotter and/or more humid for a location at that time of year." For bayside communities in West County, this could mean temperatures above 85°F, while for residents of East County this could mean temperatures above 95°F. Residents of historically cooler areas, such as West County, may be less accustomed to hot weather and may not be used to protecting themselves during hot weather. In addition to geographic differences in climate, environmental and socioeconomic factors can shape how hot weather affects county residents.

Urban areas with lots of pavement and few trees tend to be hotter, and residents without access to cars or air conditioning will have a harder time finding a cool place for refuge during hot weather.

- Groups that are at higher risk for some or all of the health threats of climate change include:
  - People working in physically demanding jobs, especially outdoors, such as construction, agriculture, landscaping, building maintenance and refinery operations;
  - Elderly residents, young children and pregnant women;
  - People with disabilities and/or preexisting health conditions, particularly respiratory and cardiovascular conditions;
  - Low-income residents with limited access to transportation, air conditioning, or healthcare;
  - Non-English speaking residents who may have difficulty accessing information.
- A combination of the factors in this report shows the following communities to be at the greatest health risk from extreme heat:
  - West County – Richmond, San Pablo, and North Richmond
  - East County – Pittsburg, Bay Point and Antioch
  - Concord's Monument District
  - Walnut Creek's Rossmoor area
  - Bethel Island
- Climate change mitigation refers to efforts to reduce human impacts on the climate, such as strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks.
  - Climate change adaptation is preparation for the effects of climate to reduce harm to human and natural systems and identify potential benefits.
  - This report is primarily concerned with adaptation: understanding the health impacts of climate change, and especially extreme heat, in order to prepare and build resilience in Contra Costa County. However, there are also opportunities to develop strategies that support both mitigation and adaptation goals.
- The report has multiple graphics showing demographic and other information and then combined them to create a heat vulnerability indicator by census tract. Indicator was created using an averaged standard score (z-score) that measures how far they differ from the average conditions. Each factor was weighted equally. They created graphics of this as well as a table of the indicator by city or place.

Cornelius, K. 2019. *How Phoenix is Working to Beat Urban Heat.*
https://www.scientificamerican.com/article/how-phoenix-is-working-to-beat-urban-heat/
RQ5

Main Point – Information on Phoenix programs.

How we used the information – Explored to learn about what programs are occurring outside of California.

Details:

- This article has information about a program called Nature's Cooling Systems (NCS – a partnership between The Nature Conservancy, ASU, and the Maricopa County Department of Health) is working to implement this program.
- The article describes where heat hits the hardest, how NCS is building trust and gathering stories, and that hurdles remain.

County of San Mateo. 2019. *Extreme Heat and Public Health. Impacts and Adaptation Solutions.*
https://www.smcsustainability.org/wp-content/uploads/Climate-Ready-SMC-Hazard-Factsheet-Extreme-Heat-and-Health-1.pdf
RQ4

Main Point – Fact sheet about heat mitigation specific to San Mateo County

How we used the information – Explored to learn about what the local government is doing to mitigating heat.

Details:

- Fact Sheet focusing on public health
- Includes substantial data (e.g., definitions, key messages, data specific to jurisdictions in San Mateo, what the county is doing, listing of vulnerable communities, mapping the health equity index (HEI), adaptation strategies, etc.)
- Has a BayREN banner that describes EE rebates for Cooler, Healthier Homes

Crownhart, Casey. 2021. MIT Technology Review "How hot is too hot for the human body?" ***https://www.technologyreview.com/2021/07/10/1028172/climate-change-human-body-extreme-heat-survival/#:~:text=A%20wet%2Dbulb%20temperature%20of,to%20maintain%20its%20core%20temperature***
RQ1

Main Point – Information on how people experience heat with description of what happens when people get too hot and information on what is too hot.

How we used the information – Exploration of heat and humans.

Details:

- Heat tolerance varies from person to person and someone's ability to withstand heat can change.
- Sweat is one of the tools to maintain core temperature – sweat that evaporates sucks heat from the skin and cools. Humidity gets in the way of this as there is already a lot of water vapor in the air and the sweat cannot evaporate as quickly.
- Children and elderly cannot regulate their temperature as well as young adults and certain medications bring about a decreased ability to sweat.
- A wet-bulb temperature of 35°C, or around 95°F, is pretty much the absolute limit of human tolerance, says Zach Schlader, a physiologist at Indiana University Bloomington. Above that, your body will not be able to lose heat to the environment efficiently enough to maintain its core temperature.
- However, conditions to get to that unlivable wet bulb varies – no wind and sunny skies with 50% relative humidity (RH), the unlivable web bulb is around 109°F, whereas if it is mostly dry air, temperatures would have to top 130°F to reach that limit.
- When the core temperature gets too hot, organs to enzymes can shut down. Extreme heat can lead to major kidney and heart problems and even brain damage.
- One can acclimatize to heat, but heat waves in cooler places are more likely to be deadly than the same conditions in hotter places or later in summer (after one is more used to the heat).

Data.gov. 2023 **https://catalog.data.gov/dataset?tags=diabetes**
RQ1

Main Point - This website has various datasets about different health issues.

How we used the information – Exploration of available data. We did not use the data from this source.

Details:

- We downloaded the U.S. Chronic Disease Indicators as a CSV.
- This is a large dataset and so have to use a PowerPivot Table with it. It has data on asthma, COPD, Diabetes, Kidney disease but only at the state level (but does have it by race or age sometimes).

FEMA. 2018. *Be Prepared for Extreme Heat.* **https://www.ready.gov/sites/default/files/2021-01/ready_extreme-heat_info-sheet.pdf**
RQ1

Main Point – Two pager with graphics about what to do if under an extreme heat warning and how to stay safe.

How we used the information – Explored to learn about what the federal government says about mitigating heat in the home.

Details:

- Try to keep your home cool:
    - Cover windows with drapes or shades.
    - Weather-strip doors and windows.
    - Use window reflectors such as aluminum foil-covered cardboard to reflect heat back outside.
    - Add insulation to keep the heat out.
    - Use a powered attic ventilator, or attic fan, to regulate the heat level of a building's attic by clearing hot air.
    - Install window air conditioners and insulate the area around them.

Fraser Health. 2023. *Fans in Extreme Heat FAQ*. **https://www.fraserhealth.ca/-/media/Project/FraserHealth/FraserHealth/Health-Topics/Sun-and-heat-safety/Fans_in_Extreme_Heat_FAQ.pdf?la=en&rev=504b5365d9b94b3bb4db6a992e3a93e9&hash=B8B28840CFFB046D3961C5A157B142C7AE2ECD2E**

RQ3

Main Point – Question and Answer format about heat and fans from a medical source (a hospital).

How we used the information – Exploration of heat and humans specific to a potential measure to mitigate heat.

Details:

- Fans create a sense of coolness when pointed directly to your body. However, they do not meaningfully lower the core body temperature, especially for older people or other susceptible people (e.g., with pre-existing conditions including heart and lung disease*). Fans do not directly cool the air and should not be used as the primary source of cooling for susceptible people in hot indoor environments. Fans are best used to circulate or move air, specifically to bring cold air into a warmer area where people are located.
    - Avoid using fans that blow air toward your body when indoor air temperatures are 35°C (95°F) or higher. Fans do not cool the air, so do not blow hot air on yourself. This can actually cause your body to get hotter.
    - When outdoor air temperatures are cooler than indoor air temperatures, use fans in windows to blow cooler air from outside into a room.
- Q: Are ceiling fans appropriate for cooling or not recommended?
    - A: These may be useful for comfort when the air is cooler than your skin, but are not advised when the temperature is above 35°C. As with other fans, ceiling fans do not provide any cooling of the air and should not be used as the primary sources of cooling for susceptible people in hot indoor environments.

Governor's Office of Planning and Research. 2018. *Defining Vulnerable Communities in the Context of Climate Adaptation.* **https://opr.ca.gov/docs/20180723-Vulnerable_Communities.pdf**

RQ1

Main Point – This report presents a definition of climate-vulnerable communities and tools that can be used to identify vulnerable communities as well as process guides for aiding in defining vulnerable communities.

How we used the information – Explored to learn how the state thinks about vulnerable communities as well as look for other potential sources of data. We did not use the data sources listed here.

Details:

- Senate Bill 246 established the Integrated Climate Adaptation and Resiliency Program (ICARP). Through its activities, the Program aims to develop holistic strategies to coordinate climate activities at the state, regional, and local levels. One of the Program's main components is the Technical Advisory Council (TAC), which brings together state and local government, non-profit and private sector practitioners,

scientists, and community leaders to help coordinate activities that better prepare California for the impacts of a changing climate.

- The document includes:
    - The ICARP Technical Advisory Council's definition of climate-vulnerable communities
    - A summary of existing statewide assessment tools that can be used to identify vulnerable communities in a climate adaptation context, including a crosswalk with the indicators that are required elements of an SB 1000 analysis
    - Additional indicators that could be used to assess underlying vulnerability on a case-by-case basis
    - A list of process guides that can serve to aid agencies undertaking efforts to define vulnerable communities
- ICARP TAC Adopted Definition: Climate vulnerability describes the degree to which natural, built, and human systems are at risk of exposure to climate change impacts. Vulnerable communities experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts. These disproportionate effects are caused by physical (built and environmental), social, political, and/or economic factor(s), which are exacerbated by climate impacts. These factors include, but are not limited to, race, class, sexual orientation and identification, national origin, and income inequality.
- Described three tools for analyzing climate risk:
    - CAL-ADAPT had climate data including annual averages, extreme heat, seal level rise, snowpack, wildfire, CDD, HDD, downscaled climate projection, and more https://cal-adapt.org/
    - Urban Heat Island Index for California - quantifies the extent and severity of urban heat islands for individual cities, including urban heat island interactive maps that show the urban heat island effect for each census tract in and around most urban areas throughout the state https://calepa.ca.gov/urban-heat-island-interactive-maps/
    - Indicators of Climate Change in California - The indicators can serve as a tool for communicating technical data in relatively simple terms and help portray the interrelationships among climate and other physical and biological elements of the environment https://oehha.ca.gov/climate-change/report/2022-report-indicators-climate-change-california
- Described four tools to begin to analyze adaptive capacity
    - CalEnviroScreen - https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40
    - Climate Change & Health Vulnerability Indicators for California (CCHVI) - The assessment data can be used to screen and prioritize where to focus deeper analysis and plan for public health actions to increase resilience. https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx
    - Healthy Places Index - interactive online data and GIS mapping tool that allows users to easily visualize the social and economic conditions that shape health in each neighborhood in California https://www.healthyplacesindex.org/
    - Regional Opportunity Index - Another mapping tool to identify census tracts lacking in opportunities and needing investment https://interact.regionalchange.ucdavis.edu/roi/
- The document includes a nice table that shows the different adaptive capacity tools and what is included in their indicators as well as a cross walk with SB 1000 (components of the Environmental Justice Element of a general plan, per Senate Bill 1000, 2016, Leyva)
- Provides a listing of three tools for local governments to use to help with any assessment process (they are not specifically created to inform a climate vulnerability assessment)
    - Executive Order B-30-15 Equity Checklist - The checklist is intended to assist agencies to ensure that plans and investments identify and protect the State's most vulnerable populations.
    - Government Alliance on Race (GARE) Racial Equity Toolkit - The Racial Equity Toolkit is designed to integrate explicit consideration of racial equity in decisions, including policies, practices, programs, and budgets

- Bay Localize Community Resilience Toolkit - The Bay Localize Community Resilience Toolkit guides groups in leading workshops to plan for resilience in their communities while decreasing reliance on fossil fuels.

Governor's Office of Planning and Research. 2018. Defining Vulnerable Communities in the Context of Climate Adaptation. https://opr.ca.gov/docs/20180723-Vulnerable_Communities.pdf

RQ1

Main Point – This document provides a listing of indicators that can be used to define vulnerable communities. The document has specific factors with multiple indicators and shows which of four different data sources that the indicator can be found.

How we used the information – Explored to learn how the state considers who is vulnerable.

Details:

- "Vulnerable communities experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts. These disproportionate effects are caused by physical (built and environmental), social, political, and/or economic factor(s), which are exacerbated by climate impacts. These factors include, but are not limited to, race, class, sexual orientation and identification, national origin, and income inequality."

Governor's Office of Planning and Research. 2023. https://opr.ca.gov/climate/icarp/grants/extreme-heat-community-resilience.html#:~:text=ICARP's%20Extreme%20Heat%20and%20Community,implementation%20in%20the%20most%20heat%2D

RQ4

Main Point – This website provides information on grants through the Extreme Heat and Community Resilience Program.

How we used the information – Explored to learn what is occurring in the state.

Details:

- The program funds projects such as creating extreme heat action plans, providing mechanical or natural shade, increasing building and surface reflectance, providing passive or low-energy cooling strategies, etc.
- Applications for funds are anticipated to be available sometime in the first quarter of 2024.

Grover, Sugeet. 2022. Cool dwellings: *Here is what you can do to make your building beat the heat.* https://www.downtoearth.org.in/author/sugeet-grover-114161

RQ3

Main Point – This document describes what influences thermal comfort and provides three examples of how to keep buildings cool.

How we used the information – Explored to learn what others recommend to occur to see if we need to include certain measures in our modeling effort.

Details:

- Human thermal comfort is a condition that expresses satisfaction with the thermal environment and is largely dependent on six key factors. They are air temperature, humidity, wind velocity, radiant temperature, metabolic rate, and clothing.
- According to the authors, shade, insulate and ventilate are three basic principles to remember for keeping the interiors of a building cool.
    - **Shade**: This can be achieved by using external shading devices, fixed or movable. Shade structures can range from awnings, horizontal sunshades to eaves, shutters, or shade sails. It is

worthwhile to remember that the internal curtains or blinds are not useful in this regard and may only be used to cut down on glare.
    - **Insulation** should be applied on external walls, especially if they are thin. Care should be taken so that the insulation covers all potential points in the building envelope from where thermal leakages can take place. In a hot climate, the insulation should ideally be placed on the exterior surface of the walls. These solutions, however, could be capital-intensive and as an immediate solution, the external walls which get direct sunlight(especially east and west facades) can be made more reflective by being painted in light colors.
    - **Ventilation** as a strategy needs to be used with precaution. Cross ventilation needs to be limited when the peak outdoor temperatures are high during the hot and dry months (April-June).This can be done by closing the windows. When the outdoor nighttime temperatures fall within comfort levels, purge the buildings by keeping the windows open at nighttime. This can store the coolth and delay the indoor peak temperatures.

Guinn Center. 2021. *Strengthening Heat Resiliency in Communities of Color in Southern Nevada*. ***https://guinncenter.org/wp-content/uploads/2021/09/Guinn-Center-Strengthening-Heat-Resiliency-in-SNV.pdf***

RQ5

Main Point – The report describes Southern Nevada's vulnerability to extreme heat that the COVID-19 pandemic exposes or exacerbates, which policies and programs have helped address those vulnerabilities, what gaps exist, and how can policy enhance adaptive capacity to extreme heat.

How we used the information – Explored to learn about what local governments are doing to mitigate heat.

Details:

- The report focused on an examination of the ways in which COVID-19 exposed existing vulnerabilities among Native Americans and Latinos in Phoenix and Las Vegas to extreme heat. According to the authors, the recommendations the research team developed are comprehensive and broad-based. As such, they are applicable to any individual and/or household who is vulnerable to extreme heat in southern Nevada.
- They analyzed 45 heat-related plans, programs, statutes, codes, and studies from 2010-2021.
    - Most of the plans, programs, and statutes address the public decision space. (According to the authors, this is not surprising, given that our team focused on government-sponsored plans, programs, and initiatives).
    - Less than half of the plans specifically address the impacts of extreme heat and vulnerabilities of residents to extreme heat in specific ways.
    - Very few of the plans include specific policies and/or interventions for mitigating extreme heat.
    - The most frequently proffered recommendations include expanded tree canopy and green streets.
- They interviewed 15 community leaders who represented a wide range of community organizations, as well as local and state government agencies. Additionally, 37 community members completed the survey; of those, 31 completed a semi-structured follow-on interview.
    - Almost two-thirds of the community members interviewed stated they were concerned about the risks posed by extreme heat.
    - Less than one-third of community members interviewed thought the government was doing enough to help the community address extreme heat.
- Provided strategies used by those interviewed to mitigate extreme heat.
- Determined policy gaps based on comparing the plans and needs described in the interviews.
- Recommendations included information and outreach, expand tree canopy, explore adoption of cool roof programs, establish fund to help residents buy or modernize home AC units, explore using the North Las Vegas ordinance of keeping room temperatures at 70 F, exploring solar roofs, ensure elderly

are connected to nonprofits that mitigate impacts of extreme heat, as well as some transit and workplace recommendations.

LBNL. 2022. *How to beat the heat: RD&D insights and directions from the experts at Berkeley Lab's Resilient Cooling Workshop 2022.* **https://drive.google.com/file/d/1zvMHJPgg-cqumqFpWE7621SICaDneXgJ/view?pli=1**

RQ3

Main Point – Over 30 leading U.S. experts in fields related to extreme heat and its mitigation gathered at Berkeley Lab's first Resilient Cooling Workshop (7 April 2022, Berkeley, CA) to unravel the societal and economical threats of climate-change driven overheating in the coming decades, and to map countermeasures.

How we used the information – Explored to learn about what experts indicate is needed to be done to help mitigate heat in buildings.

Details:

- Presenters observed that maximum urban heating often occurs in locations affected by historic racism, that community (participatory) science can advance extreme heat resilience in historically marginalized groups and communities, and that cities are already gearing up to help prevent heat-related deaths.
- Attendees of the workshop learned that building scientists around the world are investigating low-energy, low-carbon cooling strategies to protect comfort and health during disruptive events, such as heat waves coupled with power outages, and seek to upgrade building codes and other policies to promote resilient cooling.
- According to the experts,
    - near-term efforts should focus on effective deployment of readily available technologies, such as cool roofs, solar-control window films, and fans, while additional research and development (R&D) is needed to optimize and deploy cooling technologies that can seamlessly integrate into clothing, buildings, and communities with lower energy consumption, reduced environment footprint, and easy installation.
    - To accelerate the deployment of resilient cooling strategies, we need policies that (1) have measurable health and economic goals based on metrics that integrate energy efficiency and heat resilience, consider climate change, and are compared to today's baseline within a robust framework; (2) are forward looking and developed through collaboration with the scientific community, government agencies, and other key stakeholders, understanding each policy's constituency, opposition, funding sources, and potential burdens; (3) integrate incentives (e.g., financial or permitting incentives), regulations (e.g., cooling requirements in new buildings, penalties for poor performance), and a public information campaign; (4) encourage a diverse set of technologies and practices (e.g., retrofits to reduce heat gains, installation of ceiling fans or air-conditioners to provide efficient cooling, addition of thermal energy storage) as required; (5) standardize heat auditing and monitoring in buildings; and (6) promote power grid stability.

Overbey, Daniel. 2016. *Standard Effective Temperature (SET) and Thermal Comfort.* **https://www.buildingenclosureonline.com/blogs/14-the-be-blog/post/85635-standard-effective-temperature-set-and-thermal-comfort**

RQ3

Main Point – Engineering specific information about temperatures based on a specific standard and what is considered livable using that standard.

How we used the information – Explored to learn about a specific temperature that we saw others described in different literature.

Details:

- The U.S. Green Building Council adopted credits (as a pilot) for resilient design by LEED project teams. One of them is Passive Survivability and Functionality During Emergencies. Designers have to do two of the three credits to get a LEED. One of the credits is Path 2: SET.
- ANSI/ASHRAE Standard 55-2010 defines SET as follows: ***temperature, standard effective (SET):*** *the temperature of an imaginary environment at50 percent [relative humidity], less than 0.1 meters per second air speed, and [the mean radiant temperature equals the air temperature], in which the total heat loss from the skin of an imaginary occupant with an activity level of 1.0 met and a clothing level of 0.6 clo is the same as that from a person in the actual environment, with actual clothing and activity level.*
- SET is essentially the dry-bulb air temperature of a hypothetical environment at 50 percent relative humidity for occupants wearing clothing that would be standard for the given activity in the real environment.
- Livable temperatures are considered as the SET range of 54-86 degrees F.
    - According to the authors, it gets a bit complicated. For single-family and multifamily residential buildings during a one-week period occurring over the summertime peak, the building may not exceed 86 degrees F SET for more than 9 SET degrees F degree-days (216 degrees F SET hours). During the wintertime peak, the building may not drop below 54 degrees F SET for more than 9 SET degrees F degree-days throughout a one-week period.
    - For non-residential buildings, the wintertime criteria are the same as for residential, but in the summertime, a greater deviation above 86 degrees F SET is permitted: 18 degrees F SET degree-days (432 degrees F SET degree-hours) during a one-week period.

Penman A, Borst A, Hubbard S, Vearrier D. 2022. *Low-cost Options for Keeping Cool During Extreme Hot, Humid Weather*. JMSMA. 2022;63(8):210-213. **https://jmsma.scholasticahq.com/article/37291**
RQ1

Main Point – This document provides a listing of who may have difficulty with heat and how fans could be used.

How we used the information – Exploration of heat and humans from medical professionals.

Details:

- The elderly are particularly vulnerable because thermoregulatory and cardiovascular responses are impaired, with reduced physiological capacity to secrete sweat and an increased likelihood of impairment of renal function which could be exacerbated by dehydration. Certain medications (e.g., anticholinergics, antihistamines, cyclic antidepressants, medications for Parkinson's disease, and antipsychotics including phenothiazines, butyrophenones, and thioxanthenes) impair the body's ability to initiate a thermoregulatory response. Diuretics increase the risk of heat-related illness by exacerbating dehydration.
- According to the authors, the use of electric fans during a heatwave may be an effective and affordable way of keeping cool for those without (or with limited access to) air conditioning, provided consideration is taken of the ambient temperature, age, and use of medications. Skin wetting (or self-dousing) and foot immersion, but not wetting (soaking) of clothing, are useful additional measures. Electric fans are an effective method for reducing the risk of heat-related illness in typical conditions faced in hot climates with a moderately high relative humidity, such as the southern United States.

Pierce, D. W., J. F. Kalansky, and D. R. Cayan, (Scripps Institution of Oceanography). 2018. Climate, Drought, and Sea Level Rise Scenarios for the Fourth California Climate Assessment. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CNRA-CEC-2018-006**.**
https://www.energy.ca.gov/sites/default/files/2019-11/Projections_CCCA4-CEC-2018-006_ADA.pdf
RQ1

Main Point - This is the detailed report for the Fourth California Climate Assessment.

How we used the information - We used this report to help determine which of the various climate models was used for the Fourth Climate Change Assessment.

Details:

- The authors used 32 GCMs from both domestic and international institutions and developed subsets to reduce the data volume (of ~40TB for the 32 GCMs). They whittled it down to 10 and then created 4 models.

Pittalwala, Iqbal. 2021. *"It's not just hot. It's dangerous"* **https://www.universityofcalifornia.edu/news/its-not-just-hot-its-dangerous#:~:text=If%20the%20outside%20temperature%20is,%2C%20dizziness%2C%20and%20other%20symptoms**.

RQ1

Main Point – Discussion with UC Riverside physicians Rajesh Gulati and Brigham Willis about heat and humans.

How we used the information – Exploration of heat and humans from medical professionals.

Details:

- If the outside temperature is between 90 and 105 F, it can cause heat cramps.
- If it is between 105 and 130 F, heat exhaustion can occur.
- If above 130 F, it can cause heat stroke.

Public health Institute. 2023 **https://trackingcalifornia.org/main/maps-and-data**

RQ1

Main Point - This website provides county level data on asthma, COPD, heart attaches, and heat related illness (hospitalizations and deaths by county)

How we used the information – Exploration of available data. We did not use the data from this source.

Details:

- None

Regional Transportation Commission of Southern Nevada. 2023. *Extreme Heat Vulnerability.* https://www.rtcsnv.com/projects-initiatives

RQ1

Main Point – Describes a heat vulnerability index and mapping to identify areas in the region where populations are at high risk to extreme heat.

How we used the information – Explored to learn about what local governments are doing to mitigate heat.

Details:

- Current examination and discussion of extreme heat vulnerability center around three components of heat vulnerability, which take these factors into account.
    - **Exposure to extreme heat** – Weather patterns, as well as both the natural and built environments can influence levels of exposure to extreme heat.
    - **Sensitivity to extreme heat** – Demographic, physiological, and health factors may predispose individuals to greater risk from exposure during extreme heat events.
    - **Adaptive capacity** – The ability to prepare for or cope with extreme heat impacts, whether through economic, political, or social resources.

Sloman, Leila. 2019. *Fans May Be Okay for Muggy Days – but Avoid them in Extreme Dry Heat.* **https://www.scientificamerican.com/article/fans-may-be-okay-for-muggy-days-but-avoid-them-in-extreme-dry-heat/**

RQ1

Main Point – Discussion about heat and fans from a scientific source.

How we used the information – Exploration of heat and humans specific to a potential measure to mitigate heat.

Details:

- Current official guidelines hold that fans are worse than useless in extreme heat. But new research shows they can still help cool people off in ultra hot conditions—as long as the humidity is relatively high.
- The EPA's *Excessive Heat Events Guidebook* warns against relying on fans when the heat index is above 99 degrees Fahrenheit. The World Health Organization's Regional Office for Europe similarly cautions that "at temperatures above 35 [degrees Celsius (95 degrees F)] fans may not prevent heat related illness."
- In dry conditions, with a heat index of 46 degrees C (114.8 degrees F) and temperature of 47degrees C (116.6 degrees F), almost all the heat stress indicators worsened when a fan was blowing. But in humid conditions, fans improved comfort—and even slightly lowered heartrate and temperature—on average, despite a sky-high heat index of 56 degrees C (132.8degrees F) and a temperature of 40 degrees C (104 degrees F). Fan use increased the risk of dehydration in both scenarios, though.
- According to the authors, additional work is needed to draw more detailed conclusions. "It shows the principle, but unfortunately, it's not broad enough in the number of different climates to show you exactly when it changes from beneficial to nonbeneficial…"

Social Determinants of Health database. *Accessed June **2023*** **https://www.ahrq.gov/sdoh/data-analytics/sdoh-data.html**

RQ1

Main Point – Data by county and census tract of different social determinants of health.

How we used the information – We used this data to determine counts of Bay area people with certain health conditions.

Details:

- The data files include information from the 2019 American Community Survey on population, housing units and other information (e.g., median income, age), enabling counts of people and counts of households.

Solis, Jennifer. 2022. *Tree-planting program launched to mitigate severe Las Vegas "heat island effect".* **https://www.nevadacurrent.com/2022/04/29/tree-planting-program-launched-to-mitigate-a-severe-las-vegas-heat-island-effect/**

RQ1

Main Point – Information about Las Vegas and their plans to plant close to 60,000 trees across the city by 2050.

How we used the information – Explored to learn about what the local government is doing to mitigating heat.

Details:

- A recent study by American Forests examining tree canopies across the country underscored how east Las Vegas residents are negatively affected by the heat island effect because there is significantly lower tree canopy, said Daseler The study found that neighborhoods with a majority of people of color have 33% less tree canopy on average than majority white communities. And neighborhoods with 90% or more of their residents living in poverty have 41% less tree canopy than communities with only10% or less of the population in poverty.
- Finding the trees that can survive future climate hikes and water restrictions is part of the city's work, said Daseler. Ash, Catalpas, and Purple-Leaf Plum trees —all planted in Las Vegas in mass—have not "proven to be long term trees." Some trees with significant canopy have proved to be compatible with

the Las Vegas climate, including North Indian rosewood, and some varieties of acacia, eucalyptus, and mesquite.

Office of the Arizona Governor. 2023. Governor Katie Hobbs Writes Utility Companies Demanding Written Plans, Meeting on Heat Wave. https://azgovernor.gov/office-arizona-governor/news/2023/07/governor-katie-hobbs-writes-utility-companies-demanding-written
RQ5

Main Point: In the letter, Governor Hobbs also extended an invitation to attend a roundtable meeting to discuss how Arizona can better prepare for future heat waves

How we used the information: Explored to learn about what the local government is doing to mitigating heat.

Details:

- The Arizona governor asked for action plans focusing on disconnects, grid security, emergency response, customers in arrears, and community service.

The Nature Conservancy in Arizona. 2022.
https://www.phoenix.gov/oepsite/Documents/Agenda%20Item%206%20NCS_PP%20020220_ab.pdf
RQ5

Main Point – Provides details on the Nature's Cooling Systems (NCS) project.

How we used the information – Explored to learn about programs outside of California that seek to mitigate heat.

Details:

- This PowerPoint describes that the hottest communities in the greater Phoenix area have the lowest tree canopy and the highest child poverty (has maps).
- The NCS seeks to "green" areas to mitigate heat with plants.
- Includes information on the Heat Action Planning Guide.
- NCS has created a Virtual Urban Heat Leadership Academy to "equip community residents in Greater Phoenix with the knowledge, resources and skills to mobilize their communities and advocate for greener, cooler, and healthier neighborhoods."

UCLA Luskin Center for Innovation. 2022. *Guidance for an Equitable and Effective State Strategy.*
https://innovation.luskin.ucla.edu/wp-content/uploads/2022/07/Protecting-Californians-with-Heat-Resilient-Homes.pdf
RQ1, RQ3

Main Point – Provides background information on heat in homes as well as why temperatures need to be mitigated and gives recommendations to help create resilient homes.

How we used the information – Explored to learn about who has difficulty with temperature as well as what others recommend to occur to see if we need to include certain measures in our modeling effort.

Details:

- Folks with chronic health conditions, such as cardiovascular disease and obesity, face greater challenges to regulating core body temperature and reducing heat-induced stress.
- 20% of owner occupied and 29% of rental units in CA are not equipped with central or room ACs
- Even with AC, low-income residents tend to live in older and substandard structures, where there is lower thermal performance and so larger electricity costs.
- This document provides recommendations for action to heat-resilient homes and health households. These recommendations are built on their 2021 report (Adapting to Extreme Heat in California: Assessing Gaps in State-level Policies and Funding Opportunities).

- Another document they note here is “California’s Extreme Heat Action Plan”, released in April 2022 (which we review as well, California Natural Resources Agency(b)).
- Their recommendations are by area and are:
    - Update habitability standards and residential building codes for a hotter future
        - Update the definition of “habitability” to require active and/or passive cooling in rental units
        - Update building codes to set maximum temperature limits for new and remodeled housing, and existing rental housing
            - **AB 2597** (Bloom) provides a starting place for requiring access to safe indoor ambient air temperatures in homes. The bill seeks to amend the California Code of Regulations to address the lack of heat protective standards. The specifics of how the bill will address heat are still being determined through an iterative process. *(Note that this bill is not passed as of November 2022, but also has not yet died as of October 2023)*
    - Bolster funding for the installation and use of home cooling strategies
        - Robustly fund programs to retrofit homes against heat
            - Home retrofit programs, including the Low-Income Weatherization Program (LIWP), could be expanded to include more options for cooling. LIWP currently provides funding for low-income households to replace their old air conditioners with more energy-efficient options, but not to install air conditioners in homes that do not already have one. In fact, there is no state program that provides new, non-replacement air conditioners or energy-efficient heat pumps to vulnerable households at no cost.
            - SB1261 (Stern) would establish a new grant program for extreme heat mitigation and building decarbonization in multifamily dwelling buildings. *(Note that this bill is not passed as of November 2022, but also has not yet died as of October 2023)*
        - Help Californians afford to use cooling strategies at home
        - Focus on program access for frontline residents
            - We recommend that the state recruit and fund community organizations to conduct targeted outreach to heat vulnerable populations, with a focus on culturally responsive, multilingual, and direct enrollment support.
    - Address policy and programming gaps to protect the most heat-vulnerable residents
        - Research and develop interventions for vulnerable housing types
        - Expand community resilience centers to protect unhoused residents and other community members

US EPA. 2008. *Heat Island Reduction Activities.* *https://www.epa.gov/sites/default/files/2017-05/documents/reducing_urban_heat_islands_ch_6.pdf*

RQ5

Main Point - Highlights a variety of urban heat island reduction activities around the country

How we used the information – Exploration of programs outside of California

Details:

- This is a 15-year old document and many of the noted programs are no longer in place (at least that we could find) but the document does show what has been included in the past.
- Most community strategies to reduce heat islands have relied on voluntary efforts, which can generally be grouped into the following categories: • Demonstration projects • Incentive programs • Urban forestry programs • Weatherization • Outreach and education • Awards.

- Chicago established a green and cool roof grant program in 2005. *I could not find anything on the City of Chicago website about such a grant program.*
- The Pennsylvania Department of Environmental Protection's Energy Harvest Program has been providing grants for specific energy saving projects since 2003. In 2007, it dispensed more than $500,000 to green roof projects across the state. *I could not find anything on the Pennsylvania Department of Environmental Protection website about such a grant program.*
- The Houston Downtown Management District (HDMD) Vertical Gardens Matching Grant initiative first gave grants in 2007 to encourage plantings that cover walls. *I could not find anything on the Pennsylvania Department of Environmental Protection website about such a grant program.*
- Since 2002, Austin Energy has given 10-cent-per-square-foot rebates for cool roof installations. *I could not find anything on the Austin website about such a grant program (although there was information about Cool Roofs).*

US EPA. 2023. *Heat Island Community Actions Database.* **https://www.epa.gov/heatislands/heat-island-community-actions-database**

RQ5

Main Point – Listing of 32 localities taking action across five southwest states around heat island actions.

How we used the information – Explored to learn about what the local government is doing to mitigating heat.

Details:

- While the DB indicated last being updated in January 2023, much of the information is older.
- A count of the information is shown below

State	Localities in the state with initiative	Initiatives			
		Trees	Green or Cool Roofs	Cool Pavement	Other
CA	22	14	13	8	2
AZ	7	4	3	3	1
UT	1	1	1	1	0
CO	1	0	1	0	1
NM	1	1	0	0	0
Total	32	20	18	12	4

U.S. Green Building Council. 2016. *Passive Survivability and Back-up Power During Disruptions.* **https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-48**

RQ5

Main Point – This article describes how to obtain the 2 LEED pilot credits to keep buildings survivable during power disruptions.

How we used the information – Explored to learn the US Green Council is seeking to mitigate heat within buildings.

Details:

- The article defines the various compliance paths for two options.
    - Option 1: Provide for Passive Survivability (thermal safety).To ensure that buildings will maintain safe thermal conditions in the event of an extended power outage or loss of heating fuel or provide backup power to satisfy critical loads.
    - Option 2: Provide backup power for critical loads .The electricity needed by a building to maintain a reasonable level of functionality during an extended power outage will vary greatly, depending on building function.
- Note that some buildings are required by code to provide thermal conditions that may not be achievable through passive means. Most nursing homes, for example, must not fall below 71°F (22°C) in the

wintertime, or exceed 81°F (27°C) during the summer. Backup power may be required to maintain these conditions. Such buildings could still be designed to achieve passive survivability as defined herein, but such buildings would also need to rely on backup power to achieve those code-mandated comfort conditions.

Wei, M., Kaiyu S., Henry W., Patricia K., Lino S., Sang Hoon L., Miguel H., Tianzhen H., Tia T., Foster C., Kim J., Bodanyi R., Dominguez D., Kumar D. 2023. *Building Healthier and More Energy-Efficient Communities in Fresno and the Central Valley* ***https://eta-publications.lbl.gov/sites/default/files/building_healthier.pdf***
RQ3

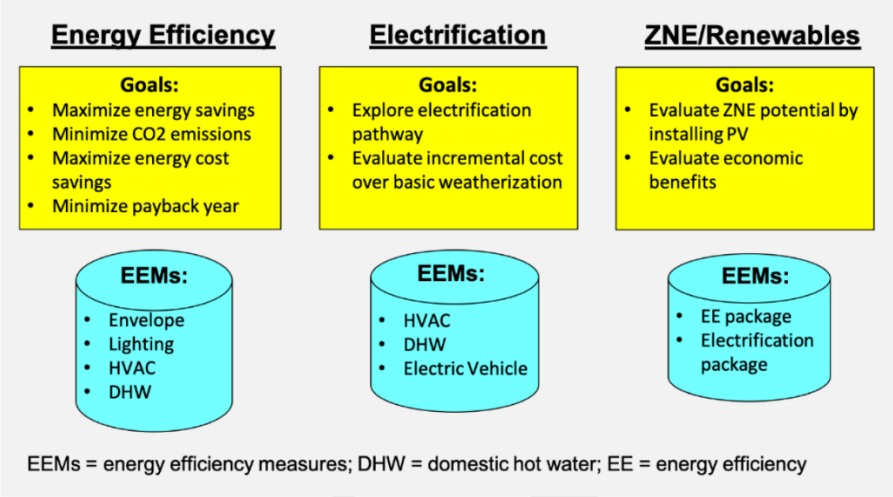
Main Point – This report discusses the creation of a community action plan to improve access to achieve climate benefits and air quality improvements through energy efficiency measures, electrification, and distributed energy resources in the residential building and light-duty (LDV) and medium-duty (MDV) transportation sectors in the city of Fresno.

How we used the information – Explored to learn about programs and activities occurring in California to mitigate heat.

Details:

- LBNL prepared this research document for the California Energy Commission under contract EPC-17-035. At the time of our research the CEC does not appear to have published this report as this document has a "draft" watermark and searching online on the CEC website did not find the publication
- The project approach combined community outreach, policy analysis, and technical modeling. Outreach methods included stakeholder interviews and phone surveys. Technical modeling included integrated modeling of residential buildings and vehicles and modeling the benefits of adding solar PV and battery storage to a community center. The project found that 70% of residents are not comfortable in their homes in hot weather and revealed a lack of awareness of existing clean energy incentives.
- Effective interventions and policy development is urgently needed to ensure resident safety at home from extreme heat. Adding used EV and rooftop PV to building electrification measures can reduce overall household energy costs, but more aggressive financing programs are needed to cover high initial costs. Awareness and transactional barriers can be mitigated with more "one-stop shop" incentive programs.
- The project's modeling included energy efficiency packages that were less than $1000 to install and indicated up to 10% annual energy savings
    - The project had three goals for the modeling

Figure 5: Scope and goals of the building modeling tasks



Source: LBNL Authors' figure

- Single- and multi-family home prototypes based on prescriptive requirements in California's Title 24, Part 6 building energy efficiency standards (hereinafter, "Title 24") (California Energy Commission, 2018a) were used to model single-building performance, using EnergyPlus version 9.2 as the simulation engine.
- The project found that "solar window films, roof/ceiling insulation, and cool walls are the among the most effective passive cooling measures that do not require electricity, and natural ventilation on top floors is very helpful."
- The project also found that "helpful active cooling measures include fans (reduce electricity costs) and mini-split heat pumps (can provide high energy efficiency cooling and heating in homes that lack ductwork). However, the benefits of installing a mini-split heat pump need to be weighed against its high initial cost."

- Appendix D of this report has all the modeling assumptions and the information on the 22 energy efficiency measures they modeled (both the baseline and the energy efficient assumptions).