Indoor Air Quality & Thermal Comfort Pilot Study

Oakland Unified School District

Laurel Elementary School

Manzanita Campus

West Oakland Middle School

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Guttmann & Blaevoet
CONSULTING ENGINEERS

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Introduction

The Oakland Unified School District (OUSD) Indoor Air Quality (IAQ) Pilot is intended to act as a program to identify and analyze deficiencies regarding thermal comfort and indoor air quality, suggest improvements, and analyze proposed retrofits for cost-benefit ratio. As climate change begins to affect older campuses, the classrooms are mainly afflicted by overheating and OUSD is seeking to improve the indoor learning environment. The focus for improvement is to prioritize passive solutions such as shading and ceiling fans, over active solutions, like air conditioning. The project also seeks to deploy temperature and IAQ sensors indoors to assist in verifying the analysis and prioritizing the areas to retrofit.

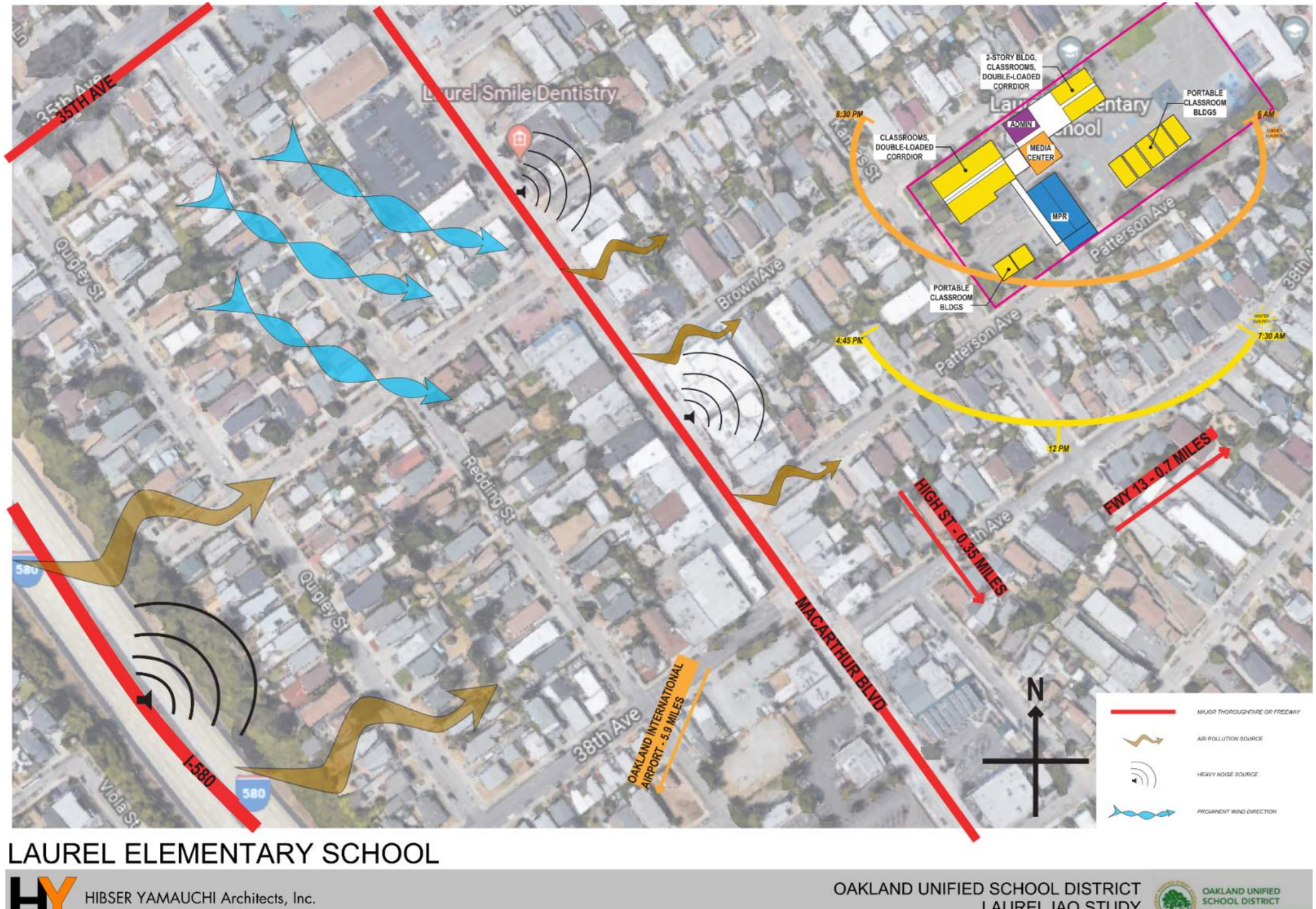
The study was conducted by a design team consisting of HY Architects, Alter Engineering, WKM Engineers, and OUSD staff. The design team conducted a site visit to each of the three campuses on June 6, 2022 and June 23, 2022 to survey which classrooms would be modeled digitally and where to implement the temperature and IAQ sensors. The information gathered during these site visits is explained in the following section, and further explored in the Existing Conditions Assessment Report. The final selection of rooms to include in the study was done by Buildings & Grounds crew on August 25, 2022 via Zoom presentation. Five rooms were selected at each campus that would be considered "typical" classrooms, administrative space, or multi-purpose rooms. The mechanical firm, Alter Engineering, conducted their digital modeling study, and the design team discussed which mitigation methods to further pursue on October 20, 2022. On December 8, 2022, the design team presented the existing conditions and five mitigation methods to OUSD at the District Offices. The Director of Facilities selected the base level mitigation, the passive mitigation, air conditioning mitigation, and air conditioning plus base level mitigation as the four methods to pursue into the cost-benefit analysis stage. At this meeting, the design team considered feedback concerns from district staff including their ability to maintain new ceiling fans and actuators for windows, plus the potential security issues of adding more operable windows. Both were addressed by including minimal new equipment and security screens at new operable windows.

After this meeting, the design team brought on the firm Guttmann & Blaevoet to provide a Life Cycle Cost Analysis to compare the lifetime cost of the four mitigation methods versus no mitigation action taken. The cost estimate was done based on the mitigation methods being performed as a part of a larger scope, and therefore does not include costs for DSA review or other design contingencies. A short-term cost estimate and life cycle cost estimate are shown in the appendix for each school and each mitigation method. An explanation of how to read the Life Cycle Cost Analyses is also provided in the Appendix. This report is intended to assist OUSD in making an informed decision on how to best improve the learning environments at each campus based on their own existing conditions.

Existing Conditions Assessment

Three campuses have been selected for study in the pilot program: Laurel Elementary School, Manzanita Elementary School Campus (which includes Manzanita Seed and Manzanita Community School), and West Oakland Middle School. The pilot program team, in conjunction with OUSD, has selected five spaces at each campus for analysis. These spaces are intended to be representative of typical classrooms or multi-use rooms across the district and would therefore be useful studies for future retrofit projects as base models.

To assist in understanding the existing conditions and evaluating which rooms to select, a site visit was conducted at each campus to document the state of existing mechanical and architectural systems. These conditions included items that affect the efficiency of the building, such as single-pane glazing, heat gain from adjacent surfaces, and unshaded south-facing glazing. See existing conditions report for additional information on this assessment, dated September 12, 2022.



LAUREL ELEMENTARY SCHOOL

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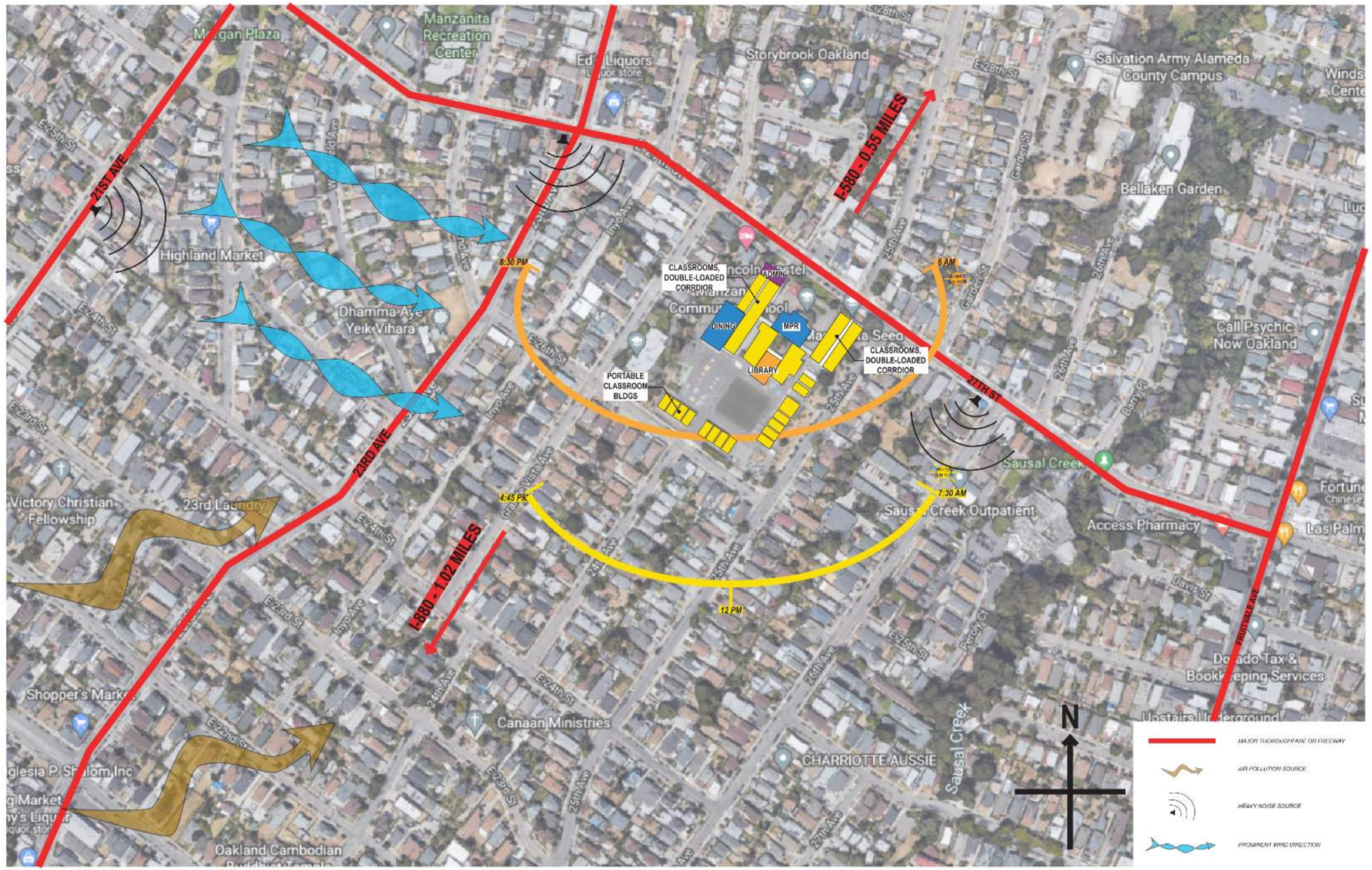
OAKLAND UNIFIED SCHOOL DISTRICT
LAUREL IAQ STUDY

MAY 2022



MANZANITA CAMPUS

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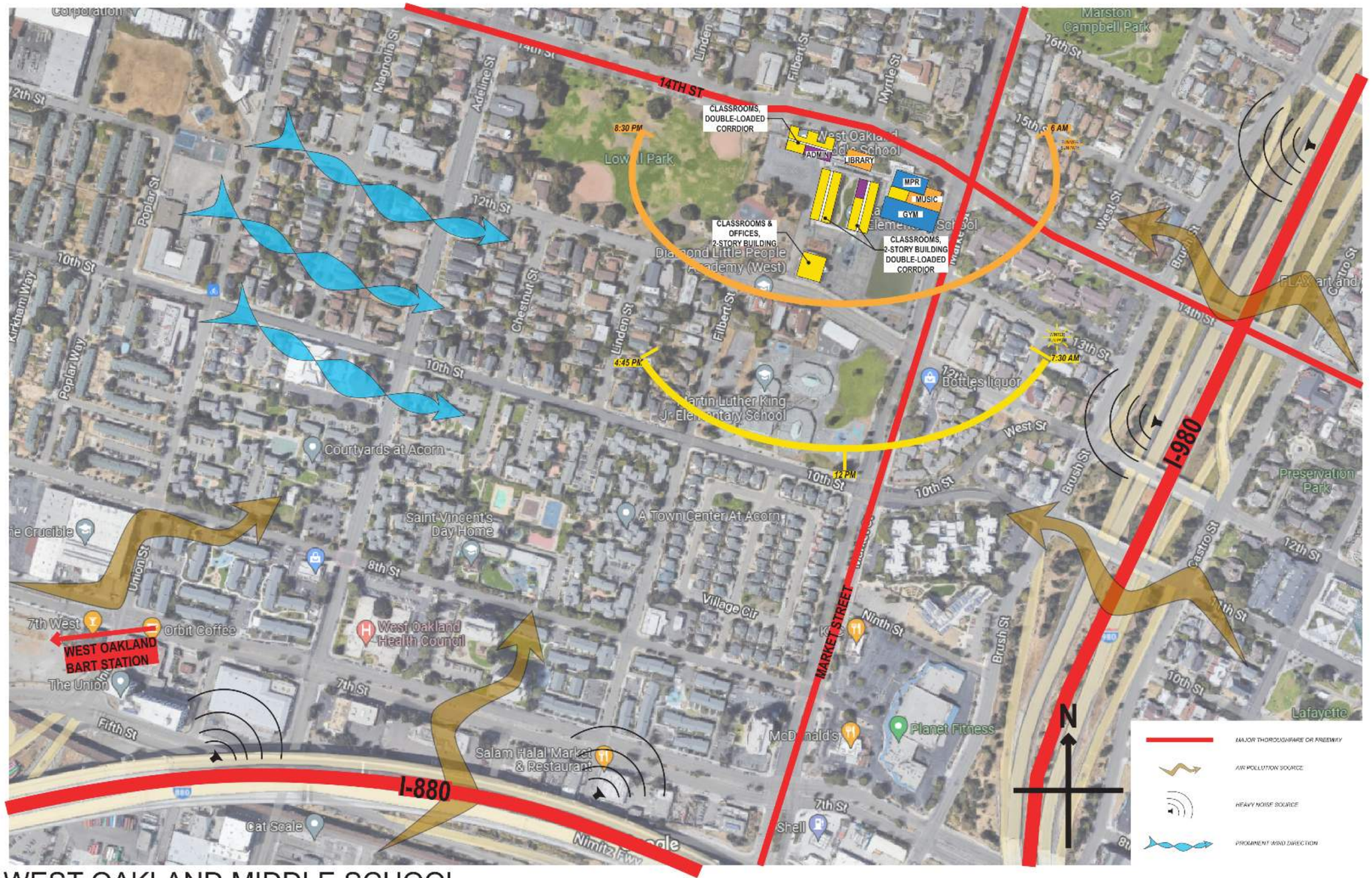
MANZANITA IAQ STUDY

MAY 2022



WEST OAKLAND MIDDLE SCHOOL

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OAKLAND UNIFIED SCHOOL DISTRICT
WEST OAKLAND MIDDLE SCHOOL IAQ STUDY

OAKLAND UNIFIED SCHOOL DISTRICT
Community Schools, Thriving Students

MAY 2022

Energy Modeling

The team used an energy modeling approach to estimate methods to improve thermal comfort at OUSD schools. Energy modeling involves the creation of a digital representation of a building. An energy model contains data which captures the key assumptions of the building such as wall materials, insulation, location in building, exposure, and windows. Assumptions are also made for heat generating items within the building, such as the heat from occupants, lights, and electricity consuming equipment such as computers.

These assumptions are then applied to a digital model of the building via a simulation program, which then estimates how the interior building temperatures will respond to the outdoor weather conditions. Weather conditions are sourced from weather files, which represent a typical year. These simulations result in the interior temperature conditions of the building at every single hour of a calendar year. Our study focuses on the hours between 8am and 4pm during the months of August to May. These temperatures help the team assess the indoor thermal comfort of the spaces.

Our study also includes the effects of building HVAC systems and passive conditioning systems. For example, the HVAC system will apply heating or cooling (if installed), to maintain the building at a particular temperature setpoint. Natural ventilation will allow operable windows to open or close, bringing outdoor air into the space to assist in maintaining desirable temperature setpoints. Operating strategies and schedules will determine the effectiveness of the building HVAC systems.

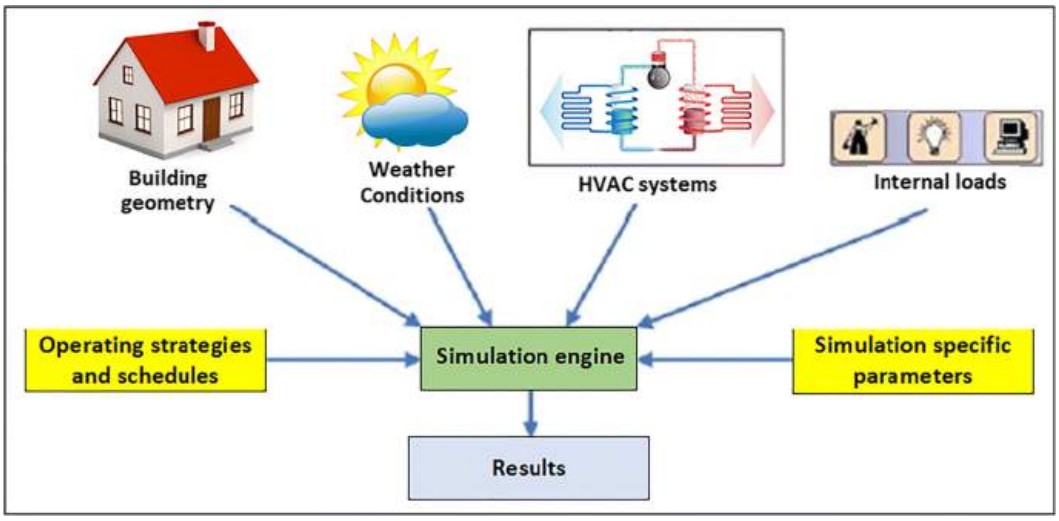

Figure 1: Building Energy Model Chart

Thermal Comfort Analysis

While energy modeling provides the interior temperature data of the school, thermal comfort analysis provides insight on the resulting temperatures' effect on how occupants will feel. Though the human body perceives thermal comfort from a number of factors, indoor air temperature is the most typical factor in which the indoor thermal environment is considered. The science of thermal comfort has produced models of thermal comfort or dissatisfaction which take input from a number of variables, summarized in Figure 2.

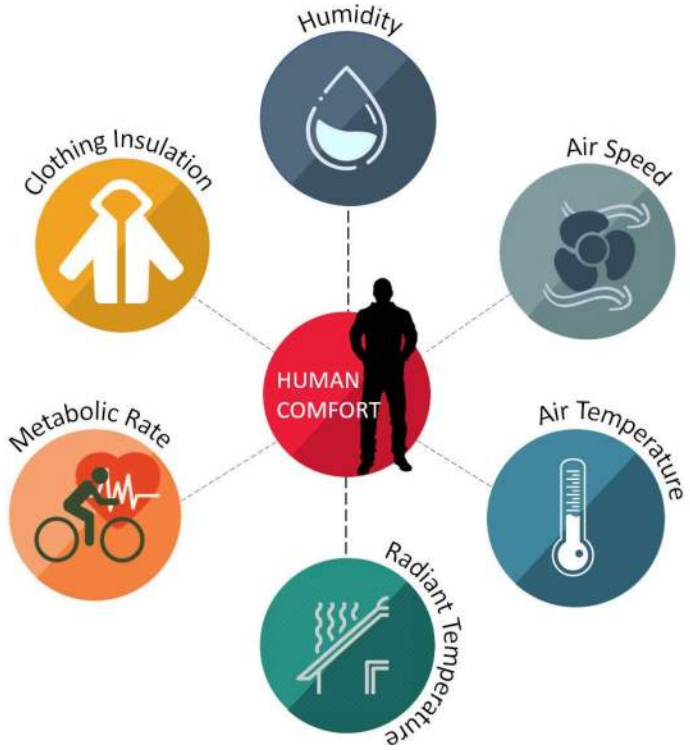

Figure 2: Variables which effect thermal comfort

Most of these variables' effects on thermal comfort are well-documented. Most people know to put on a sweater if they are cold or that standing near a fan will help cool them off. Less commonly discussed is the effect of radiant temperature. The radiant temperature is defined as the average surface temperature of objects surrounding the occupant. The radiant temperature can easily be understood by considering the effect a fireplace has on an occupant. These provide heat to occupants via radiant exchange rather than heating the air.

The variables shown in Figure 2 are used in many thermal comfort models to estimate the comfort level of occupants in buildings, such as the PMV model. These models were noted to perform poorly in passive spaces relying on natural ventilation, suggesting there is a psychological and seasonal component to comfort in passively conditioned spaces. In order to better understand and predict thermal comfort in passively conditioned spaces, the Adaptive Thermal Comfort Standard was created. Rather than being based on theoretical heat transfer principles, it is based on empirical data – specifically, a collection of surveys of occupants in passively conditioned spaces. The development of the

standard found that, in naturally ventilated spaces, the most important variables are interior air temperature, interior radiant temperature, air speed, and mean monthly outdoor air temperature.

A few assumptions are made regarding the standard:

- The building must not have air conditioning installed.
- The heating system must not be running.
- Occupants must be free to vary their clothing for their own comfort (e.g., not valid for an office that requires business suits every day)

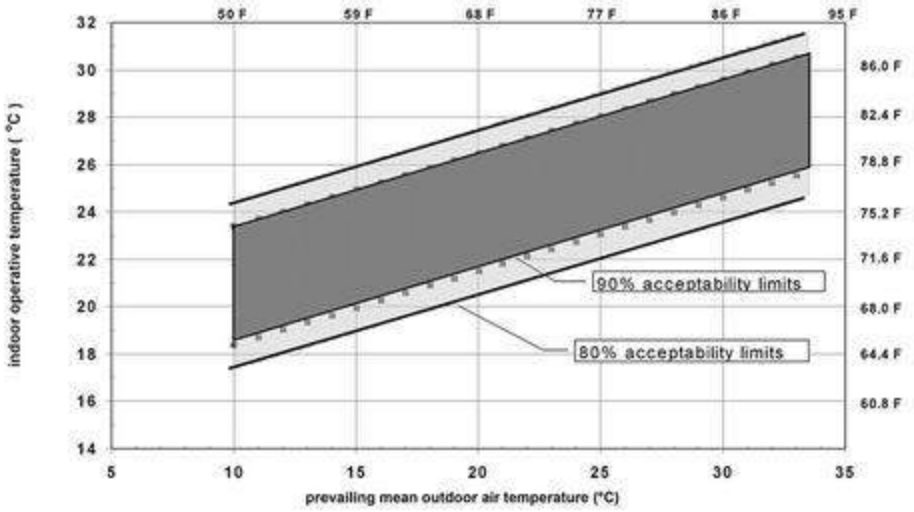

Figure 3: Adaptive Thermal Comfort Standard

Since the standard isn't meant to be used when the heating is operating, we recommend only considering the standard for analyzing when the building is too hot.

For the purposes of our study, we use the Adaptive Comfort model for evaluating the thermal comfort of the schools in our study, since the existing schools are all passively conditioned.

There is a modification of the Adaptive Thermal Comfort study that can be used in air-conditioned buildings. This allows us to study solutions to thermal comfort problems provided by air conditioning in a more directly comparable way to passive solutions. This alternative formulation uses the same empirical relationships, but uses a different dataset, which was formulated via a survey of fully conditioned buildings. The results will be presented in terms of the summed hours of the year which are "too hot" according to the Adaptive Thermal Comfort Standard, as well as the annual summation of the "degrees from neutral", meaning how much higher the operative temperature of the space is compared to the neutral, comfortable operative temperature.

Mitigation Method Selection

The mitigation methods to include in the study were selected by a group of district representatives on the advice of the design analysis team on December 8, 2022. The design team presented energy model-based data on the effects of the following mitigation options:

- Ceiling fans
- Increase operable window area (keep existing windows)
- Night flush
- Shading at exterior windows
- New low-E double-pane windows
- Daylight sensors
- R-30 roof insulation

The effect of each mitigation option demonstrated that while each individually influenced comfort hours, the best possible outcome would be achieved by improving the building envelope performance. Interestingly, improving the building envelope also increased the effectiveness of the other mitigation options. While the ultimate goal of Oakland Unified is to avoid air conditioning across the district, the design team and district elected to include this option in the study to demonstrate the necessity of upgrading the building envelope as a prerequisite before any other mitigation method is implemented.

This information led the design team and district representatives to choose the following mitigation methods for the pilot study:

1. *Basic mitigation* – Remove and replace the existing windows and frames with dual-glazed, low-E window systems that will maximize operable vents.
2. *Passive mitigation* – Basic mitigation plus actuators tied to an Energy Management System, ceiling fans in each classroom, natural night flush, security screens at operable windows, and R-30 roof insulation.
3. *Air Conditioning Retrofit* – Modify existing mechanical systems to include air conditioning.
4. *Air Conditioning Retrofit PLUS* – Basic Mitigation plus Air Conditioning Retrofit

These four methods are applied to each campus and each specific classroom selected for the study is modeled in the Appendix.

Cost Benefit Analysis

Once the mitigation methods had been selected, Silva Cost Consulting prepared a cost estimate. The scope of work for each school includes only that which is described in the mitigation methods; it does not include DSA fees or other soft costs and it also assumes price of construction in 2023 dollars. This allows the district to look at the hard construction cost of each method rather than comparing additional soft costs, which would likely remain the same across all methods. This is meant to allow the costs to be taken as a standalone project or as part of a larger campus modernization project.

	Laurel Elementary School					Manzanita Elementary School					West Oakland Middle School				
	Initial Cost	Normalized Initial Cost*	Lifecycle Cost	% Increased Comfort Hours from Existing Conditions	% ICH per $	Initial Cost	Normalized Initial Cost*	Lifecycle Cost	% Increased Comfort Hours from Existing Conditions	% ICH per $	Initial Cost	Normalized Initial Cost*	Lifecycle Cost	% Increased Comfort Hours from Existing Conditions	% ICH per $
Basic Mitigation	$883,388	$149,174	$414,670	47%	5.32%	$1,758,813	$151,531	$242,531	59%	3.35%	$2,963,031	$349,203	$481,606	55%	1.86%
Passive Mitigation	$1,724,910	$543,966	$803,865	90%	5.22%	$3,519,724	$303,243	$393,052	91%	2.59%	$4,427,024	$999,654	$1,109,487	91%	2.06%
Air Conditioning Retrofit	$4,844,206	$1,527,664	$1,985,908	91%	1.88%	$5,628,678	$484,941	$622,637	99%	1.76%	$8,702,931	$1,965,185	$2,099,633	68%	0.78%
Air Conditioning Retrofit PLUS	$5,727,594	$1,639,151	$2,096,121	100%	1.75%	$7,387,492	$636,473	$765,432	100%	1.35%	$12,615,308	$2,279,310	$2,411,247	97%	0.77%

** Normalized Initial Cost is the basis of the life cycle cost analysis, and is a modified version of the Initial Cost. The normalized cost is derived dividing Initial Cost by the total affected area to obtain a cost/square foot. This dollar amount is then applied to the area analyzed.*

Conclusions & Next Steps

The methods studied are intended to represent a basic economic option, an optimal fully passive option, and a combination of air conditioning with passive options as the best possible reduction in discomfort. The results of the digital modeling show that replacing windows to improve the building envelope does significantly reduce discomfort, and by studying air conditioning as a standalone solution, it becomes clear that the air conditioning is not a complete mitigation effort. Though it does reduce discomfort hours, the perceived temperature is not as cooling due to the large amount of window exposure. The initial cost of air conditioning is much higher than initial costs of passive options, plus the maintenance cost of upkeep for a district wide system, the structural implications of installing newer, heavier equipment on aging roofs, and the utility cost of continuously running air conditioning throughout the day for many months of the school year. As a long-term solution, the building envelope needs to be more robust to prevent heat exchange with the outdoor environment. While passive solutions will never mitigate the extreme temperatures we are coming to expect from climate change, the comfort levels afforded through off-the-grid measures are affordable and achievable for the vast majority of the school year.

A final presentation of these findings will be given in person to OUSD to review the recommendations in this assessment.

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Appendix

Laurel Elementary School

5 energy models were developed to represent the thermal conditions of Laurel Elementary School. The following describes the assumptions and results of each model.

Model 1 – Administrative Office

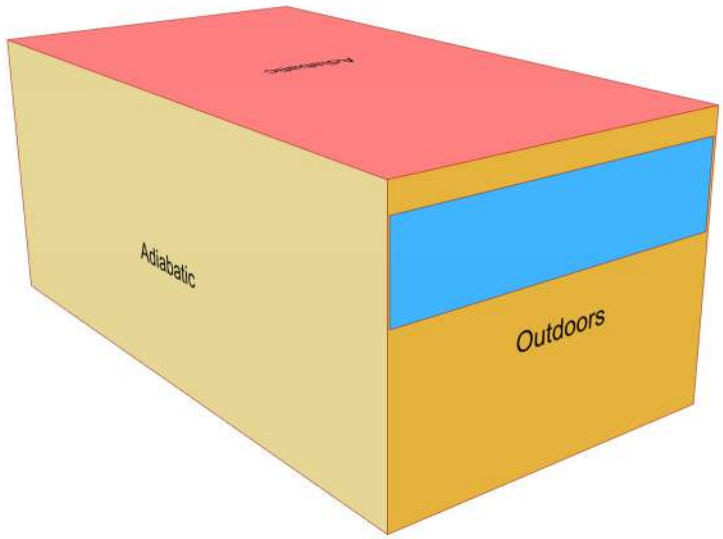


Figure 4: Energy model geometry

	Description	**Value**	**Unit**
Campus	Laurel Elementary School		
Model	Administration		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	*N/A*	*N/A*	R-value
Roof Construction (Passive Approach)	*N/A*	*N/A*	R-value
Space Type	Primary School Office		
Space Area	Conditioned Floor Area	503	square feet
People	Number of occupants	2.5	People

Lights	Lighting Load Density (Installed)	1.1	W/sq ft
Plug Loads	Plug Load Density (Installed)	1.0	W/sq ft
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	65	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	0	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	5	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

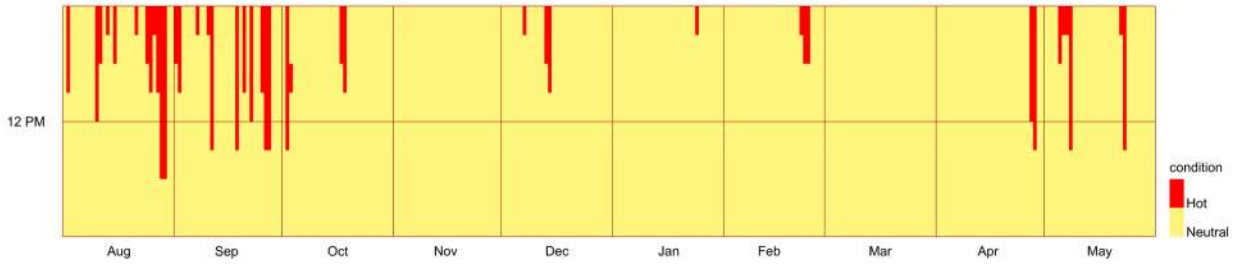


Figure 5: Distribution of hours which are too hot throughout the year

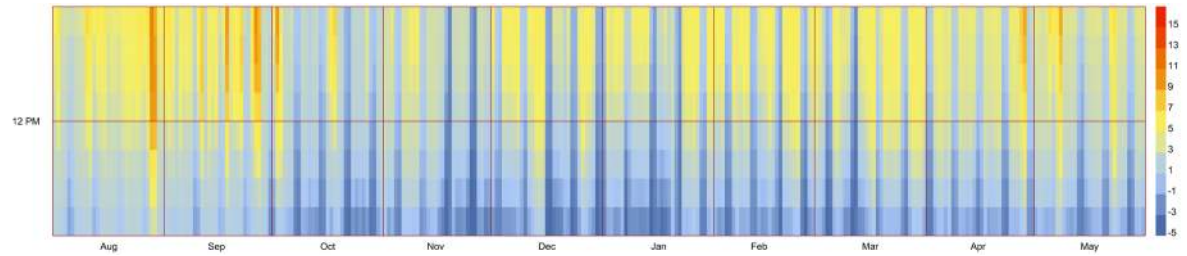


Figure 6: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 118 hours which feel too hot, and the magnitude of the discomfort hours is 709 degreeF-hours.

Basic Mitigation

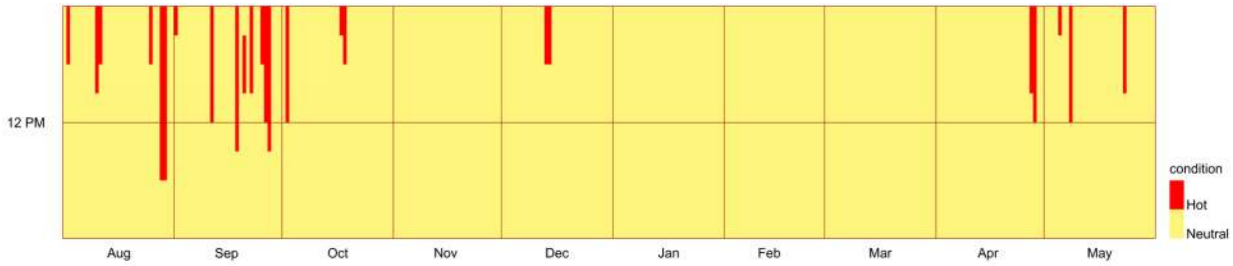


Figure 7: Distribution of hours which are too hot throughout the year

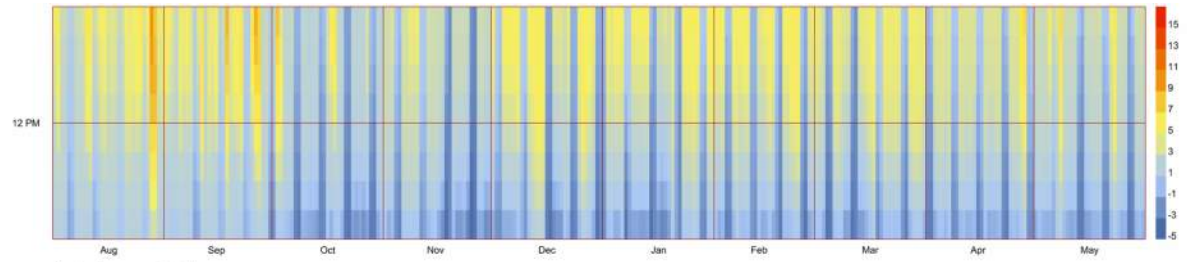


Figure 8: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 73 hours which feel too hot, and the magnitude of discomfort hours is 419 degreeF-hours.

Passive Mitigation

Figure 9: Distribution of hours which are too hot throughout the year

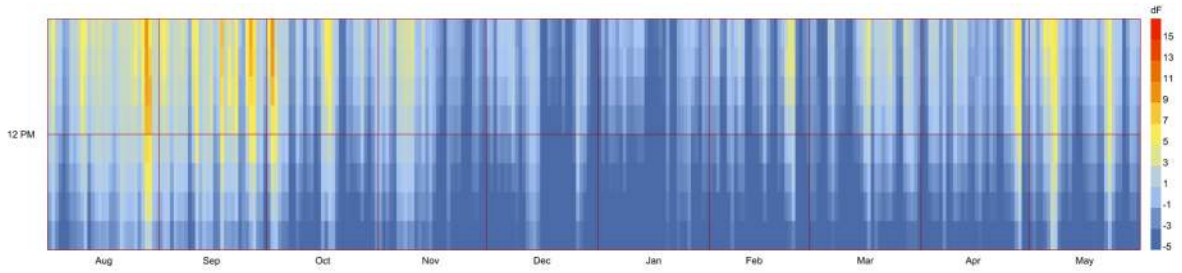


Figure 10: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 9 hours which feel too hot, and the magnitude of discomfort is 66 degreeF-hours.

Air-Conditioning Retrofit

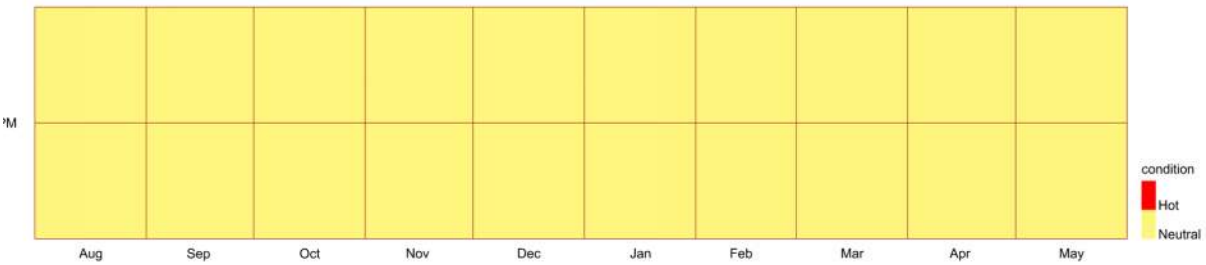


Figure 11: Distribution of hours which are too hot throughout the year

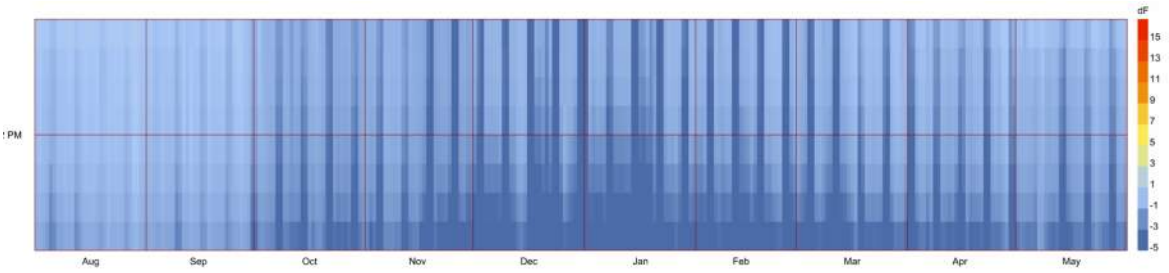


Figure 12: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 13: Distribution of hours which are too hot throughout the year

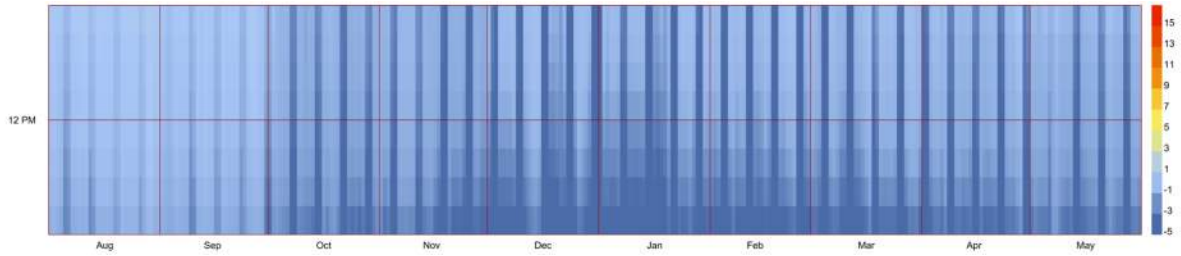


Figure 14: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 2 – First Floor Classroom in One-Story Building

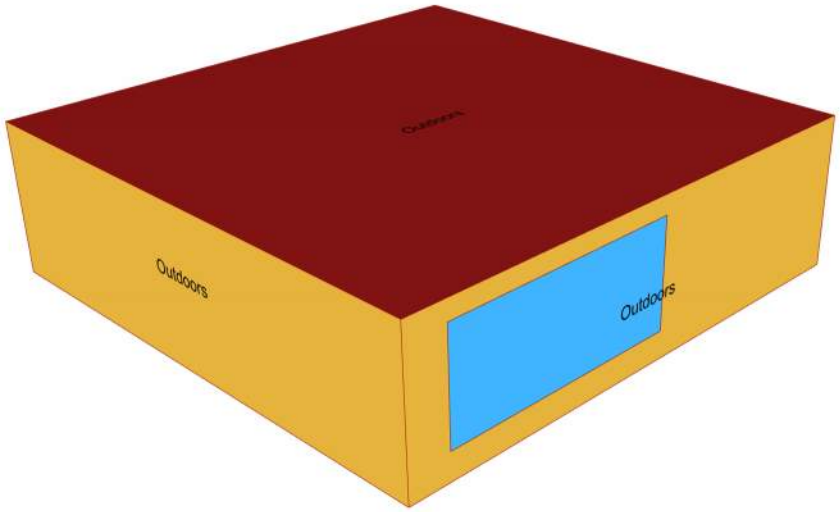


Figure 15: Energy model geometry

	Description	Value	Unit
Campus	Laurel Elementary School		
Model	Classroom - 1st floor of 2-story building		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	1225	square feet
People	Number of occupants	20.0	People
Lights	Lighting Load Density (Installed)	367.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	112	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	4.3	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%

Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

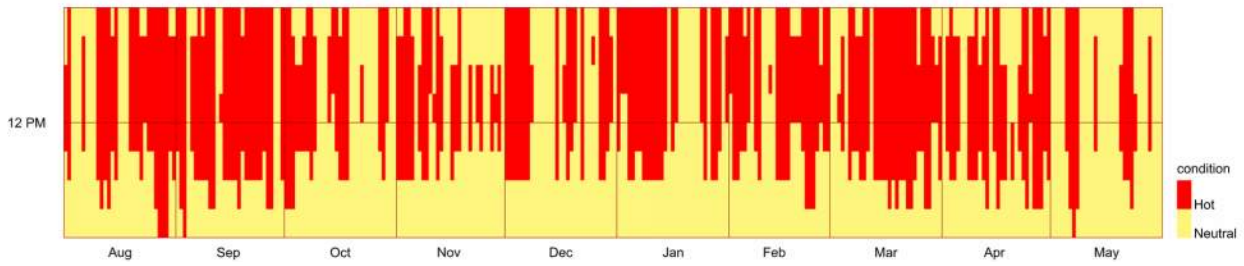


Figure 16: Distribution of hours which are too hot throughout the year

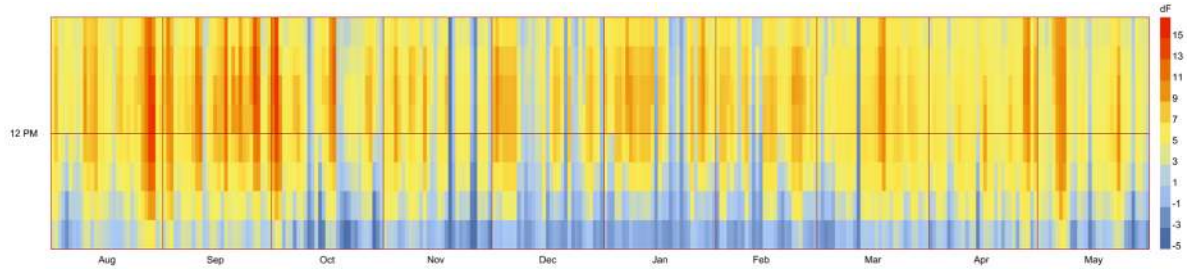


Figure 17: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,092 hours which feel too hot, and the magnitude of the discomfort hours is 7,197 degreeF-hours.

Basic Mitigation

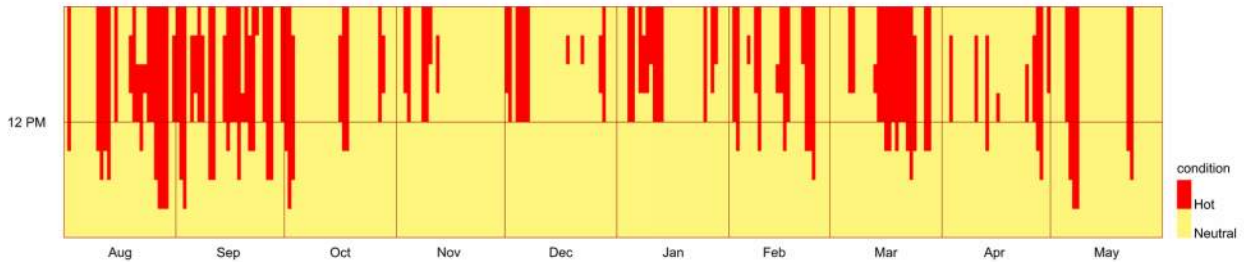


Figure 18: Distribution of hours which are too hot throughout the year

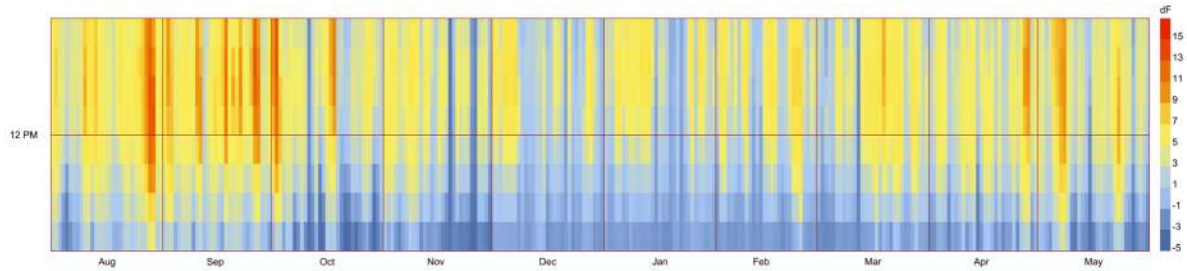


Figure 19: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 485 hours which feel too hot, and the magnitude of discomfort hours is 3,004 degreeF-hours.

Passive Mitigation

Figure 20: Distribution of hours which are too hot throughout the year

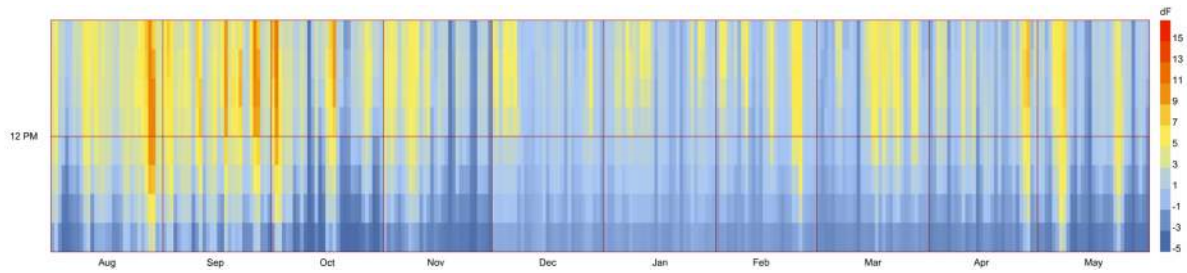


Figure 21: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 64 hours which feel too hot, and the magnitude of discomfort is 434 degreeF-hours.

Air-Conditioning Retrofit

Figure 22: Distribution of hours which are too hot throughout the year

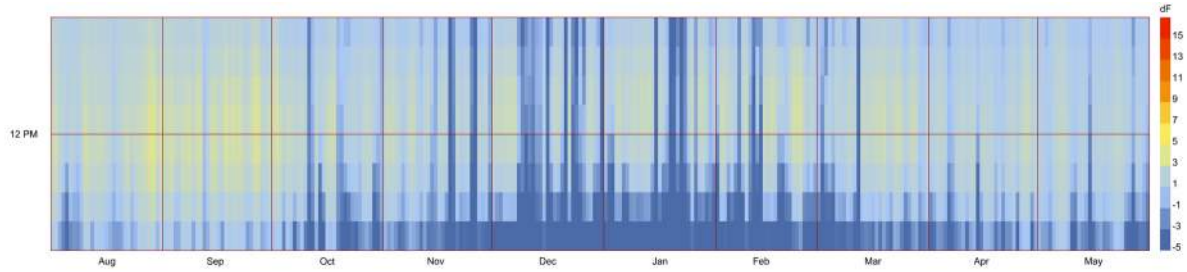


Figure 23: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 24: Distribution of hours which are too hot throughout the year

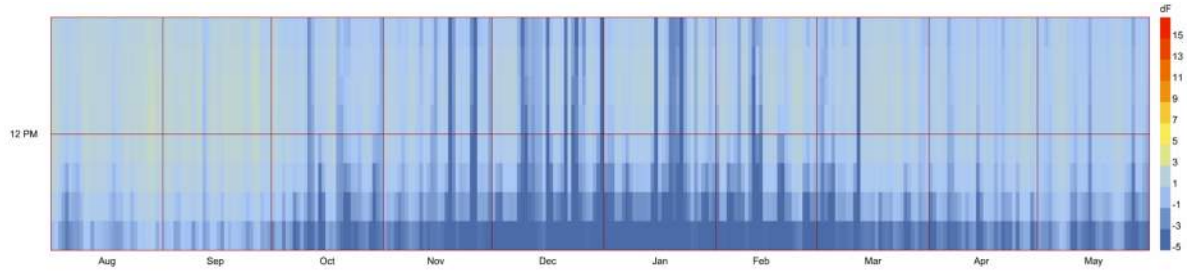


Figure 25: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 3 – 2nd Floor Classroom in 2-Story Building

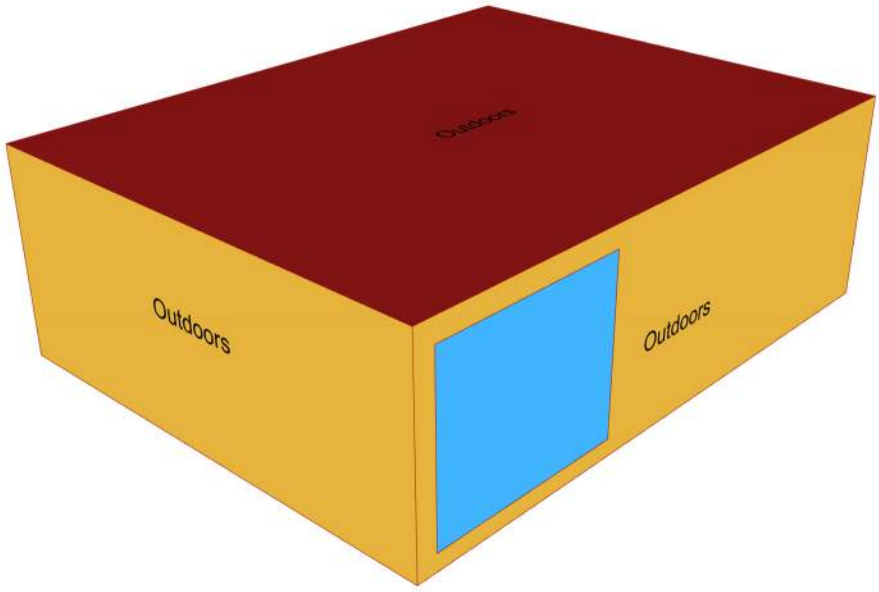


Figure 26: Energy Model Geometry

	Description	Value	Unit
Campus	Laurel Elementary School		
Model	Classroom - 2nd floor of 2-story building		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	705	square feet
People	Number of occupants	20.0	People
Lights	Lighting Load Density (Installed)	367.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts

Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	112	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	4.3	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

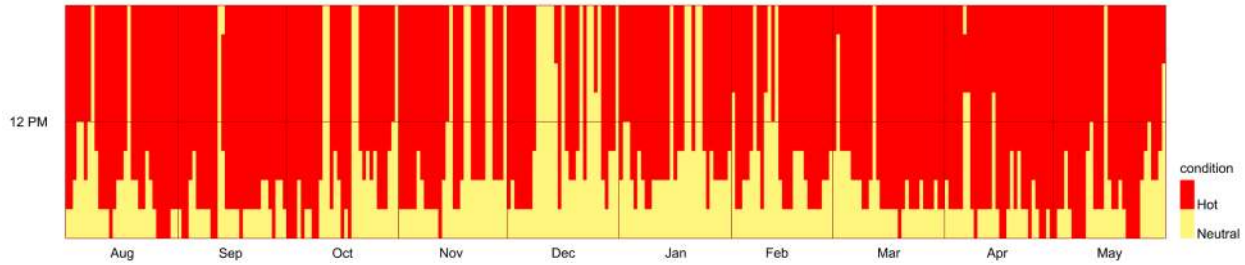


Figure 27: Distribution of hours which are too hot throughout the year

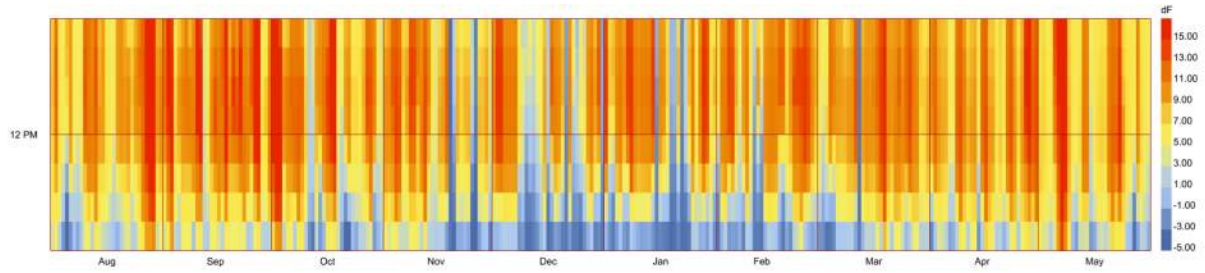


Figure 28: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,704 hours which feel too hot, and the magnitude of the discomfort hours is 15,504 degreeF-hours.

Basic Mitigation

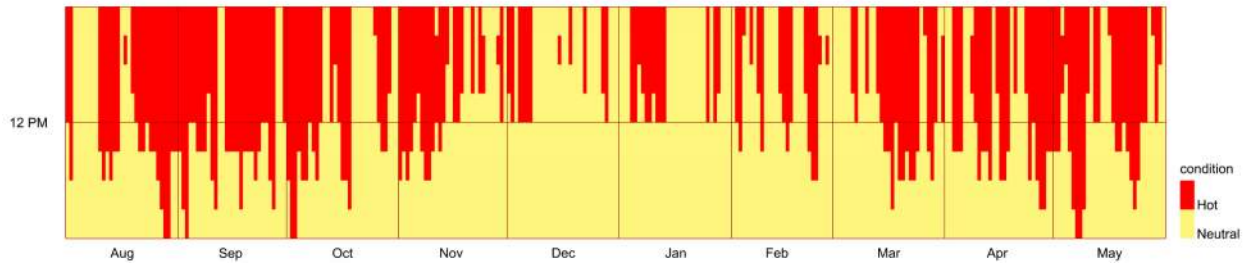


Figure 29: Distribution of hours which are too hot throughout the year

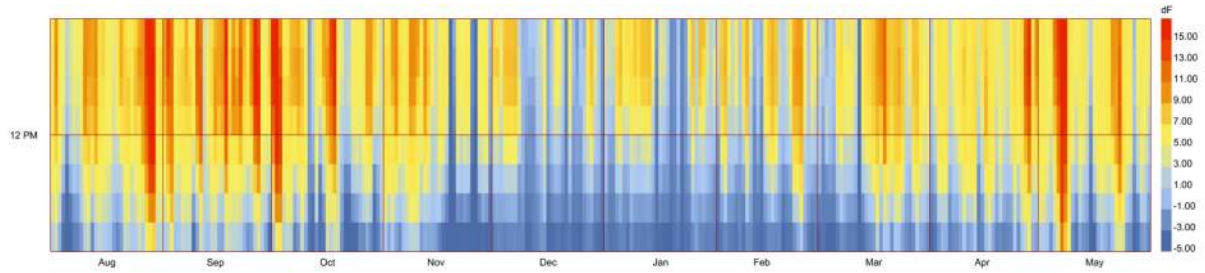


Figure 30: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 903 hours which feel too hot, and the magnitude of discomfort hours is 6,575 degreeF-hours.

Passive Mitigation

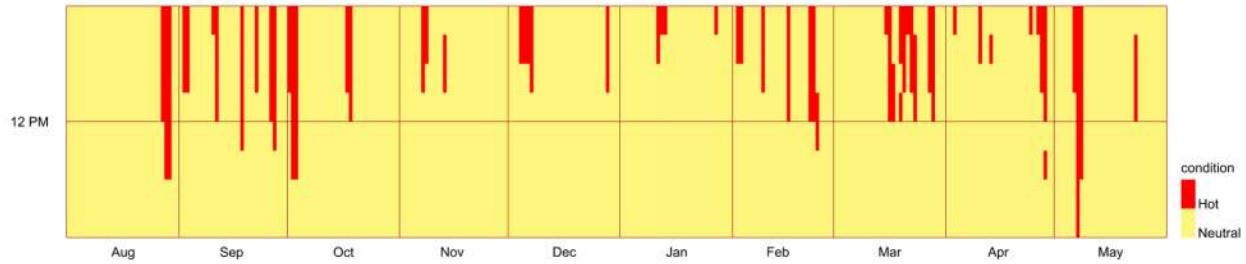


Figure 31: Distribution of hours which are too hot throughout the year

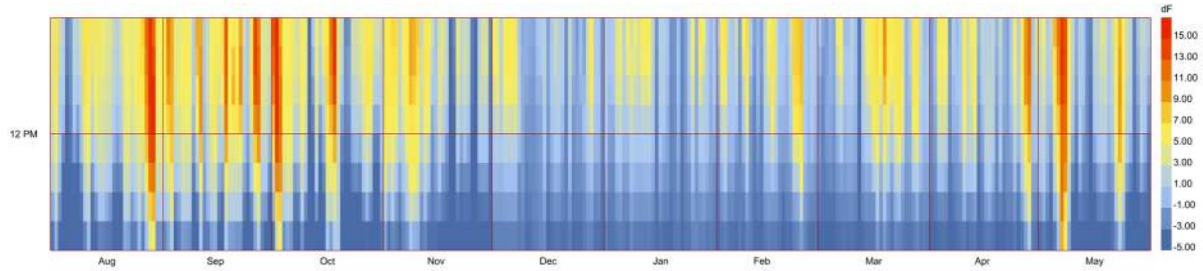


Figure 32: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 170 hours which feel too hot, and the magnitude of discomfort is 1,452 degreeF-hours.

Air-Conditioning Retrofit

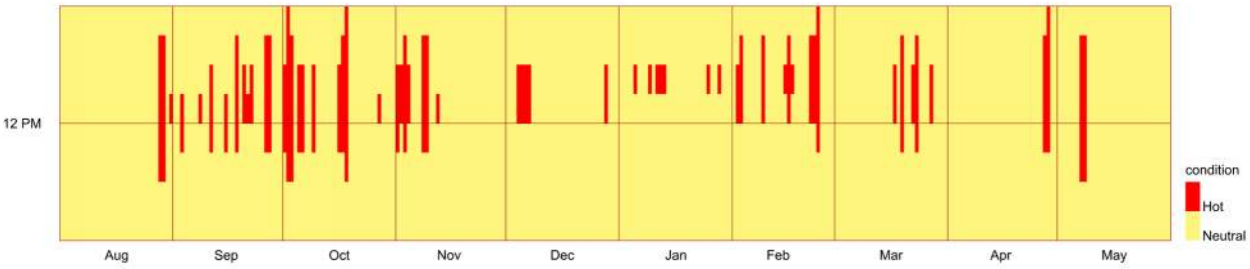


Figure 33: Distribution of hours which are too hot throughout the year

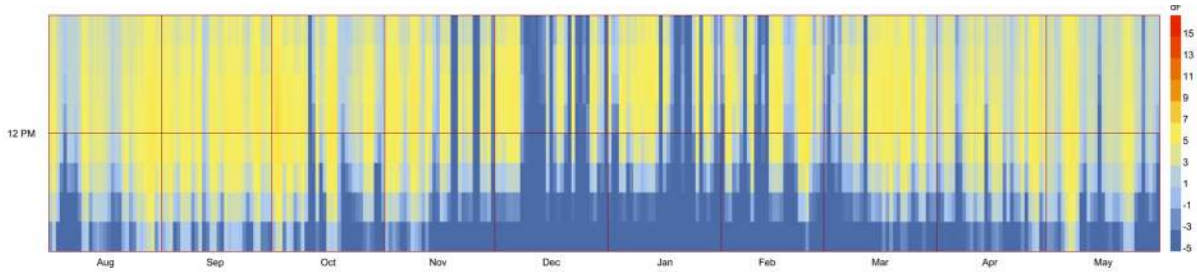


Figure 34: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 167 hours which feel too hot, and the magnitude of discomfort is 829 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 35: Distribution of hours which are too hot throughout the year

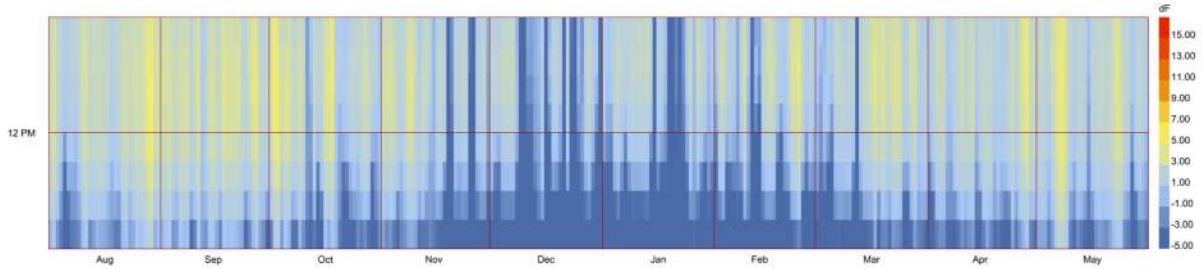


Figure 36: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 4 – Media Center

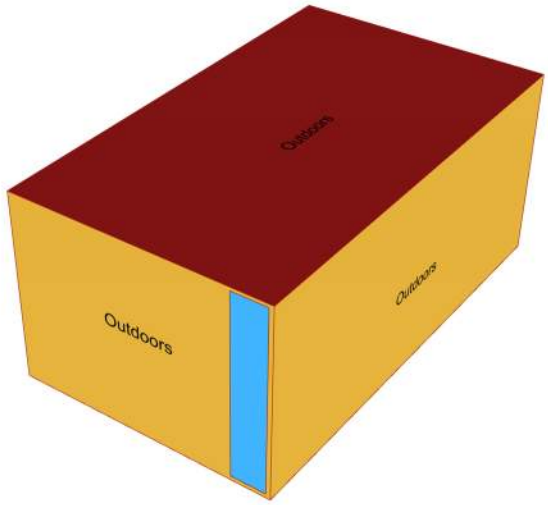


Figure 37: Energy Model Geometry

	Description	Value	Unit
Campus	Laurel Elementary School		

Model	Media Center		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Computer Room		
Space Area	Conditioned Floor Area	516	square feet
People	Number of occupants	12.9	People
Lights	Lighting Load Density (Installed)	1.2	Watts/sf
Plug Loads	Plug Load Density (Installed)	1.9	Watts/sf
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	29	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	1.7	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%

Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

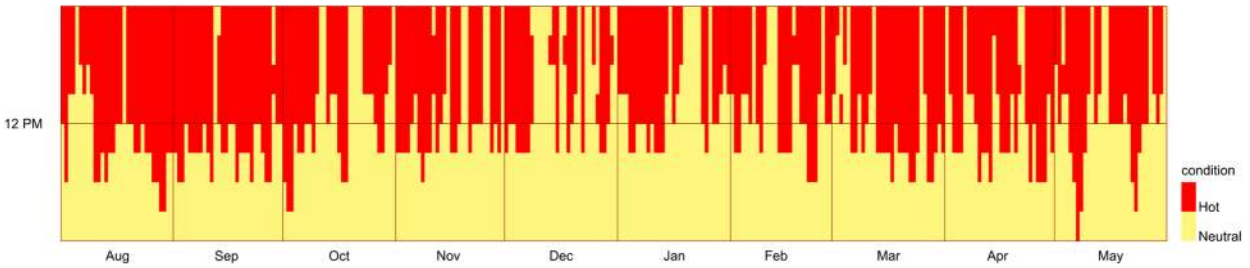


Figure 38: Distribution of hours which are too hot throughout the year

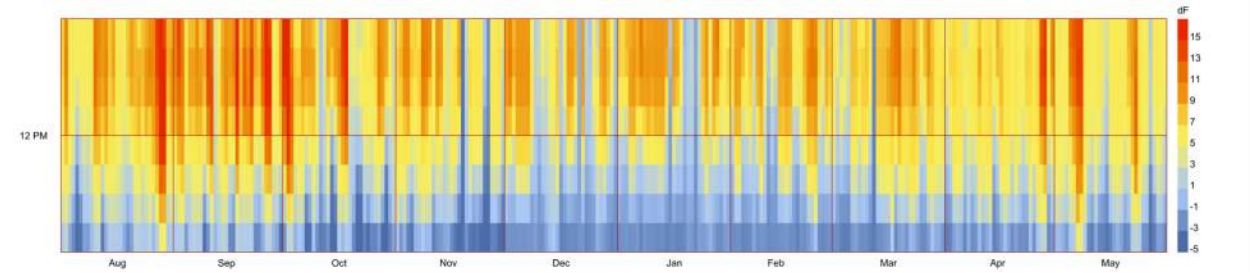


Figure 39: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,102 hours which feel too hot, and the magnitude of the discomfort hours is 8,124 degreeF-hours.

Basic Mitigation

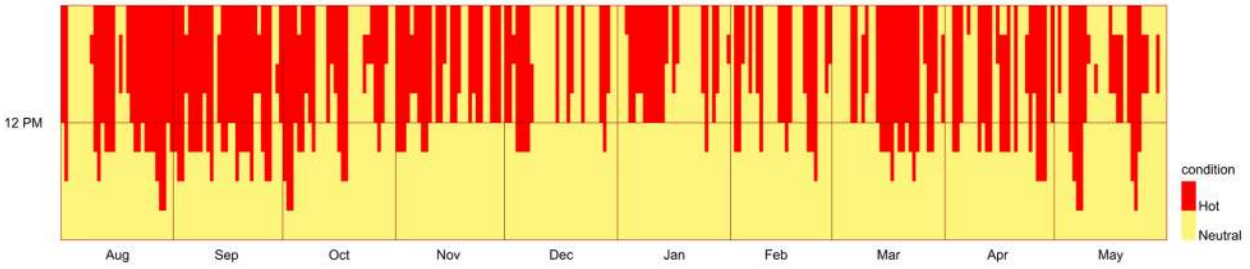


Figure 40: Distribution of hours which are too hot throughout the year

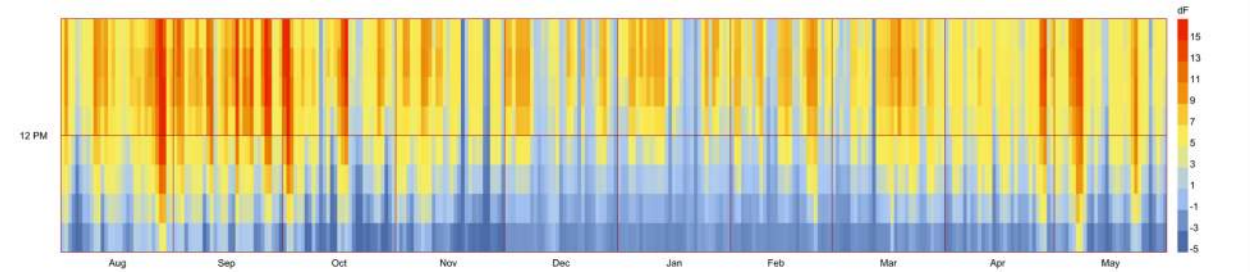


Figure 41: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 851 hours which feel too hot, and the magnitude of discomfort hours is 6,054 degreeF-hours.

Passive Mitigation

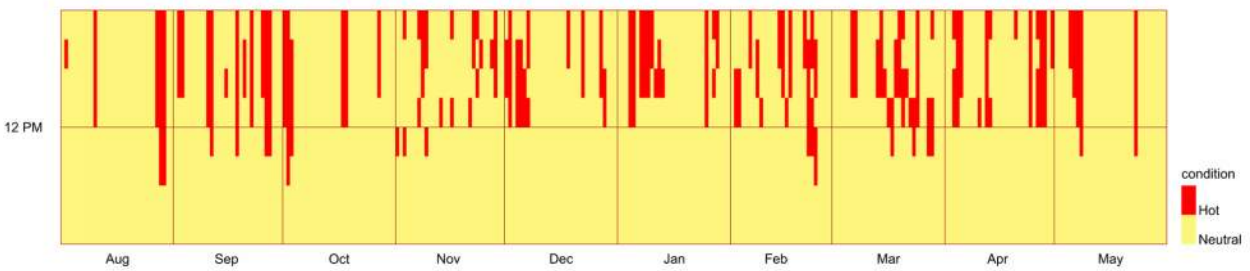


Figure 42: Distribution of hours which are too hot throughout the year

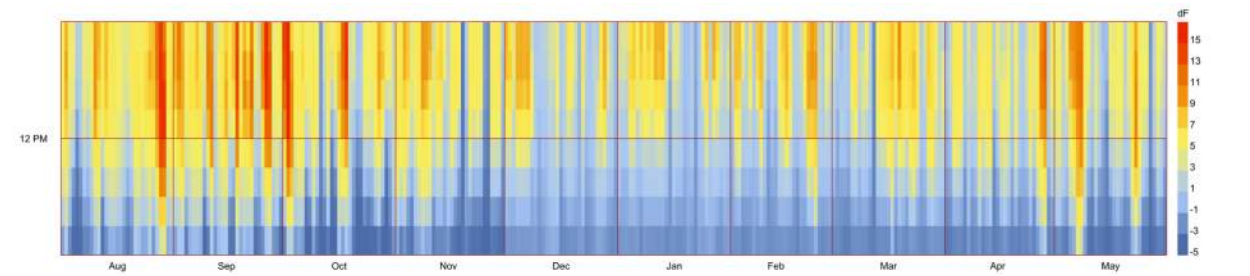


Figure 43: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 290 hours which feel too hot, and the magnitude of discomfort is 2,239 degreeF-hours.

Air-Conditioning Retrofit

Figure 44: Distribution of hours which are too hot throughout the year

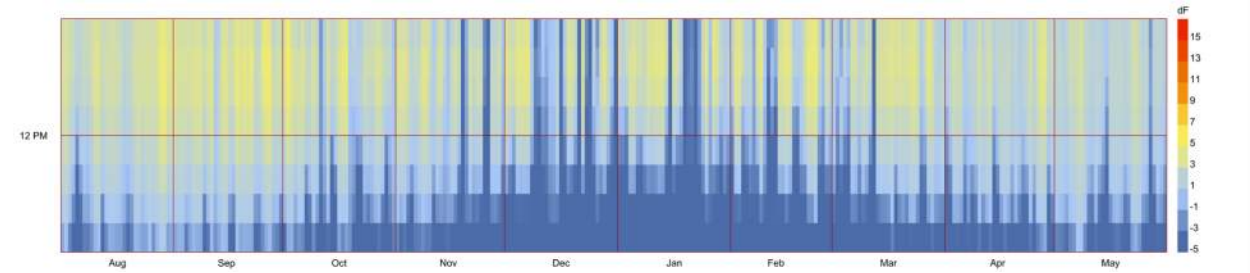


Figure 45: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 46: Distribution of hours which are too hot throughout the year

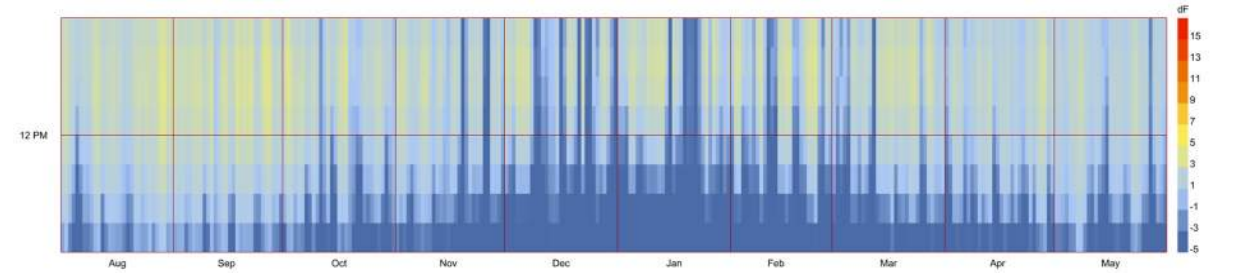


Figure 47: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 5 – Multi-Purpose

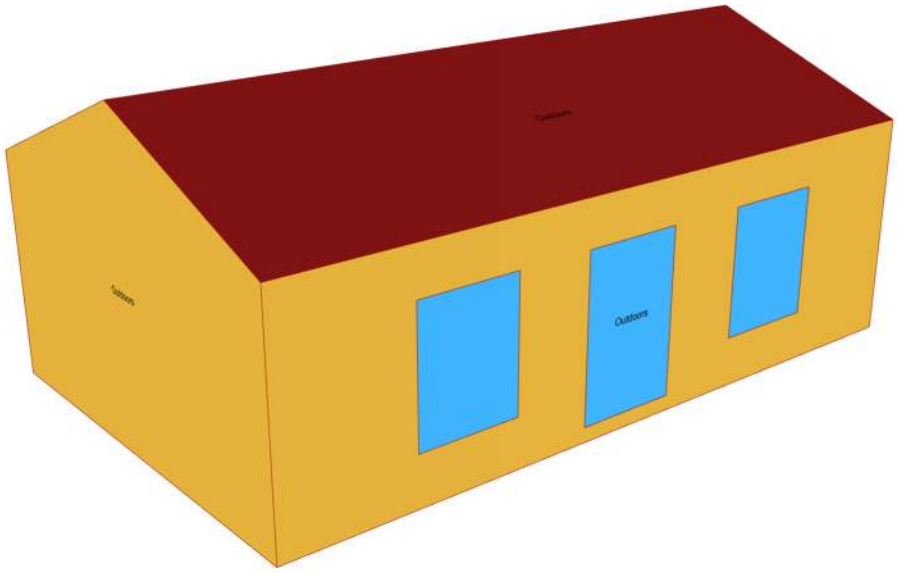


Figure 48: Energy Model Geometry

	Description	Value	Unit
Campus	Laurel Elementary School		
Model	Multipurpose		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	*N/A*	*N/A*	R-value
Space Type	Primary School Cafeteria		
Space Area	Conditioned Floor Area	4420	square feet
People	Number of occupants	441.8	People
Lights	Lighting Load Density (Installed)	0.7	Watts/sf

Plug Loads	Plug Load Density (Installed)	2.4	Watts/sf
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	672	square feet
Baseline Window Operability	Only the doors are opened	33	%
Basic Mitigation Window Operability	N/A	N/A	%
Passive Mitigation Window Operability	N/A	N/A	%
Window Opening Thresholds - Baseline	N/A		
Window Opening Thresholds - Passive Mitigation	N/A		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

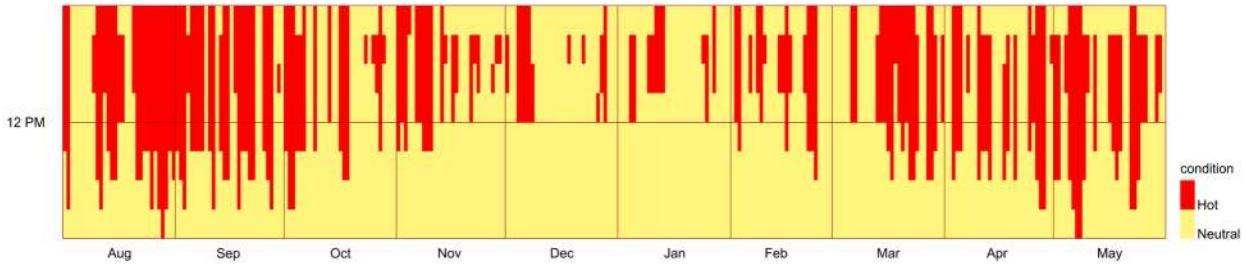


Figure 49: Distribution of hours which are too hot throughout the year

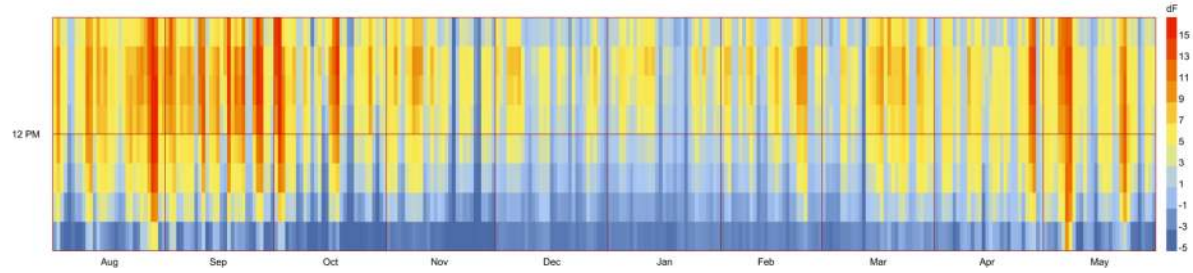


Figure 50: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 727 hours which feel too hot, and the magnitude of the discomfort hours is 5,171 degreeF-hours.

Passive Mitigation

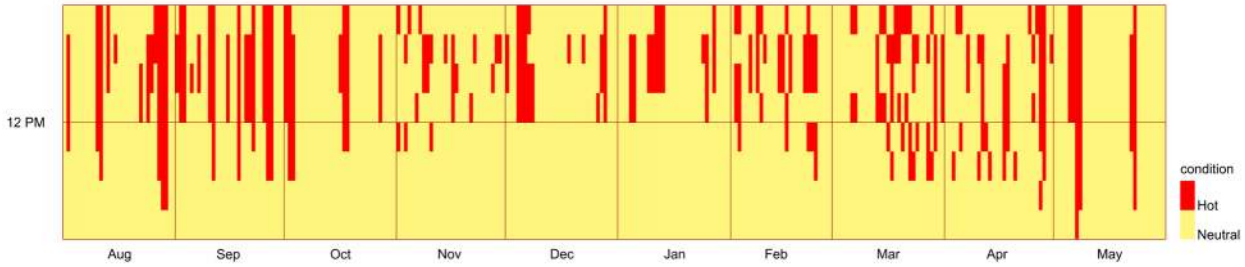


Figure 51: Distribution of hours which are too hot throughout the year

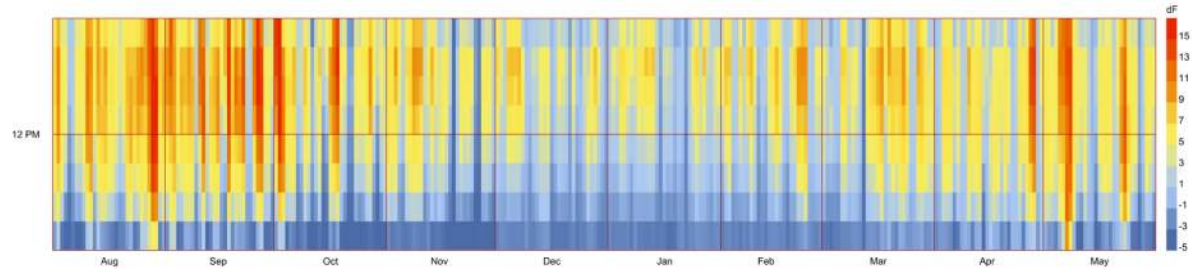


Figure 52: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 371 hours which feel too hot, and the magnitude of discomfort is 3,039 degreeF-hours.

Air-Conditioning Retrofit

Figure 53: Distribution of hours which are too hot throughout the year

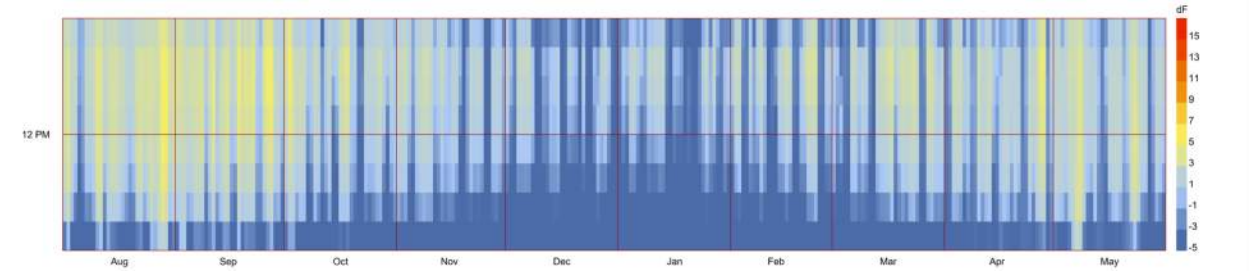


Figure 54: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Campus Wide Measures

Passive Approach

1. Provide (1) 20A/1P circuit for each fan. It is assumed that electrical circuits are available, however, pricing should include (1) 100A, 120/208V panel if needed.
2. Provide (1) Fire Alarm Control Relay for each fan to shut off fan in the event of the fire alarm system going into alarm. The control relay shall connect to the nearest smoke detector with SLC cable.

Air Conditioning Retrofit and Air Conditioning Retrofit Plus

1. Provide a new 1800 amp 120/208V, 3ph, 4W Main Switchboard and backfeed existing 1000 amp 120/208V, 3ph, 4W switchboard. All new panels shown shall be fed from new MSB.
2. Provide (1) 200 amp 120/208V, 3 ph, 4w panel for Classrooms 1-6 building.
3. Provide 1000 amp 120/208v, 3ph, 4w panel for Media/Admin/Classrooms 7-18 building.
4. Provide (1) 225 amp 120/208v, 3ph, 4w panel for MPR building.
5. Provide (1) 100 amp 120/208v, 3ph, 4w panel for Classrooms 19-20 building.

LAUREL ELEMENTARY SCHOOL ELECTRICAL LOAD CALCULATIONS

NEW SERVICE LOAD CALCULATION — Existing Main Switchboard is 1000 amps at 120/208v, 3 phase

(E) PEAK DEMAND - 322 KW	83.0	KW AT	125%	=	103.8	KVA
NEW CONNECTED LOAD PER BELOW	361.6	KVA AT	100%	=	361.6	KVA
				TOTAL	465.4	KVA

465.4 KVA = **1292.6 AMPS AT 120/208V, 3 PHASE**

PROVIDE 1800 AMP SWITCHBOARD AT 120/208V, 3 PHASE, 4 WIRE

LAUREL ADDITIONAL LOADS TO EXISTING SERVICE

EAST BUILDING C	VOLTAGE	QTY	KVA EACH	TOTAL		CONNECTED LOAD		PANEL SIZE
RTU-1	208/3	12	16.3	195.6	KVA			
RTU-2	208/3	1	34.5	34.5	KVA			
RTU-3	208/3	1	17.3	17.3	KVA			
			SUBTOTAL	247.4	KVA	687.22	AMPS	1000 AMPS
WEST BUILDING B	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**				
VHP-1	208/3	6	7.3	43.8	KVA			
			SUBTOTAL	43.8	KVA	121.67	AMPS	200 AMPS
MPR	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**				
RTU-4	208/3	2	28	56.0	KVA			
			SUBTOTAL	56.0	KVA	155.56	AMPS	225 AMPS
PORTABLE CLASSROOMS 19/20	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**				
VHP-1	208/3	2	7.2	14.4	KVA			
			SUBTOTAL	14.4	KVA	40.00	AMPS	100 AMPS
			TOTAL	361.6	KVA			
				1,004.4	AMPS			

@120/208V, 3 PHASE

Cost Estimate

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	Laurel Elementary			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
1	**Basic Mitigation**				
	Remove windows and frames	2,181	sf	20.00	43,620
	New windows and frames	2,181	sf	187.50	408,938
	Rough carpentry per window set	22	ea	2,500.00	55,000
	Patching and repairing	1	ls	50,755.75	50,756
	SUBTOTAL				**558,313**
	GENERAL CONDITIONS			10.0%	55,831
	BONDS & INSURANCE			2.0%	12,283
	OVERHEAD AND PROFIT			10.0%	62,643
	DESIGN CONTINGENCY			20.0%	137,814
	ESCALATION			6.8%	56,504
	TOTAL CONSTRUCTION COST				**883,388**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	Laurel Elementary			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
2	**Passive Approach**				
	Remove windows and frames	2,181	sf	20.00	43,620
	New windows and frames	2,181	sf	187.50	408,938
	Rough carpentry per window set	22	ea	2,500.00	55,000
	Actuators, complete	22	ea	3,000.00	66,000
	Tie into EMS controls and test	1	ls	16,500.00	16,500
	Patching and repairing	1	ls	59,005.75	59,006
	Window security screens, perforated metal panel	436	sf	125.00	54,525
	Roof insulation	12,600	sf	15.00	189,000
	Ceiling fans	31	ea	1,000.00	31,000
	Power and controls to ceiling fans	31	ea	1,437.50	44,563
	100a panel and feeder	3	ea	14,583.33	43,750
	Fire alarm control relay with SLC cable	31	ea	1,250.00	38,750
	Patching and repairing	1	ls	39,515.63	39,516
	SUBTOTAL				**1,090,166**
	GENERAL CONDITIONS			10.0%	109,017
	BONDS & INSURANCE			2.0%	23,984
	OVERHEAD AND PROFIT			10.0%	122,317
	DESIGN CONTINGENCY			20.0%	269,097
	ESCALATION			6.8%	110,330
	TOTAL CONSTRUCTION COST				**1,724,910**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			**DATE:**	3/27/2023
LEVEL:	Conceptual			**ESTIMATOR:**	Javier Silva
CLIENT:	HY Architects			**SCHEDULE:**	12 Months
LOCATION:	Laurel Elementary			**AREA (SF):**	
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT COST**	**TOTAL AMOUNT**
3	**Air Conditioning Retrofit**				
	York 4 ton rooftop packaged heat pump unit	12	ea	20,000.00	240,000
	York 12 ton rooftop packaged heat pump unit	1	ea	60,000.00	60,000
	York 5 ton rooftop packaged heat pump unit	1	ea	25,000.00	25,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	6	ea	15,000.00	90,000
	Ductwork and distribution	35,500	sf	20.00	710,000
	Controls	1	ls	24,000.00	24,000
	Testing, adjusting and balancing	35,500	sf	2.50	88,750
	Structural roof upgrade	35,500	sf	25.00	887,500
	Mechanical power	20	ea	3,750.00	75,000
	Condensate drainage	20	ea	3,437.50	68,750
	Patching and repairing	35,500	sf	5.00	177,500
	1800a main switchboard	1	ea	118,750.00	118,750
	Back feed existing 1000a switchboard	1	ea	83,333.33	83,333
	225a panel and feeder	1	ea	60,937.50	60,938
	1000a panel and feeder	1	ea	270,833.33	270,833
	200a panel and feeder	1	ea	54,166.67	54,167
	100a panel and feeder	1	ea	27,083.33	27,083
	SUBTOTAL				**3,061,604**
	GENERAL CONDITIONS			10.0%	306,160
	BONDS & INSURANCE			2.0%	67,355
	OVERHEAD AND PROFIT			10.0%	343,512
	DESIGN CONTINGENCY			20.0%	755,726
	ESCALATION			6.8%	309,848
	TOTAL CONSTRUCTION COST				**4,844,206**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	Laurel Elementary			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
4	**Air Conditioning Retrofit Plus**				
	Remove windows and frames	2,181	sf	20.00	43,620
	New windows and frames	2,181	sf	187.50	408,938
	Rough carpentry per window set	22	ea	2,500.00	55,000
	Patching and repairing	1	ls	50,755.75	50,756
	York 4 ton rooftop packaged heat pump unit	12	ea	20,000.00	240,000
	York 12 ton rooftop packaged heat pump unit	1	ea	60,000.00	60,000
	York 5 ton rooftop packaged heat pump unit	1	ea	25,000.00	25,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	6	ea	15,000.00	90,000
	Ductwork and distribution	35,500	sf	20.00	710,000
	Controls	1	ls	24,000.00	24,000
	Testing, adjusting and balancing	35,500	sf	2.50	88,750
	Structural roof upgrade	35,500	sf	25.00	887,500
	Mechanical power	20	ea	3,750.00	75,000
	Condensate drainage	20	ea	3,437.50	68,750
	Patching and repairing	35,500	sf	5.00	177,500
	1800a main switchboard	1	ea	118,750.00	118,750
	Back feed existing 1000a switchboard	1	ea	83,333.33	83,333
	225a panel and feeder	1	ea	60,937.50	60,938
	1000a panel and feeder	1	ea	270,833.33	270,833
	200a panel and feeder	1	ea	54,166.67	54,167
	100a panel and feeder	1	ea	27,083.33	27,083
	SUBTOTAL				**3,619,917**
	GENERAL CONDITIONS			10.0%	361,992
	BONDS & INSURANCE			2.0%	79,638
	OVERHEAD AND PROFIT			10.0%	406,155
	DESIGN CONTINGENCY			20.0%	893,540
	ESCALATION			6.8%	366,352
	TOTAL CONSTRUCTION COST				**5,727,594**

LIFE CYCLE COSTING SUMMARY

LCC-1

Project Name: *Laurel Campus*

Date: *4/28/2023*

ANNUAL ENERGY USE AND COST

Option	Description	Electricity			Natural Gas		Simple Payback (years)
		Consumption (kWh)	Demand (kW)	Cost ($)	Consumption (therms)	Cost ($)	
Base	Baseline (Existing Conditions)	38,913	0	$13,755	314	$782	N/A
1	Basic	38,964	0	$13,773	350	$872	N/A
2	Passive	38,836	0	$13,728	259	$645	3,316.9
3	AC Retrofit	72,257	0	$25,542	0	$0	N/A
4	AC Retrofit+	72,055	0	$25,471	0	$0	N/A

LIFE CYCLE COST PRESENT VALUE

Option	Initial Cost	Utility Incentive	Annual Recurring Costs	Electricity Costs	Natural Gas Costs	Non Annual Recurring OM&R Cost	Replacem. Costs	Residual Value	Total LCC	Additional Costs
Base	$0	$0	$0	$246,776	$16,498	$0	$0	$0	$263,274	$0
1	$149,174	$0	$0	$247,099	$18,397	$0	$0	$0	$414,670	$151,396
2	$543,966	$0	$0	$246,291	$13,608	$0	$0	$0	$803,865	$540,591
3	$1,527,664	$0	$0	$458,244	$0	$0	$0	$0	$1,985,908	$1,722,634
4	$1,639,151	$0	$0	$456,970	$0	$0	$0	$0	$2,096,121	$1,832,847

Study Parameters

Study Period: 25 years

Real Discount Rate: 3.0%

☑ DOE/FEMP Escalation Rates

Region: Western US

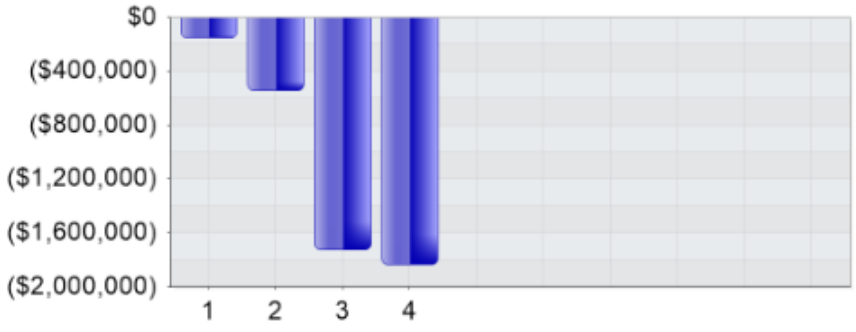
Fuel Sector: Commercial

☐ Uniform Escalation Rates

Electricity: N/A

Natural Gas: N/A

LIFE CYCLE COST SAVINGS



EnergyLCC 8.3 by EnergySoft 1 of 1

To estimate the campus-wide performance of the different strategies, a weighted average of the energy modeling results is applied. Each room at the campus is assigned an energy model to be represented by, based on the building's space type, orientation, etc. The total discomfort hours for each building on campus are added up. For the different mitigation strategies, we can consider the amount that the discomfort hours are reduced by.

The total discomfort hours for each campus are shown in the table below:

Campus-wide discomfort hours	Baseline	Basic Mitigation	Passive Mitigation	Air Conditioning Retrofit	Air Conditioning Retrofit Plus
Laurel Elementary School	31,131	16,367	3,222	2,004	0

The total reduction percentage of discomfort hours is shown in the table below:

Scenario Improvement %	Basic Mitigation	Passive Mitigation	Air Conditioning Retrofit	Air Conditioning Retrofit Plus
Laurel Elementary School	47%	90%	89%	100%

Manzanita Elementary School

5 energy models were developed to represent the thermal conditions of Manzanita Elementary School. The following describes the assumptions and results of each model.

Model 1 – North Campus South Facing Classroom

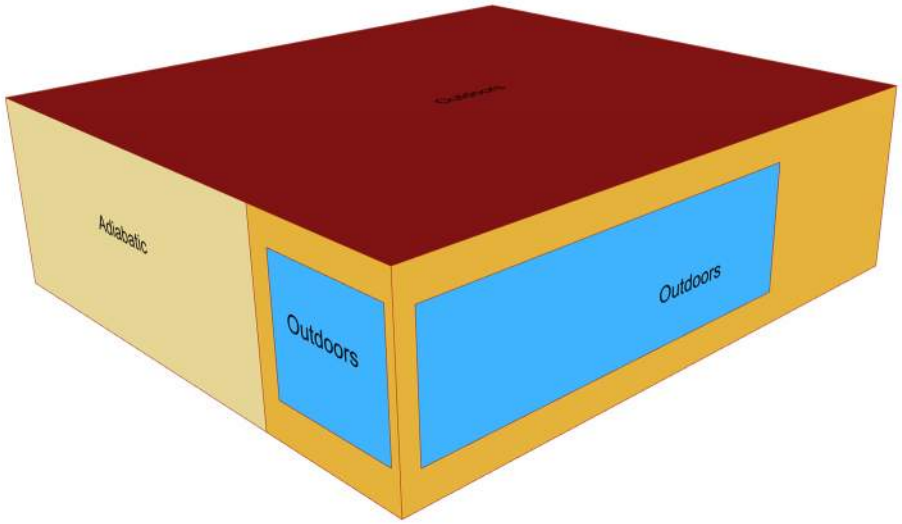


Figure 55: Energy Model Geometry

	Description	Value	Unit
Campus	Manzanita Elementary School		
Model	Classroom - North Campus South Facing		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	1135	square feet
People	Number of occupants	20.0	People

Lights	Lighting Load Density (Installed)	375.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	217	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	1.7	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

Figure 56: Distribution of hours which are too hot throughout the year

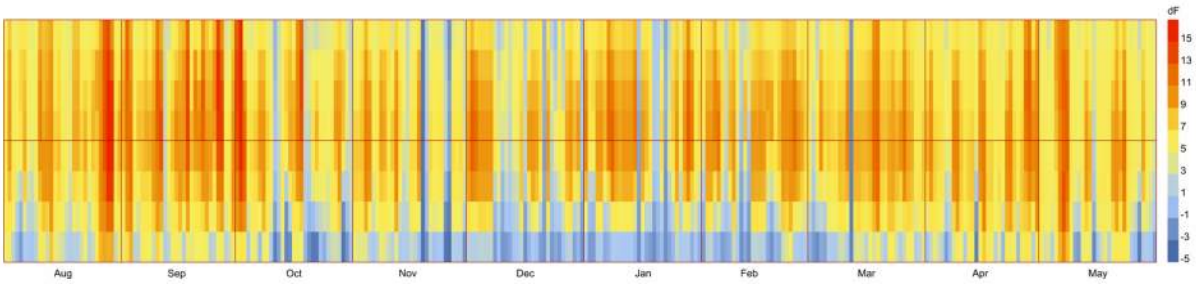


Figure 57: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,541 hours which feel too hot, and the magnitude of the discomfort hours is 6,253 degreeF-hours.

Basic Mitigation

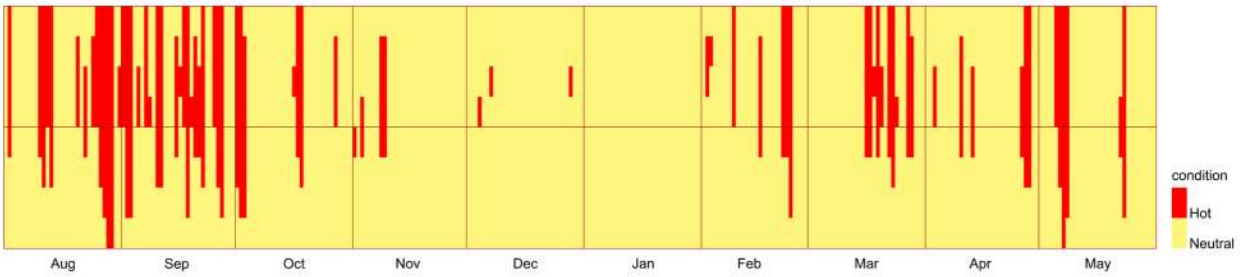


Figure 58: Distribution of hours which are too hot throughout the year

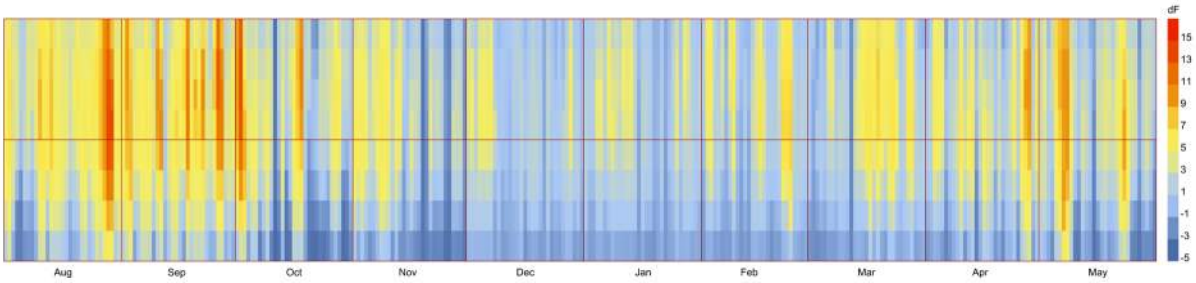


Figure 59: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 327 hours which feel too hot, and the magnitude of discomfort is 2,176 degreeF-hours.

Passive Mitigation

Figure 60: Distribution of hours which are too hot throughout the year

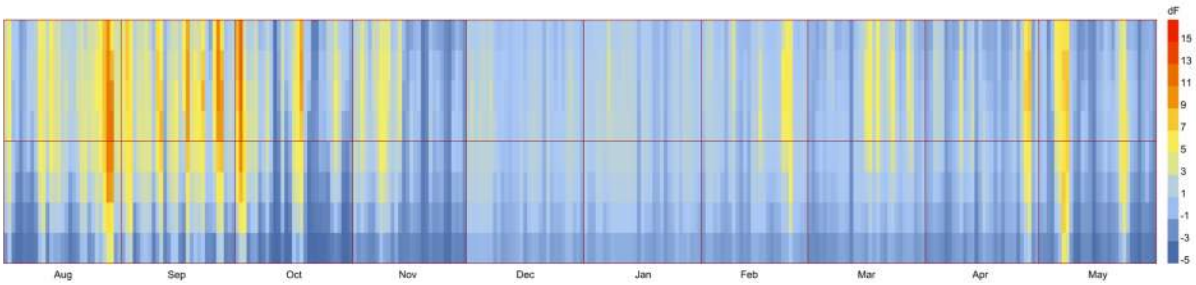


Figure 61: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 36 hours which feel too hot, and the magnitude of discomfort is 306 degreeF-hours.

Air-Conditioning Retrofit

Figure 62: Distribution of hours which are too hot throughout the year

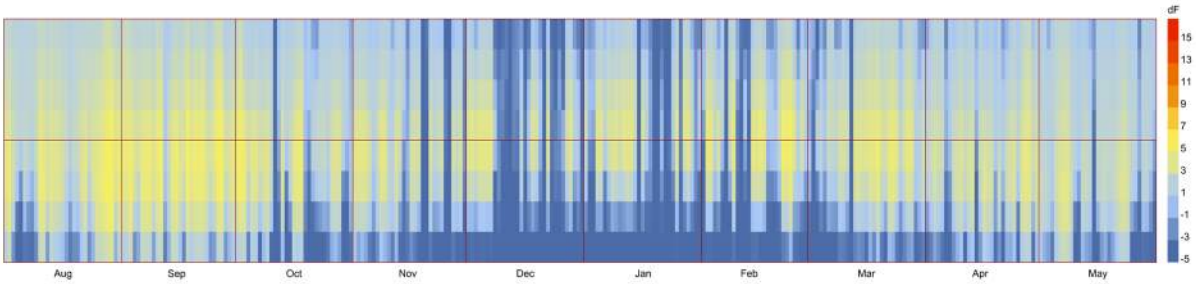


Figure 63: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 64: Distribution of hours which are too hot throughout the year

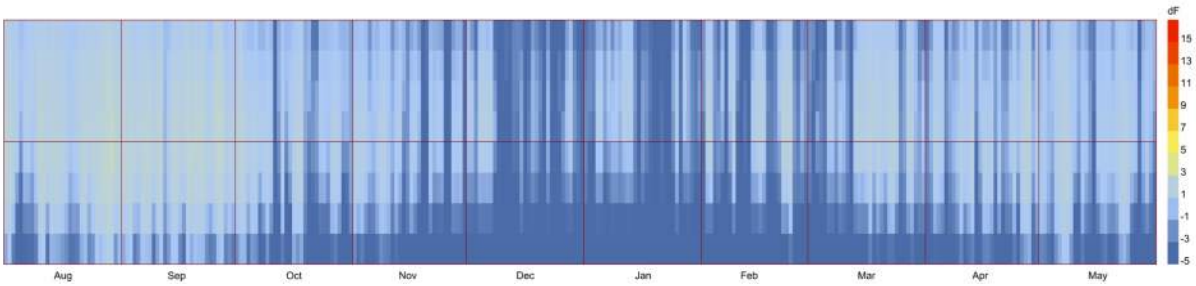


Figure 65: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 2 – NW Campus South Facing Classroom

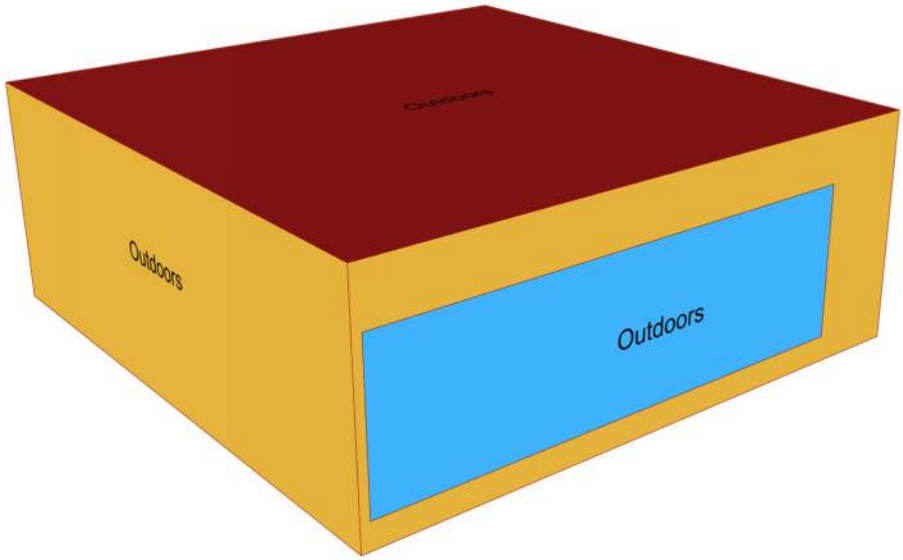


Figure 66: Energy Model Geometry

	Description	Value	Unit
Campus	Manzanita Elementary School		
Model	Classroom - NW Campus South Facing		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	811	square feet
People	Number of occupants	20.0	People
Lights	Lighting Load Density (Installed)	375.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	165	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	1.7	%
Basic Mitigation Window Operability	% of window area opened with a glazing	10	%

	replacement		
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

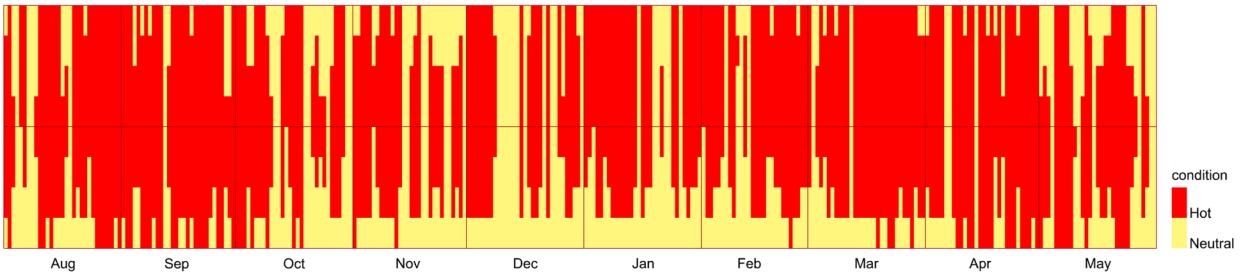


Figure 67: Distribution of hours which are too hot throughout the year

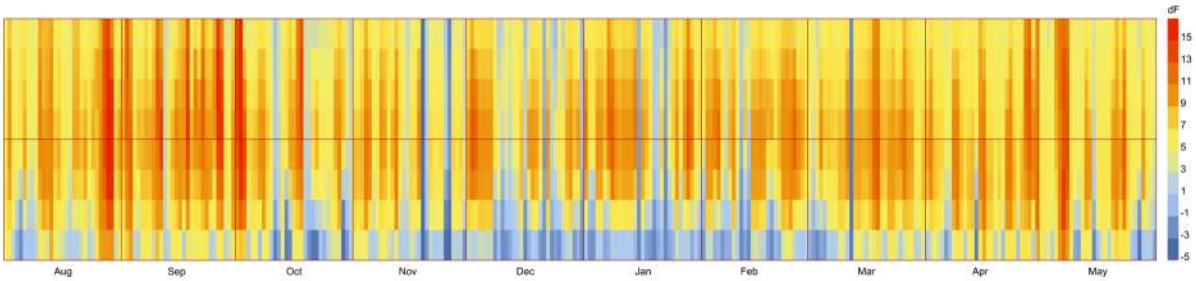


Figure 68: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,603 hours which feel too hot, and the magnitude of the discomfort hours is 11,291 degreeF-hours.

Basic Mitigation

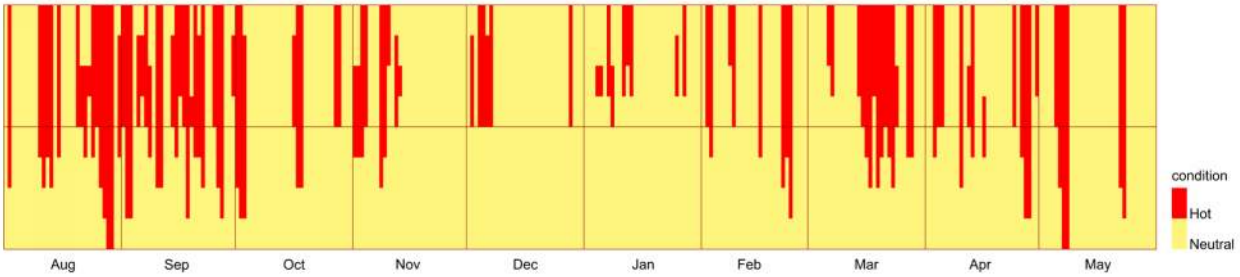


Figure 69: Distribution of hours which are too hot throughout the year

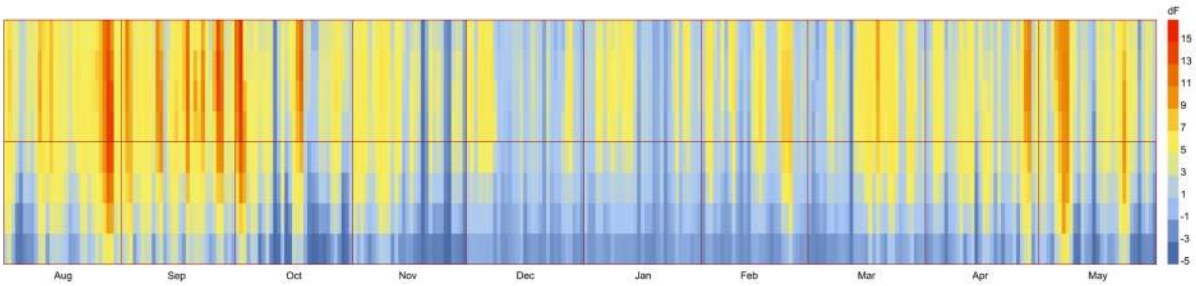


Figure 70: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 495 hours which feel too hot, and the magnitude of discomfort is 3,232 degreeF-hours.

Passive Mitigation

Figure 71: Distribution of hours which are too hot throughout the year

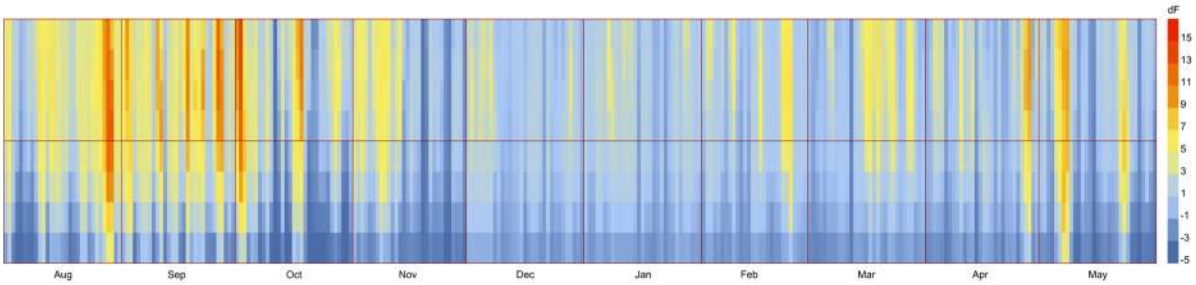


Figure 72: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 89 hours which feel too hot, and the magnitude of discomfort is 390 degreeF-hours.

Air-Conditioning Retrofit

Figure 73: Distribution of hours which are too hot throughout the year

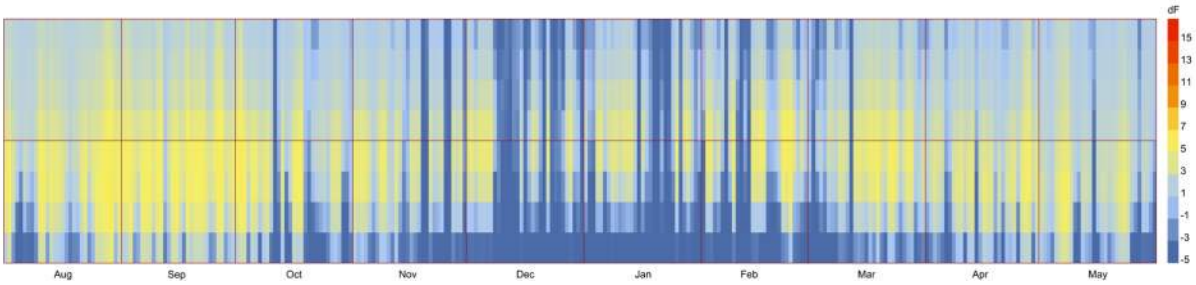


Figure 74: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 7 hours which feel too hot, and the magnitude of discomfort is 18 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 75: Distribution of hours which are too hot throughout the year

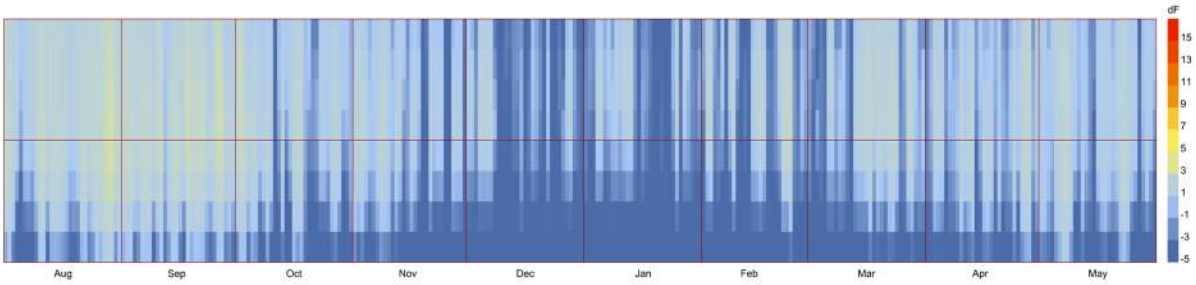


Figure 76: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 3 – NW Campus South Facing Classroom

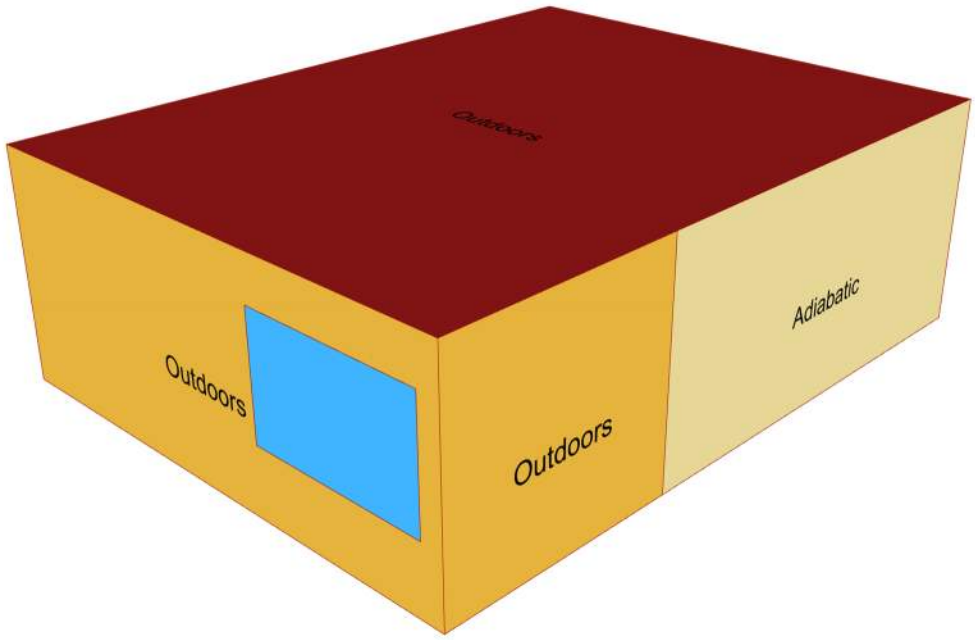


Figure 77: Energy Model Geometry

	Description	**Value**	**Unit**
Campus	Manzanita Elementary School		
Model	Classroom - Central Campus South Facing		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	716	square feet
People	Number of occupants	20.0	People

Lights	Lighting Load Density (Installed)	375.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	41	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	3	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

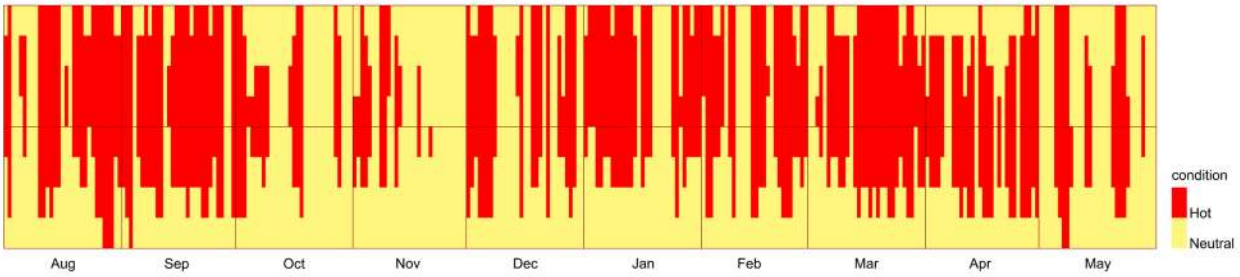


Figure 78: Distribution of hours which are too hot throughout the year

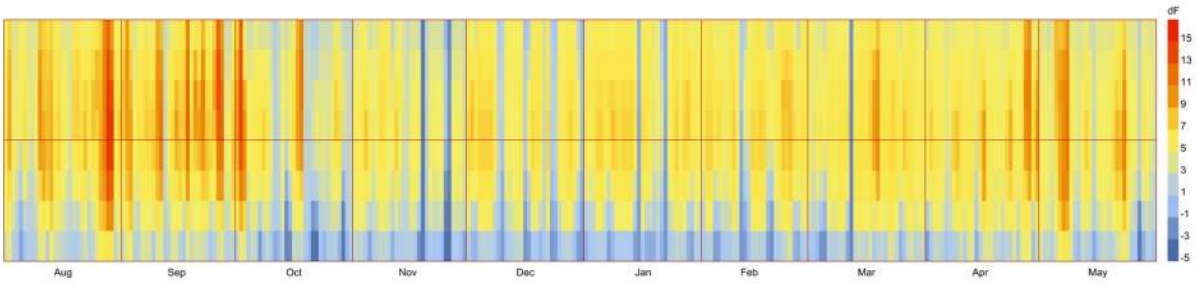


Figure 79: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,090 hours which feel too hot, and the magnitude of the discomfort hours is 6,822 degreeF-hours.

Basic Mitigation

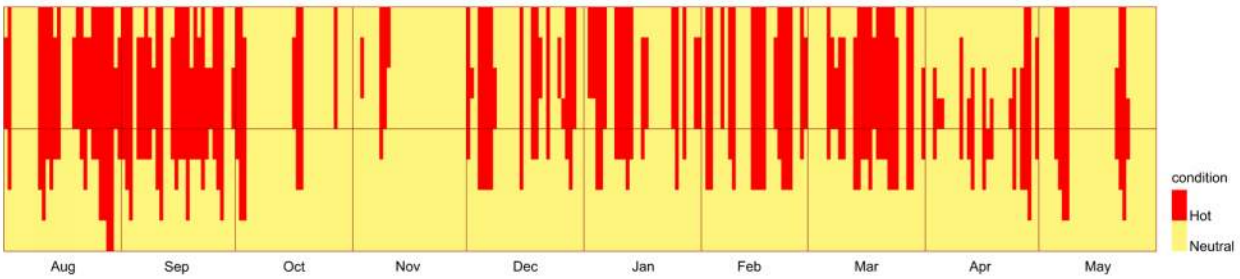


Figure 80: Distribution of hours which are too hot throughout the year

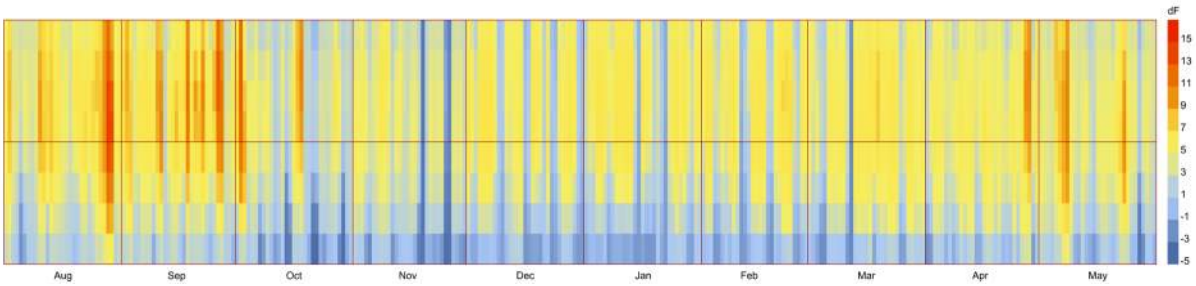


Figure 81: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 698 hours which feel too hot, and the magnitude of discomfort is 4,147 degreeF-hours.

Passive Mitigation

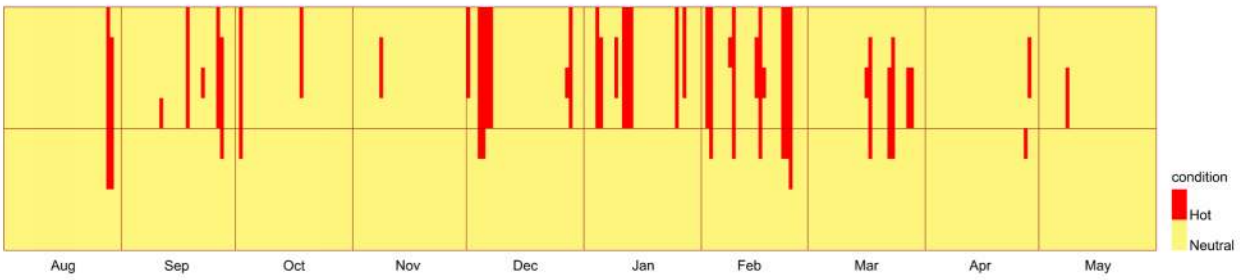


Figure 82: Distribution of hours which are too hot throughout the year

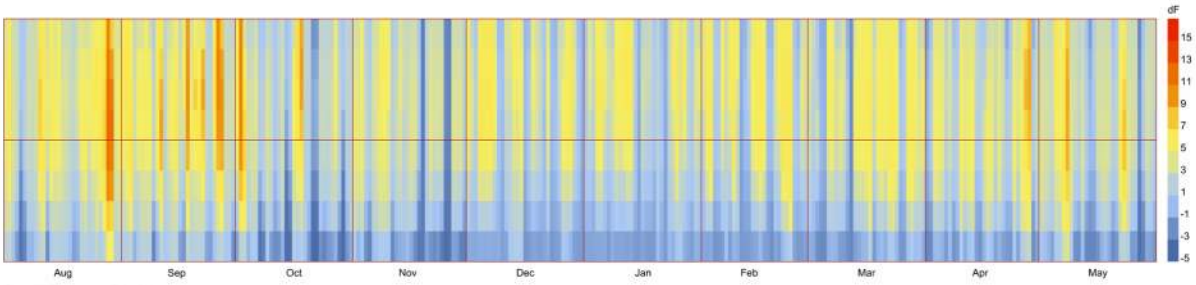


Figure 83: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 149 hours which feel too hot, and the magnitude of discomfort is 893 degreeF-hours.

Air-Conditioning Retrofit

Figure 84: Distribution of hours which are too hot throughout the year

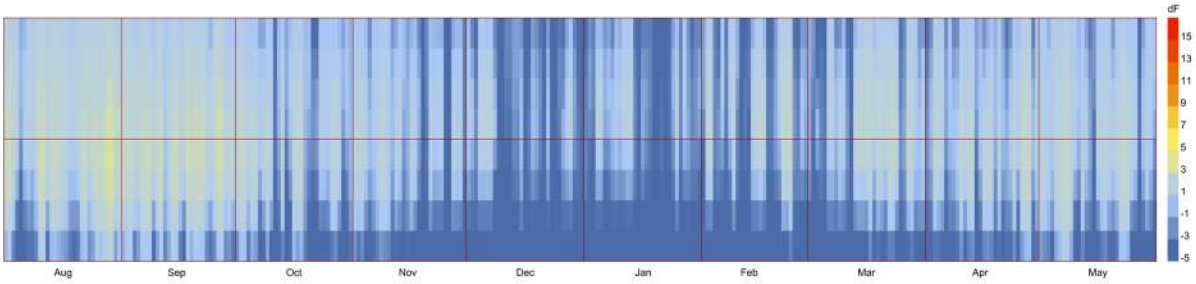


Figure 85: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 86: Distribution of hours which are too hot throughout the year

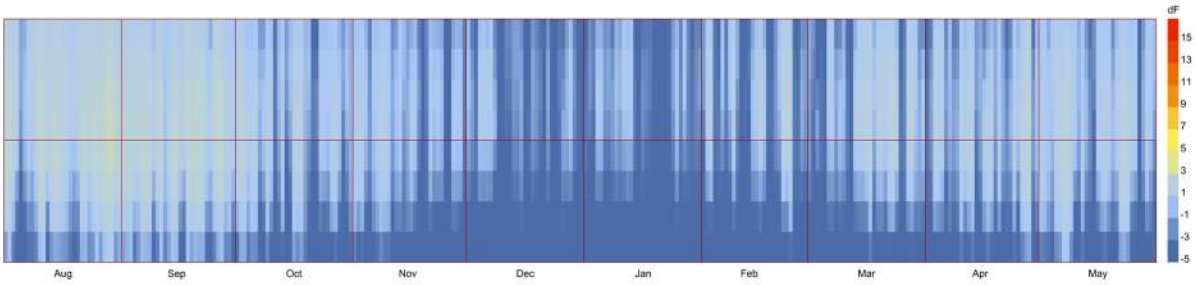


Figure 87: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 4 – SW Campus North Facing Classroom

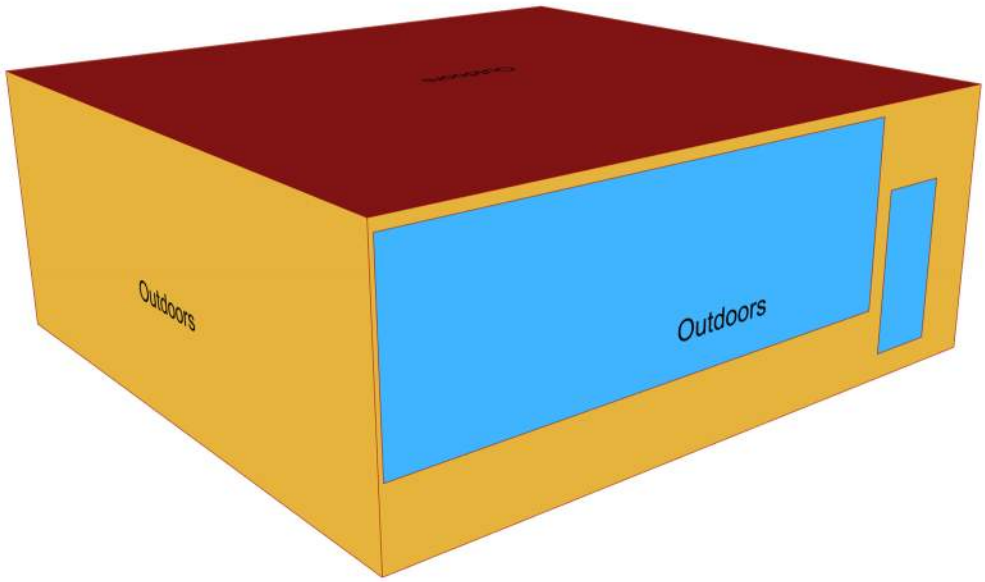


Figure 88: Energy Model Geometry

	Description	Value	Unit
Campus	Manzanita Elementary School		
Model	Classroom - SW Campus North Facing		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	854	square feet
People	Number of occupants	20.0	People
Lights	Lighting Load Density (Installed)	375.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	209	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	4.2	%
Basic Mitigation Window Operability	% of window area opened with a glazing	10	%

	replacement		
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

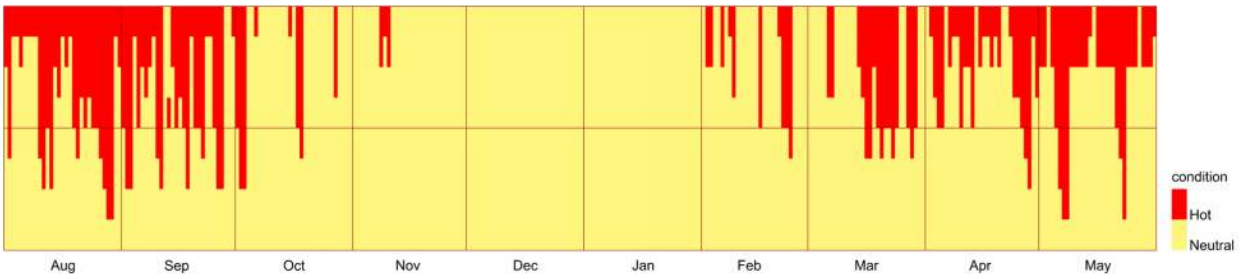


Figure 89: Distribution of hours which are too hot throughout the year

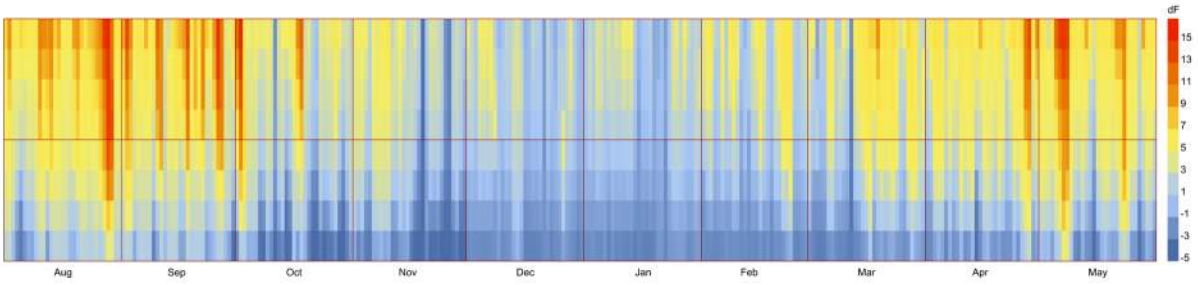


Figure 90: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 461 hours which feel too hot, and the magnitude of the discomfort hours is 3,122 degreeF-hours.

Basic Mitigation

Figure 91: Distribution of hours which are too hot throughout the year

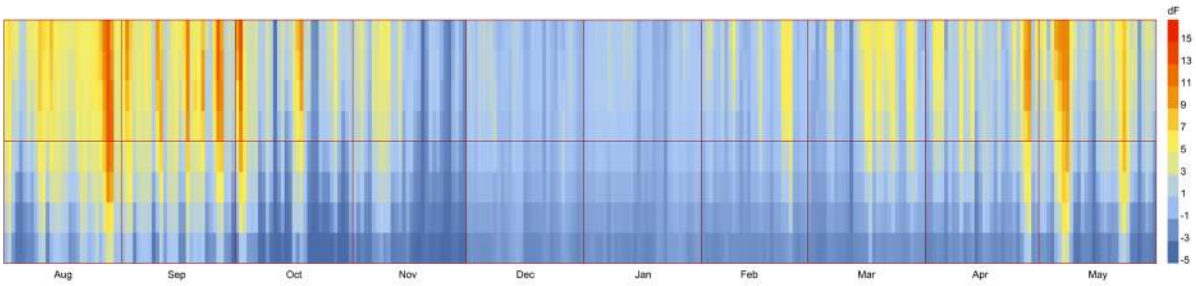


Figure 92: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 190 hours which feel too hot, and the magnitude of discomfort is 1,326 degreeF-hours.

Passive Mitigation

Figure 93: Distribution of hours which are too hot throughout the year

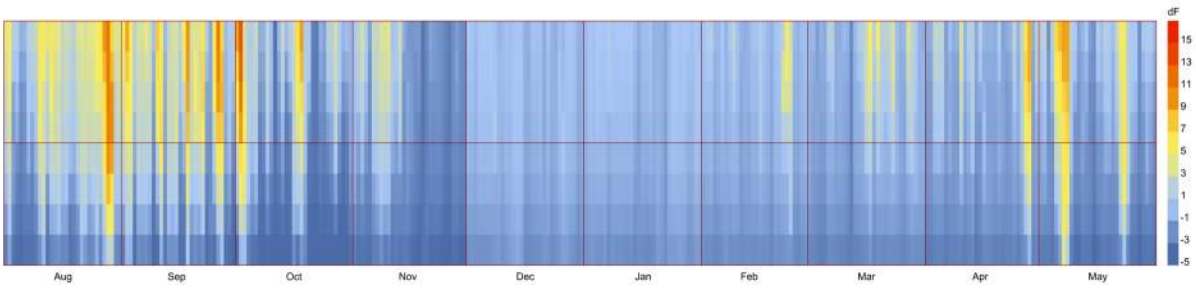


Figure 94: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 28 hours which feel too hot, and the magnitude of discomfort is 254 degreeF-hours.

Air-Conditioning Retrofit

Figure 95: Distribution of hours which are too hot throughout the year

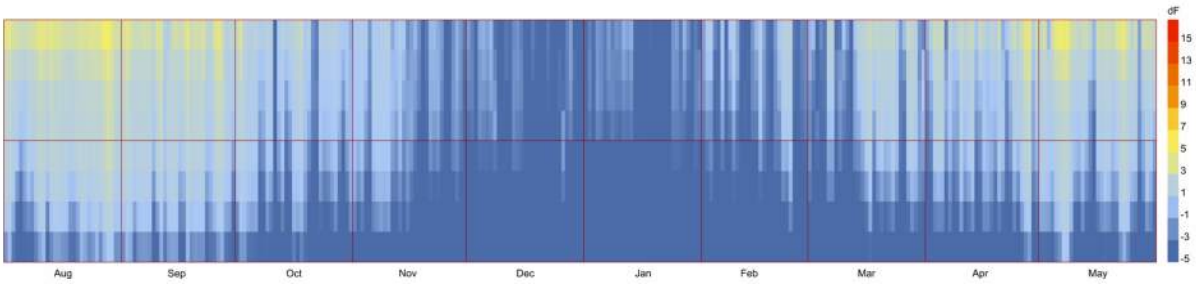


Figure 96: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 97: Distribution of hours which are too hot throughout the year

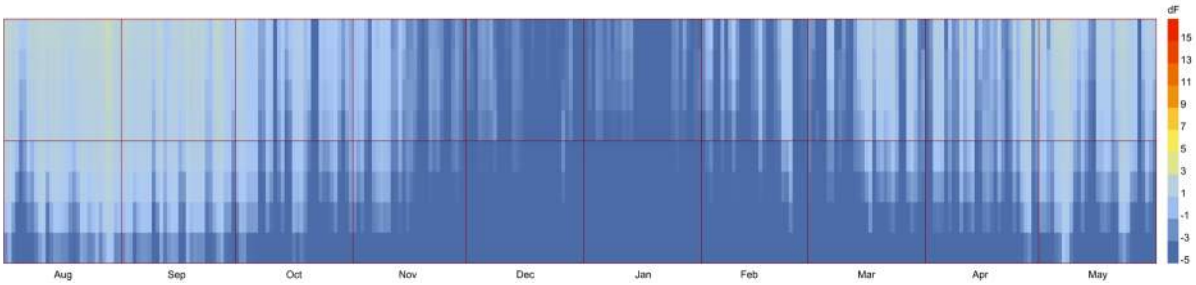


Figure 98: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 5 – SW Campus South Facing Classroom

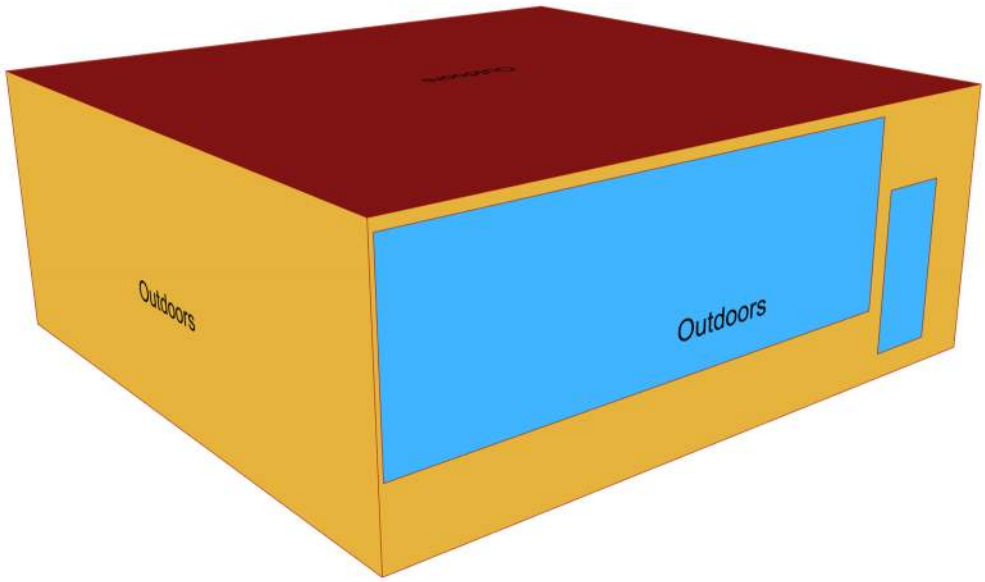


Figure 99: Energy Model Geometry

	Description	**Value**	**Unit**
Campus	Manzanita Elementary School		
Model	Classroom - SW Campus South Facing		
Wall Construction	Insulated wood framed wall	4	R-value
Roof Construction	Wood Joist Insulation	10	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	854	square feet
People	Number of occupants	20.0	People

Lights	Lighting Load Density (Installed)	375.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	188	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	1.2	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

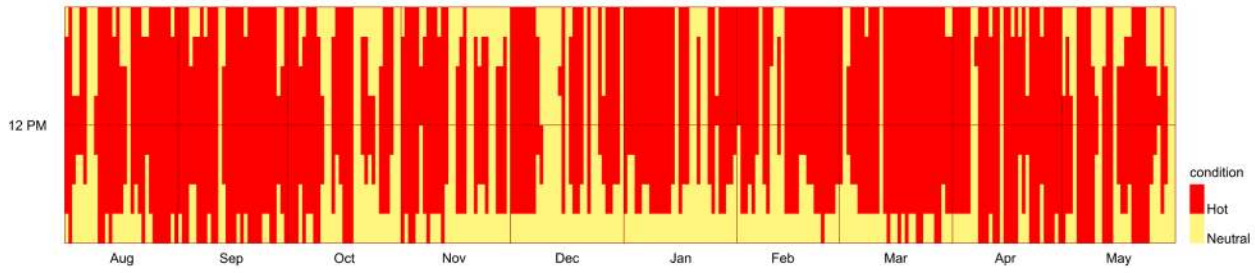


Figure 100: Distribution of hours which are too hot throughout the year

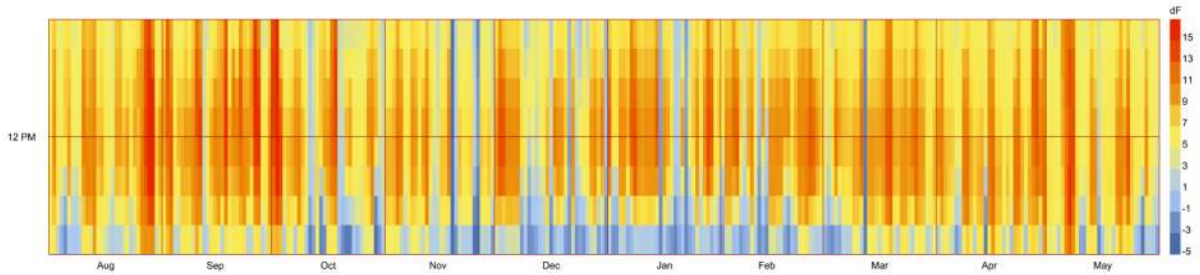


Figure 101: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,659 hours which feel too hot, and the magnitude of the discomfort hours is 12,798 degreeF-hours.

Basic Mitigation

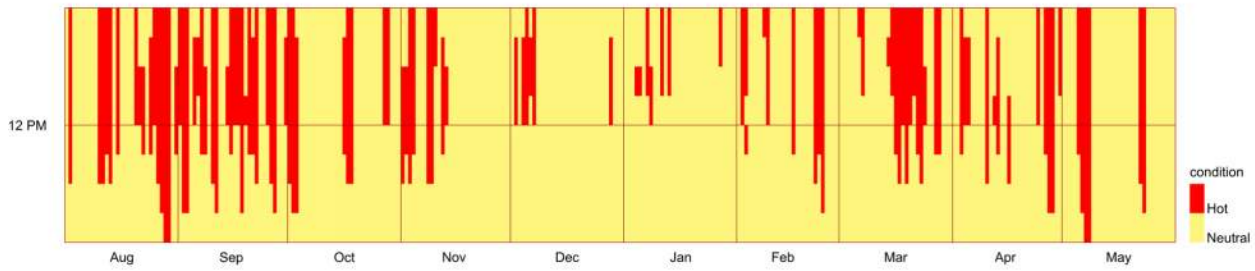


Figure 102: Distribution of hours which are too hot throughout the year

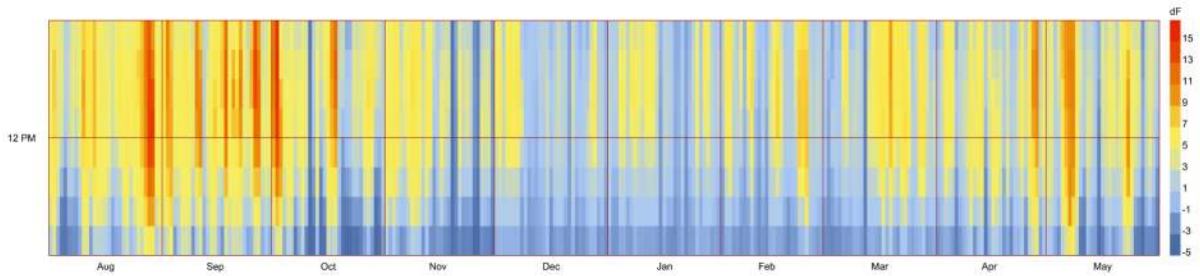


Figure 103: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 487 hours which feel too hot, and the magnitude of discomfort is 3,202 degreeF-hours.

Passive Mitigation

Figure 104: Distribution of hours which are too hot throughout the year

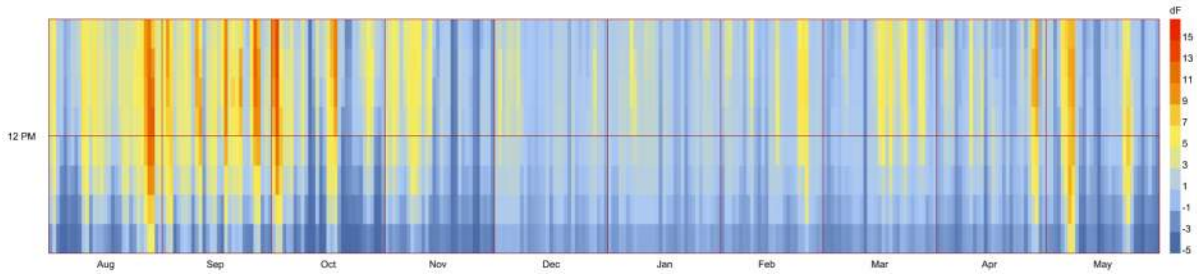


Figure 105: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 89 hours which feel too hot, and the magnitude of discomfort is 707 degreeF-hours.

Air-Conditioning Retrofit

Figure 106: Distribution of hours which are too hot throughout the year

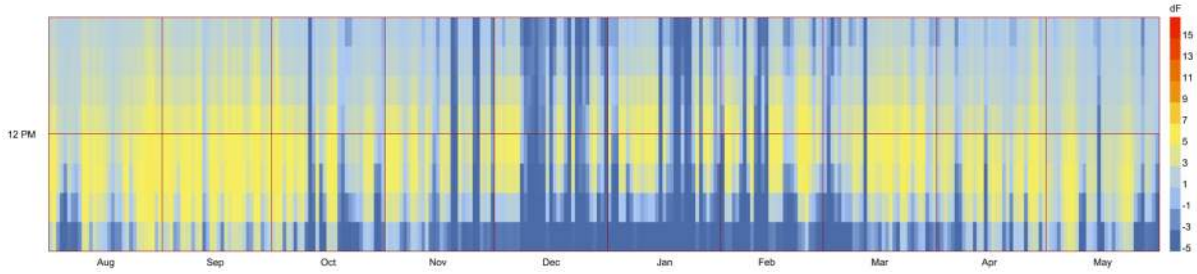


Figure 107: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 22 hours which feel too hot, and the magnitude of discomfort is 105 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 108: Distribution of hours which are too hot throughout the year

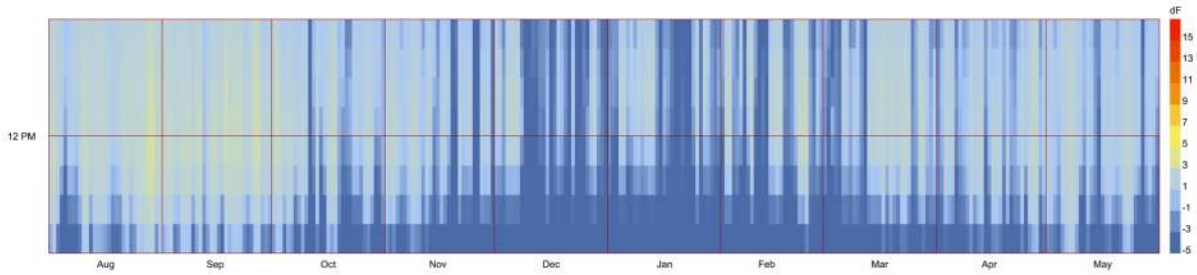


Figure 109: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Campus Wide Measures

Passive Approach

1. Provide (1) 20A/1P circuit for each fan. It is assumed that electrical circuits are available in the MPR.
2. Provide (3) 100A, 120/208V panels, (1) for each Buildings A, B, and D.
3. Provide (1) Fire Alarm Control Relay for each fan to shut off fan in the event of the fire alarm system going into alarm. The control relay shall connect to the nearest smoke detector with SLC cable.

Air Conditioning Retrofit and Air Conditioning Retrofit Plus

1. Provide a new 2500 amp 120/208V, 3ph, 4W Main Switchboard with 100% rated main breaker and backfeed existing 1200 amp 120/208V, 3ph, 4W switchboard. All new panels shown shall be fed from new MSB.
2. Provide (1) 800 amp 120/208V, 3ph, 4w panel for Classrooms 1-10/MPR/Admin building.
3. Provide (1) 225 amp 120/208v, 3ph, 4w panel for MPR building.
4. Provide (1) 800 amp 120/208v, 3ph, 4w panel for Classrooms 11-18/Media building.
5. Provide (1) 600 amp 120/208v, 3ph, 4w panel for Classrooms 19-23 building.

MANZANITA ELEMENTARY SCHOOL ELECTRICAL LOAD CALCULATIONS

NEW SERVICE LOAD CALCULATION — Existing Main Switchboard is 1200 amps at 120/208v, 3 phase, 4 wire

(E) PEAK DEMAND - 104 KW	104.0	KW AT	125%	=	130.0	KVA
NEW CONNECTED LOAD PER BELOW	584.0	KVA AT	100%	=	584.0	KVA
				TOTAL	714.0	KVA

714.0 KVA = **1983.3 AMPS AT 120/208V, 3 PHASE**

PROVIDE 2500 AMP SWITCHBOARD AT 120/208V, 3 PHASE, 4 WIRE

MANZANITA ADDITIONAL LOADS TO EXISTING SERVICE

STUDENT DINING	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**		CONNECTED LOAD		PANEL SIZE
RTU-4	208/3	2	28.04	56.1	KVA			
			SUBTOTAL	56.1	KVA	155.78	AMPS	800 AMPS
								STUDENT DINING AND BUILDING A ON 1 PANEL
BUILDING A	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**				
RTU-1	208/3	9	16.27	146.4	KVA			
			SUBTOTAL	146.4	KVA	406.75	AMPS	
BUILDING B	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**				
RTU-1	208/3	11	16.27	179.0	KVA			
			SUBTOTAL	179.0	KVA	497.14	AMPS	800 AMPS
BUILDING C	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**				
RTU-4	208/3	2	28.04	56.1	KVA			
			SUBTOTAL	56.1	KVA	155.78	AMPS	225 AMPS
BUILDING D	**VOLTAGE**	**QTY**	**KVA EACH**	**TOTAL**				
RTU-1	208/3	9	16.27	146.4	KVA			
			SUBTOTAL	146.4	KVA	406.75	AMPS	600 AMPS

TOTAL	584.0	KVA
	1,622.2	AMPS
	@120/208V, 3 PHASE	

Cost Estimate

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	Manzanita Elementary			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
1	**Basic Mitigation**				
	Remove windows and frames	4,352	sf	20.00	87,040
	New windows and frames	4,352	sf	187.50	816,000
	Rough carpentry per window set	43	ea	2,500.00	107,500
	Patching and repairing	1	ls	101,054.00	101,054
	SUBTOTAL				**1,111,594**
	GENERAL CONDITIONS			10.0%	111,159
	BONDS & INSURANCE			2.0%	24,455
	OVERHEAD AND PROFIT			10.0%	124,721
	DESIGN CONTINGENCY			20.0%	274,386
	ESCALATION			6.8%	112,498
	TOTAL CONSTRUCTION COST				**1,758,813**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	Manzanita Elementary			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
2	**Passive Approach**				
	Remove windows and frames	4,352	sf	20.00	87,040
	New windows and frames	4,352	sf	187.50	816,000
	Rough carpentry per window set	43	ea	2,500.00	107,500
	Actuators, complete	43	ea	3,000.00	129,000
	Tie into EMS controls and test	1	ls	32,250.00	32,250
	Patching and repairing	1	ls	117,179.00	117,179
	Window security screens, perforated metal panel	870	sf	125.00	108,800
	Roof insulation	45,000	sf	15.00	675,000
	Ceiling fans	31	ea	1,000.00	31,000
	Power and controls to ceiling fans	31	ea	1,437.50	44,563
	100a panel and feeder	1	ea	14,583.33	14,583
	Fire alarm control relay with SLC cable	25	ea	1,250.00	31,250
	Patching and repairing	1	ls	30,348.96	30,349
	SUBTOTAL				**2,224,514**
	GENERAL CONDITIONS			10.0%	222,451
	BONDS & INSURANCE			2.0%	48,939
	OVERHEAD AND PROFIT			10.0%	249,590
	DESIGN CONTINGENCY			20.0%	549,099
	ESCALATION			6.8%	225,131
	TOTAL CONSTRUCTION COST				**3,519,724**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	Manzanita Elementary			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
3	**Air Conditioning Retrofit**				
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 4 ton rooftop packaged heat pump unit	8	ea	20,000.00	160,000
	York 4 ton rooftop packaged heat pump unit	1	ea	20,000.00	20,000
	York 4 ton rooftop packaged heat pump unit	11	ea	20,000.00	220,000
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 4 ton rooftop packaged heat pump unit	9	ea	20,000.00	180,000
	Ductwork and distribution	33,000	sf	20.00	660,000
	Controls	1	ls	13,200.00	13,200
	Testing, adjusting and balancing	33,000	sf	2.50	82,500
	Structural roof upgrade	33,000	sf	25.00	825,000
	Mechanical power	11	ea	3,750.00	41,250
	Condensate drainage	20	ea	3,437.50	68,750
	Patching and repairing	33,000	sf	5.00	165,000
	2500a main switchboard	1	ea	164,930.56	164,931
	Back feed existing 1200a switchboard	1	ea	100,000.00	100,000
	225a panel and feeder	1	ea	60,937.50	60,938
	800a panel and feeder	2	ea	216,666.67	433,333
	600a panel and feeder	1	ea	162,500.00	162,500
	SUBTOTAL				**3,557,401**
	GENERAL CONDITIONS			10.0%	355,740
	BONDS & INSURANCE			2.0%	78,263
	OVERHEAD AND PROFIT			10.0%	399,140
	DESIGN CONTINGENCY			20.0%	878,109
	ESCALATION			6.8%	360,025
	TOTAL CONSTRUCTION COST				**5,628,678**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	Manzanita Elementary			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
4	**Air Conditioning Retrofit Plus**				
	Remove windows and frames	4,352	sf	20.00	87,040
	New windows and frames	4,352	sf	187.50	816,000
	Rough carpentry per window set	43	ea	2,500.00	107,500
	Patching and repairing	1	ls	101,054.00	101,054
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 4 ton rooftop packaged heat pump unit	8	ea	20,000.00	160,000
	York 4 ton rooftop packaged heat pump unit	1	ea	20,000.00	20,000
	York 4 ton rooftop packaged heat pump unit	11	ea	20,000.00	220,000
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 4 ton rooftop packaged heat pump unit	9	ea	20,000.00	180,000
	Ductwork and distribution	33,000	sf	20.00	660,000
	Controls	1	ls	13,200.00	13,200
	Testing, adjusting and balancing	33,000	sf	2.50	82,500
	Structural roof upgrade	33,000	sf	25.00	825,000
	Mechanical power	11	ea	3,750.00	41,250
	Condensate drainage	20	ea	3,437.50	68,750
	Patching and repairing	33,000	sf	5.00	165,000
	2500a main switchboard	1	ea	164,930.56	164,931
	Back feed existing 1200a switchboard	1	ea	100,000.00	100,000
	225a panel and feeder	1	ea	60,937.50	60,938
	800a panel and feeder	2	ea	216,666.67	433,333
	600a panel and feeder	1	ea	162,500.00	162,500
	SUBTOTAL				**4,668,995**
	GENERAL CONDITIONS			10.0%	466,900
	BONDS & INSURANCE			2.0%	102,718
	OVERHEAD AND PROFIT			10.0%	523,861
	DESIGN CONTINGENCY			20.0%	1,152,495
	ESCALATION			6.8%	472,523
	TOTAL CONSTRUCTION COST				**7,387,492**

LIFE CYCLE COSTING SUMMARY

LCC-1

Project Name: *Manzanita Campus*

Date: *4/28/2023*

ANNUAL ENERGY USE AND COST

Option	Description	Electricity			Natural Gas		
		Consumption (kWh)	Demand (kW)	Cost ($)	Consumption (therms)	Cost ($)	Simple Payback (years)
Base	Baseline (Existing Conditions)	12,765	0	$4,589	79	$99	N/A
1	Basic	13,027	0	$4,683	265	$331	N/A
2	Passive	12,980	0	$4,666	232	$289	N/A
3	AC Retrofit	21,348	0	$7,675	0	$0	N/A
4	AC Retrofit+	19,995	0	$7,188	0	$0	N/A

LIFE CYCLE COST PRESENT VALUE

Option	Initial Cost	Utility Incentive	Annual Recurring Costs	Electricity Costs	Natural Gas Costs	Non Annual Recurring OM&R Cost	Replacem. Costs	Residual Value	Total LCC	Additional Costs
Base	$0	$0	$0	$82,330	$2,089	$0	$0	$0	$84,419	$0
1	$151,531	$0	$0	$84,017	$6,983	$0	$0	$0	$242,531	$158,112
2	$303,243	$0	$0	$83,712	$6,097	$0	$0	$0	$393,052	$308,633
3	$484,941	$0	$0	$137,696	$0	$0	$0	$0	$622,637	$538,218
4	$636,473	$0	$0	$128,959	$0	$0	$0	$0	$765,432	$681,012

Study Parameters

Study Period: 25 years

Real Discount Rate: 3.0%

☑ DOE/FEMP Escalation Rates

Region: Western US

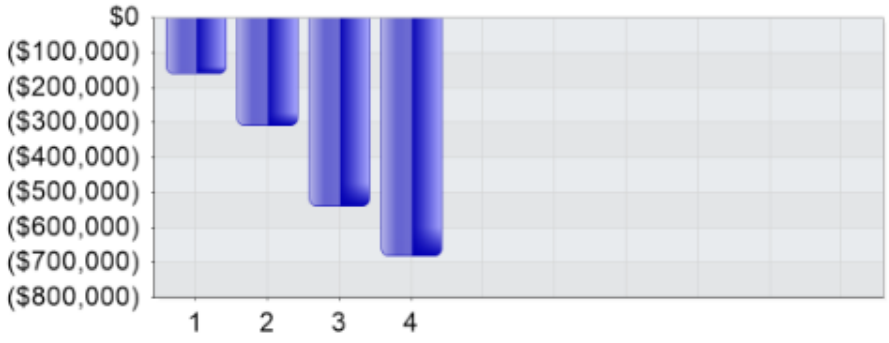
Fuel Sector: Commercial

☐ Uniform Escalation Rates

Electricity: N/A

Natural Gas: N/A

LIFE CYCLE COST SAVINGS



EnergyLCC 8.3 by EnergySoft 1 of 1

To estimate the campus-wide performance of the different strategies, a weighted average of the energy modeling results is applied. Each room at the campus is assigned an energy model representation, which is based on the building's space type, orientation, etc. The total discomfort hours for each building on campus are added up. For the different mitigation strategies, we can consider the amount that the discomfort hours are reduced by.

The total discomfort hours for each campus is shown in the table below:

Campus-wide discomfort hours	Baseline	Basic Mitigation	Passive Mitigation	Air Conditioning Retrofit	Air Conditioning Retrofit Plus
Manzanita Elementary School	30,550	12,402	2,703	131	0

The total reduction percentage of discomfort hours is shown in the table below:

Scenario Improvement %	Basic Mitigation	Passive Mitigation	Air Conditioning Retrofit	Air Conditioning Retrofit Plus
Manzanita Elementary School	59%	91%	100%	100%

West Oakland Middle School

Five energy models were developed to represent the thermal conditions of West Oakland Middle School. The following pages describe the assumptions and results of each school.

Model 1 – Administrative Office

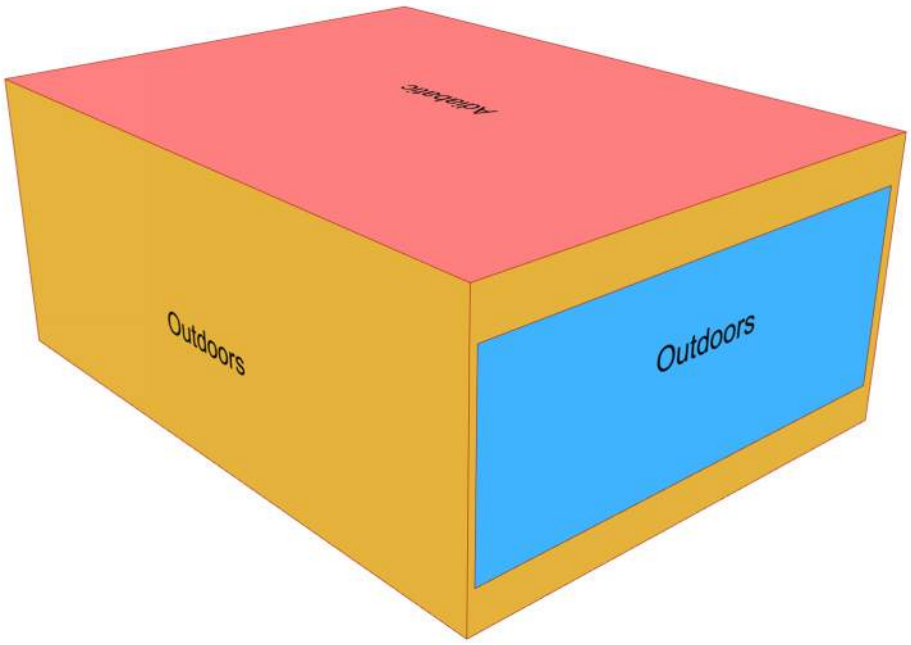


Figure 110: Energy Model Geometry

	Description	Value	Unit
Campus	West Oakland Middle School		
Model	Administration		
Wall Construction	Uninsulated Concrete Wall	4	R-value
Roof Construction	*N/A*	*N/A*	R-value
Roof Construction (Passive Approach)	*N/A*	*N/A*	R-value
Space Type	Primary School Office		
Space Area	Conditioned Floor Area	507	sq feet

People	Number of occupants	2.5	People
Lights	Lighting Load Density (Installed)	1.1	W/sq ft
Plug Loads	Plug Load Density (Installed)	1.0	W/sq ft
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	140	sq feet
Baseline Window Operability	% of window area that are opened when conditions allow	3.75	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

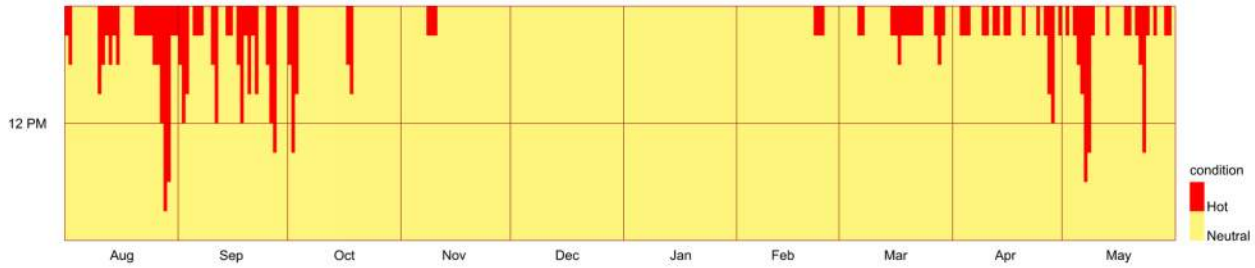


Figure 111: Distribution of hours which are too hot throughout the year

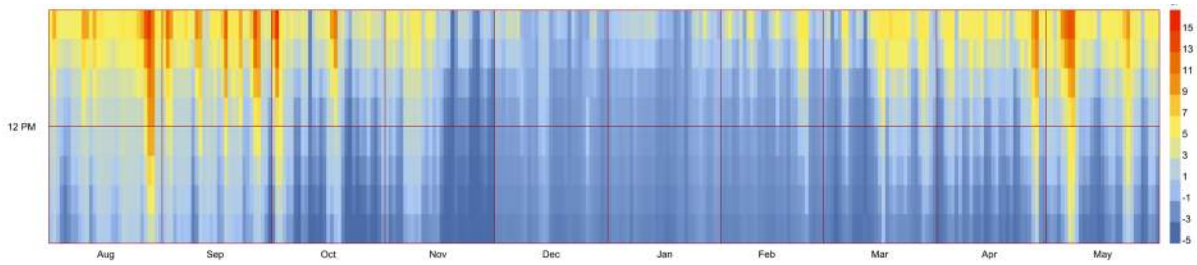


Figure 112: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 178 hours which feel too hot, and the magnitude of the discomfort hours is 1,196 degreeF-hours.

Basic Mitigation

Figure 113: Distribution of hours which are too hot throughout the year

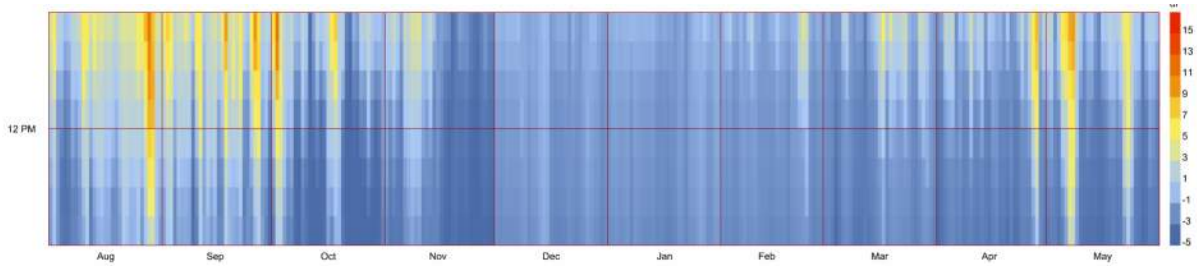


Figure 114: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 65 hours which feel too hot, and the magnitude of discomfort is 413 degreeF-hours.

Passive Mitigation

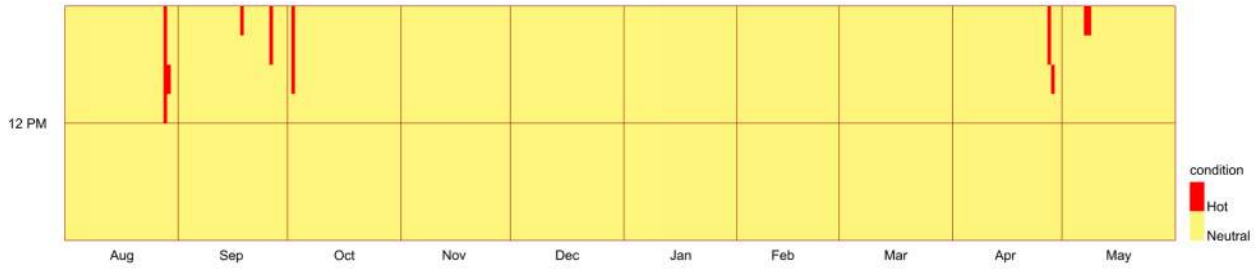


Figure 115: Distribution of hours which are too hot throughout the year

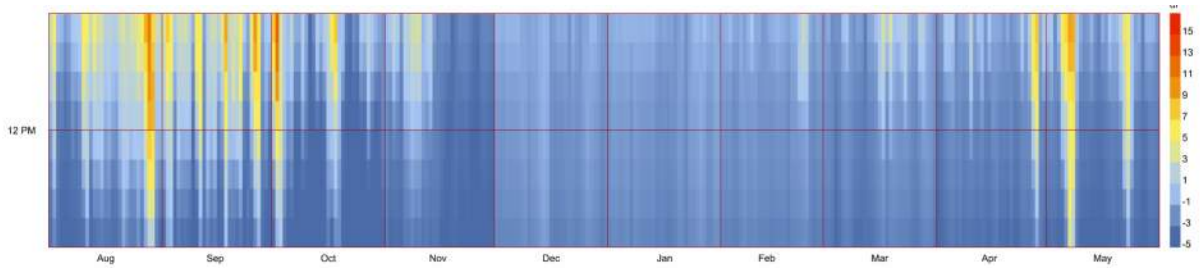


Figure 116: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 16 hours which feel too hot, and the magnitude of discomfort is 130 degreeF-hours.

Air-Conditioning Retrofit

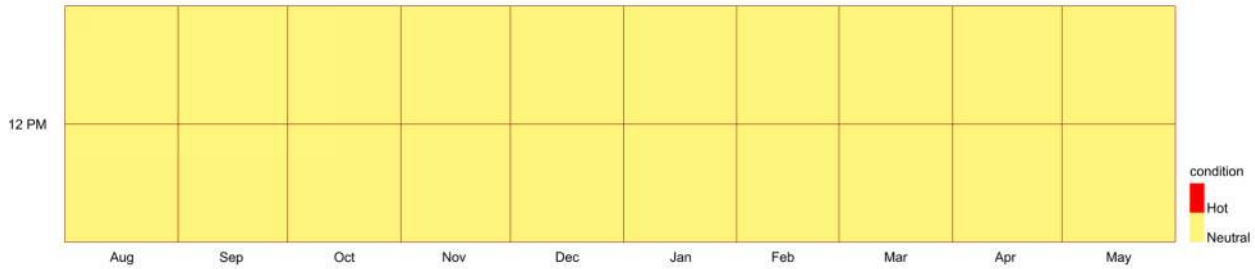


Figure 117: Distribution of hours which are too hot throughout the year

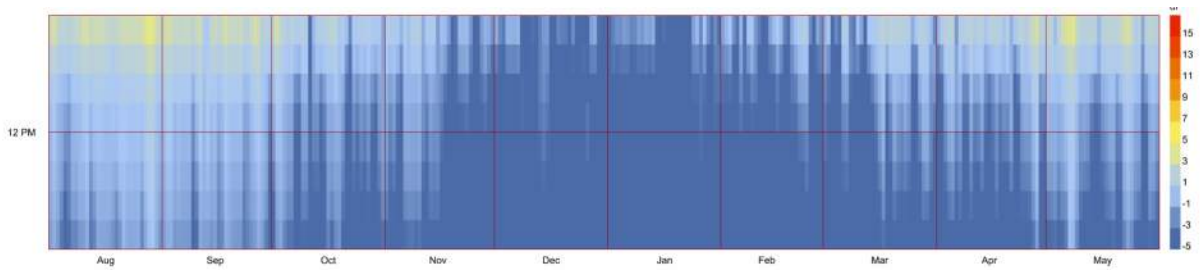


Figure 118: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

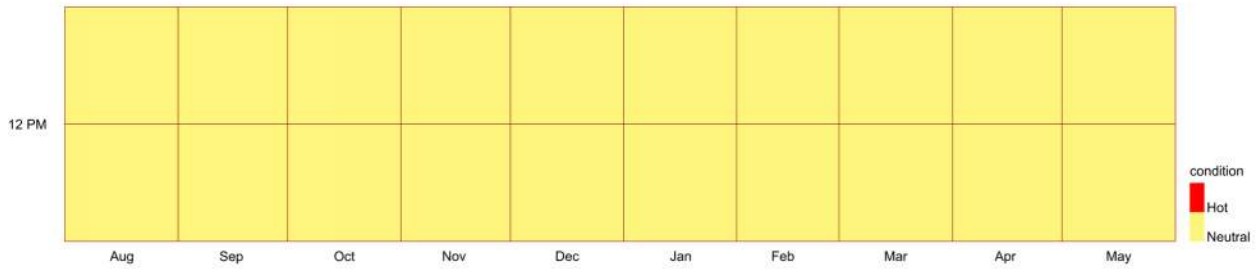


Figure 119: Distribution of hours which are too hot throughout the year

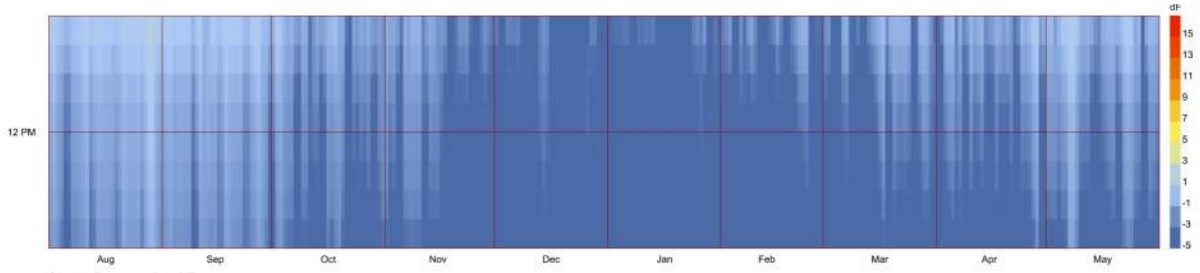


Figure 120: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 2 – First Floor West Facing Classroom

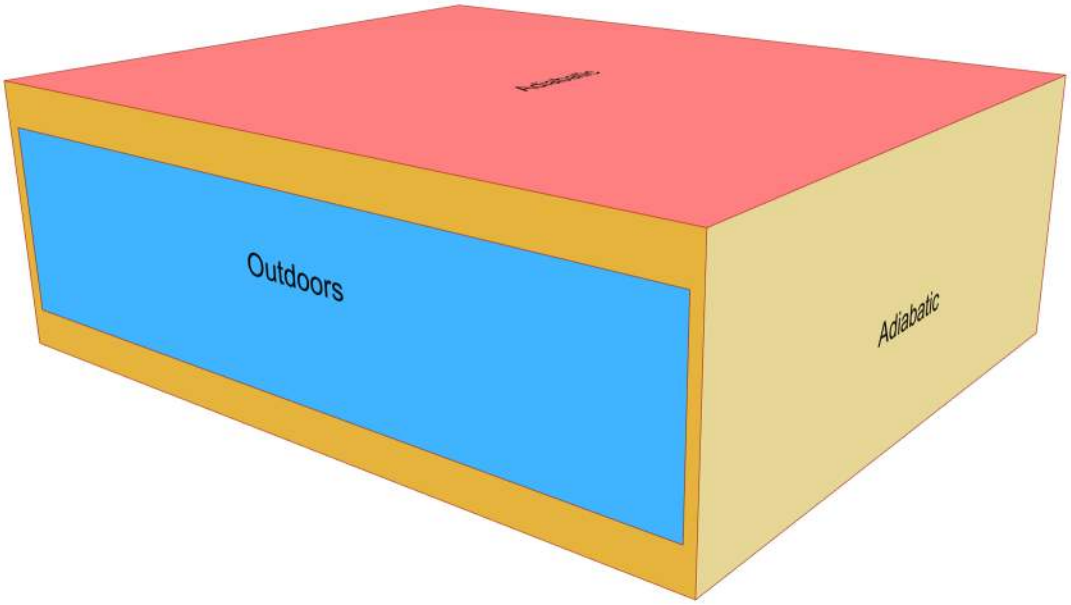


Figure 121: Energy Model Geometry

	Description	Value	Unit
Campus	West Oakland Middle School		
Model	Classroom - 1st Floor West Facing		
Wall Construction	Uninsulated Concrete Wall	1	R-value
Roof Construction	*N/A*	*N/A*	
Roof Construction (Passive Approach)	*N/A*	*N/A*	
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	831	square feet
People	Number of occupants	20.0	People
Lights	Lighting Load Density (Installed)	300.0	Watts

Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	232	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	3.75	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

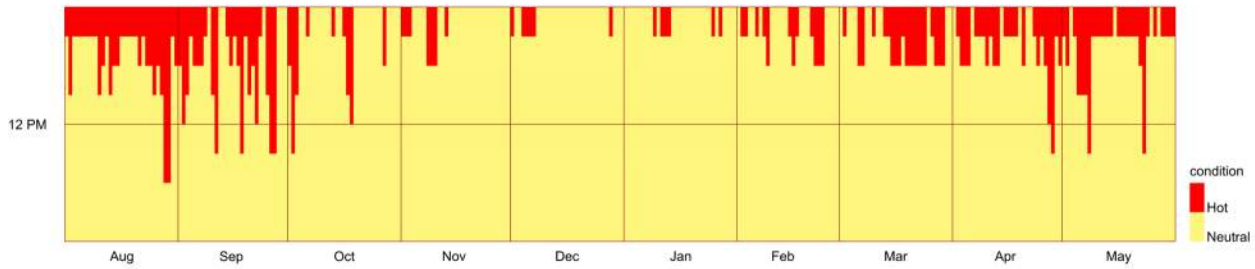


Figure 122: Distribution of hours which are too hot throughout the year

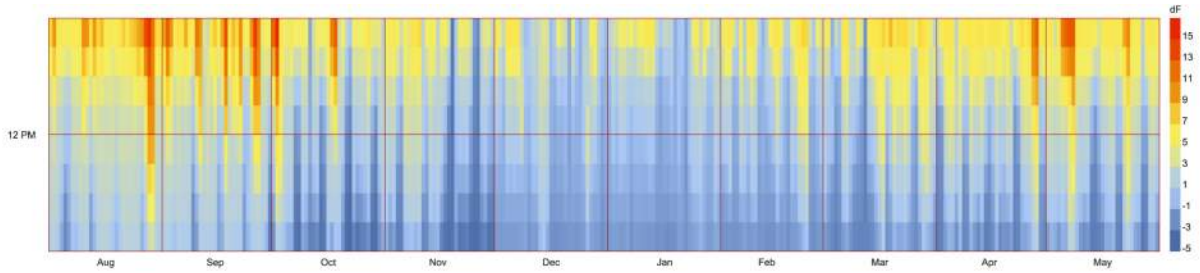


Figure 123: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 298 hours which feel too hot, and the magnitude of the discomfort hours is 1,939 degreeF-hours.

Basic Mitigation

Figure 124: Distribution of hours which are too hot throughout the year

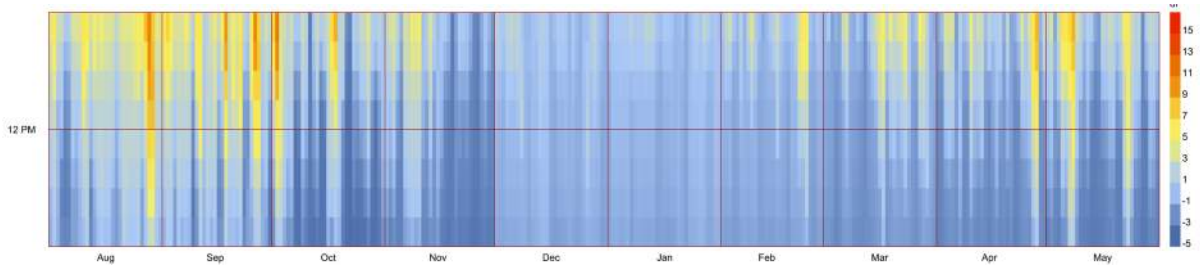


Figure 125: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 77 hours which feel too hot, and the magnitude of discomfort is 483 degreeF-hours.

Passive Mitigation

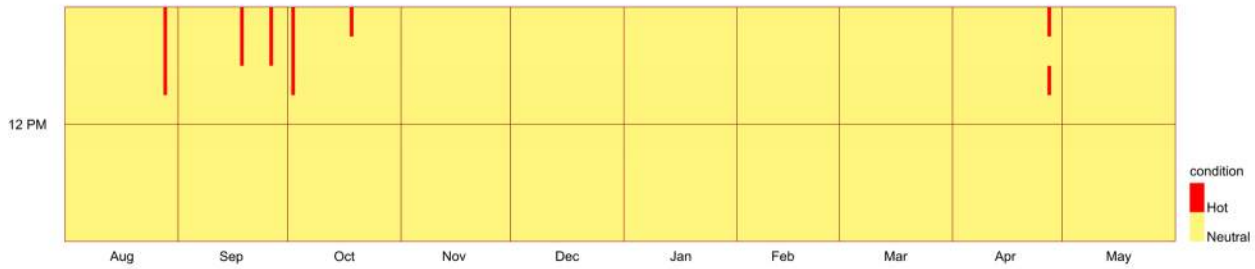


Figure 126: Distribution of hours which are too hot throughout the year

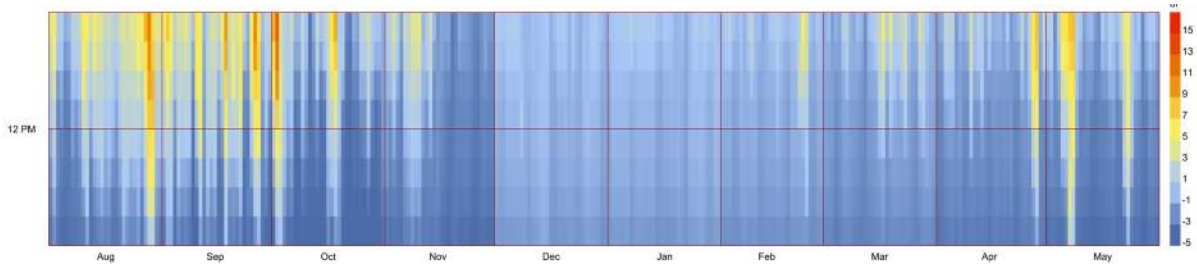


Figure 127: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 13 hours which feel too hot, and the magnitude of discomfort is 110 degreeF-hours.

Air-Conditioning Retrofit

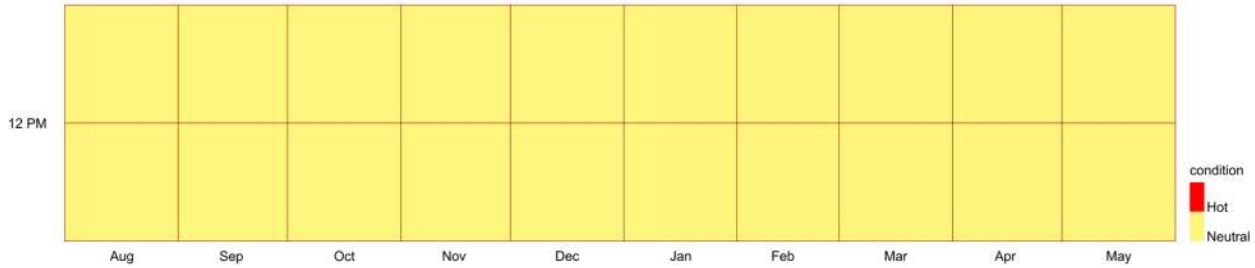


Figure 128: Distribution of hours which are too hot throughout the year

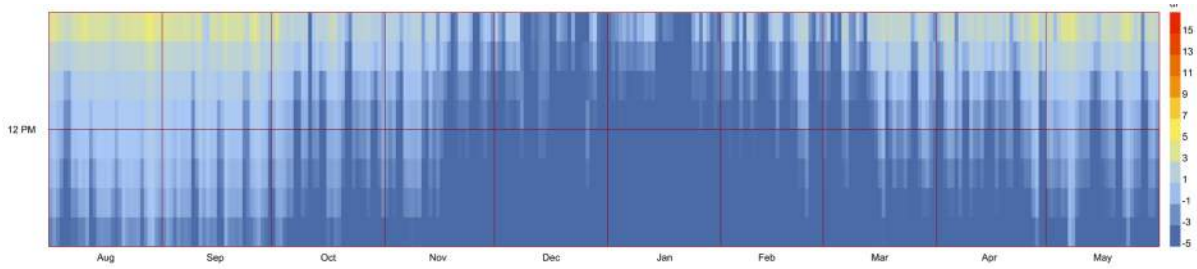


Figure 129: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 130: Distribution of hours which are too hot throughout the year

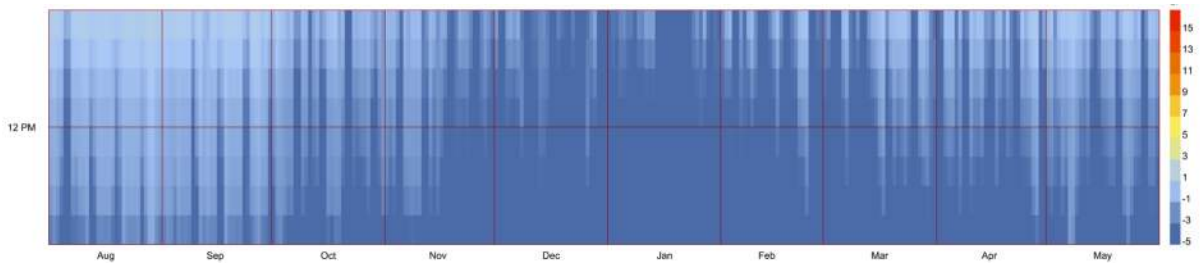


Figure 131: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Model 3 – Second Floor East Facing Classroom

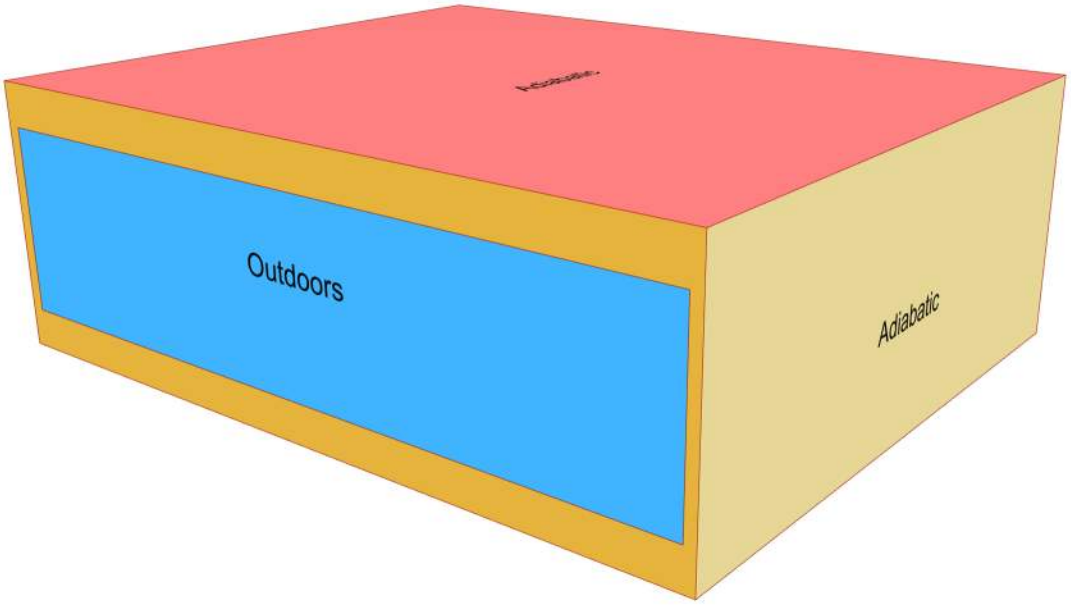


Figure 132: Energy Model Geometry

	Description	Value	Unit
Campus	West Oakland Middle School		
Model	Classroom - 2nd Floor East Facing		
Wall Construction	Uninsulated Concrete Wall	1	R-value
Roof Construction	Uninsulated Concrete Roof	4	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	831	square feet
People	Number of occupants	20.0	People
Lights	Lighting Load Density (Installed)	300.0	Watts

Plug Loads	Plug Load Density (Installed)	300.0	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	232	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	3.75	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

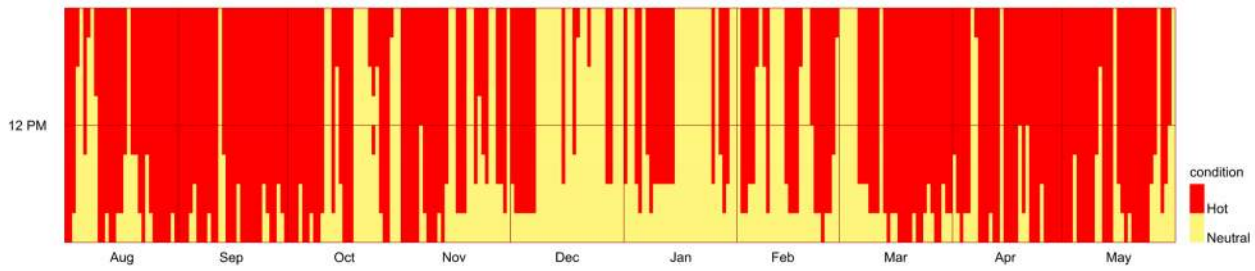


Figure 133: Distribution of hours which are too hot throughout the year

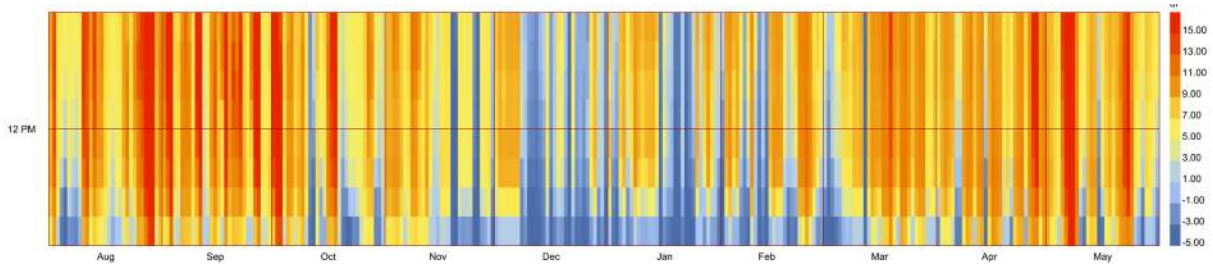


Figure 134: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 1,555 hours which feel too hot, and the magnitude of the discomfort hours is 13,381 degreeF-hours.

Basic Mitigation

Figure 135: Distribution of hours which are too hot throughout the year

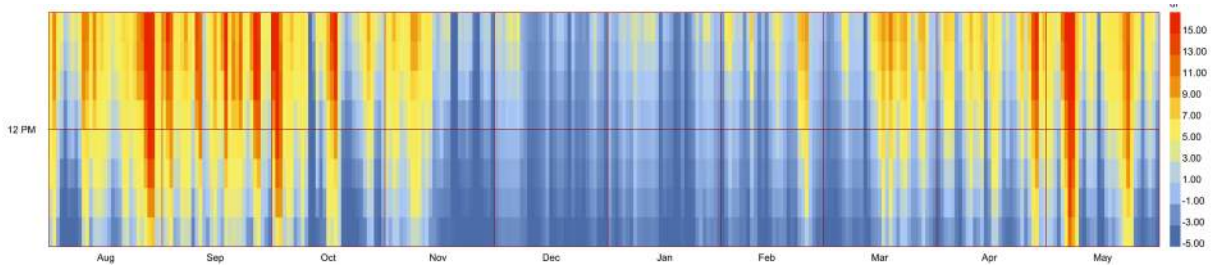


Figure 136: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 531 hours which feel too hot, and the magnitude of discomfort is 4,082 degreeF-hours.

Passive Mitigation

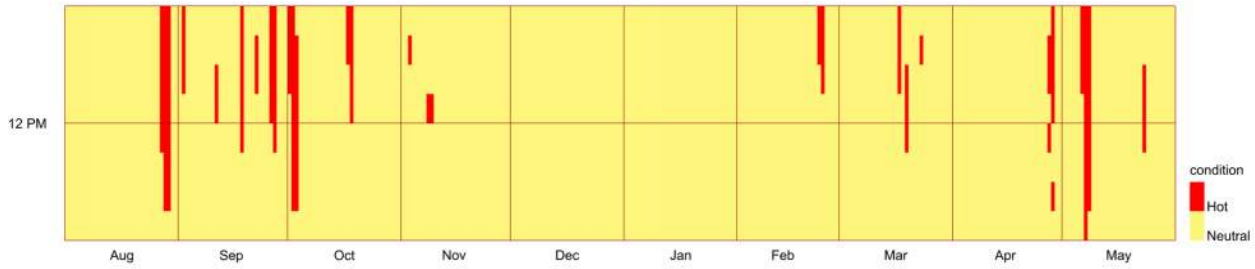


Figure 137: Distribution of hours which are too hot throughout the year

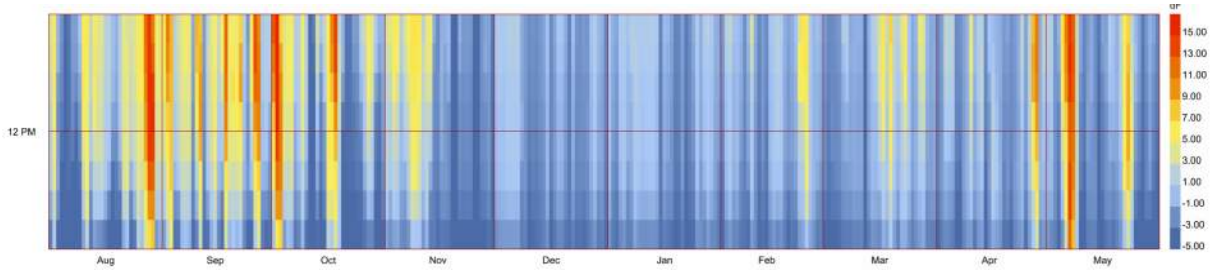


Figure 138: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 106 hours which feel too hot, and the magnitude of discomfort is 1,068 degreeF-hours.

Air-Conditioning Retrofit

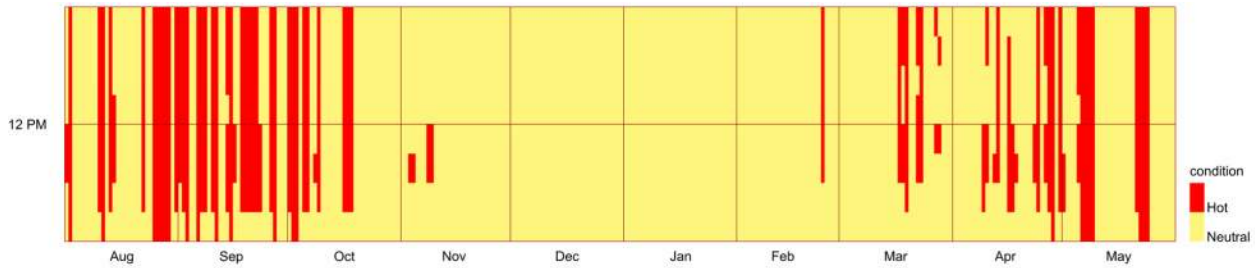


Figure 139: Distribution of hours which are too hot throughout the year

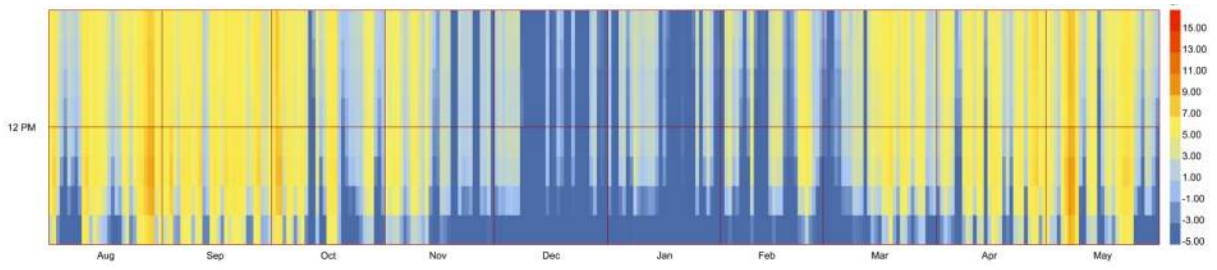


Figure 140: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 455 hours which feel too hot, and the magnitude of discomfort is 2,531 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 141: Distribution of hours which are too hot throughout the year

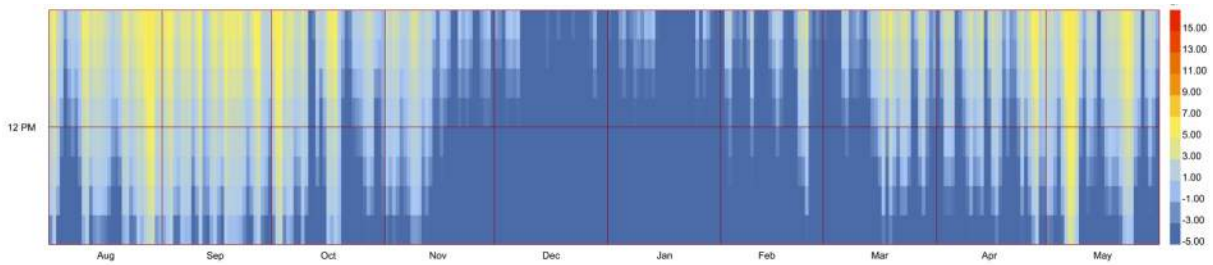


Figure 142: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 14 hours which feel too hot, and the magnitude of discomfort is 69 degreeF-hours.

Model 4 – 2nd Floor West Facing Classroom

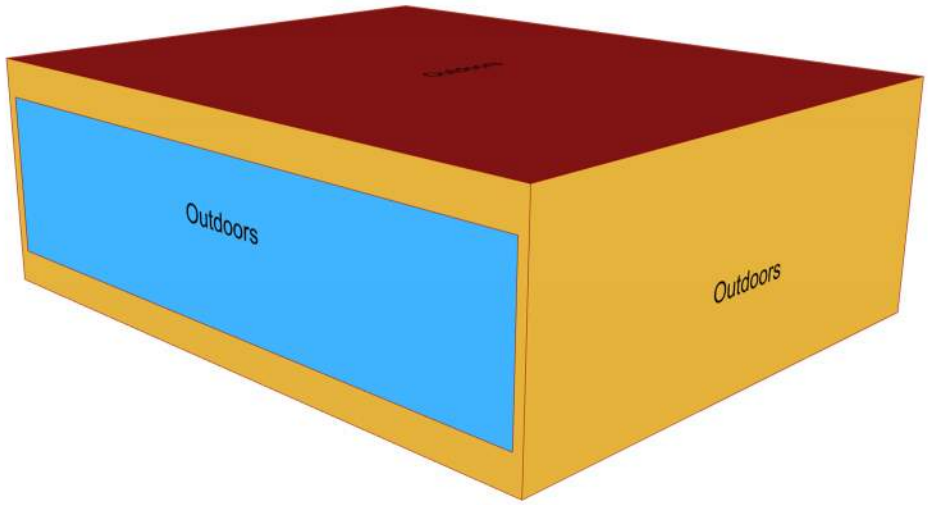


Figure 143: Energy Model Geometry

	Description	Value	Unit
Campus	West Oakland Middle School		
Model	Classroom - 2nd Floor West Facing		
Wall Construction	Uninsulated Concrete Wall	1	R-value
Roof Construction	Uninsulated Concrete Roof	4	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Primary School Classroom		
Space Area	Conditioned Floor Area	831	square feet
People	Number of occupants	20.0	People
Lights	Lighting Load Density (Installed)	300.0	Watts
Plug Loads	Plug Load Density (Installed)	300.0	Watts

Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	232	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	3.75	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	10	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	20	%
Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed to open 24/7		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

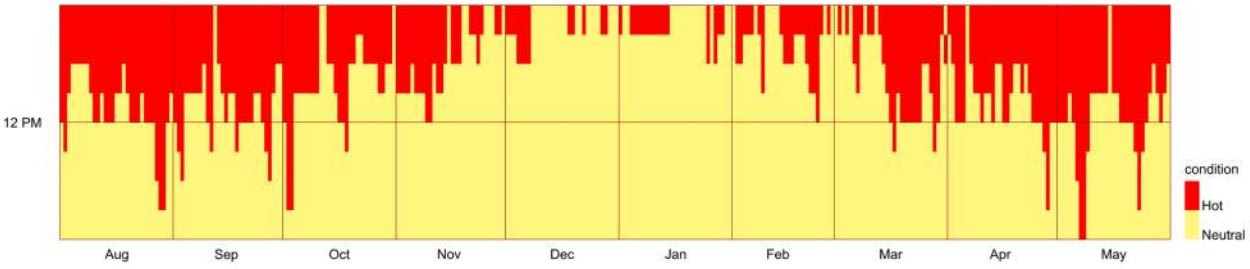


Figure 144: Distribution of hours which are too hot throughout the year

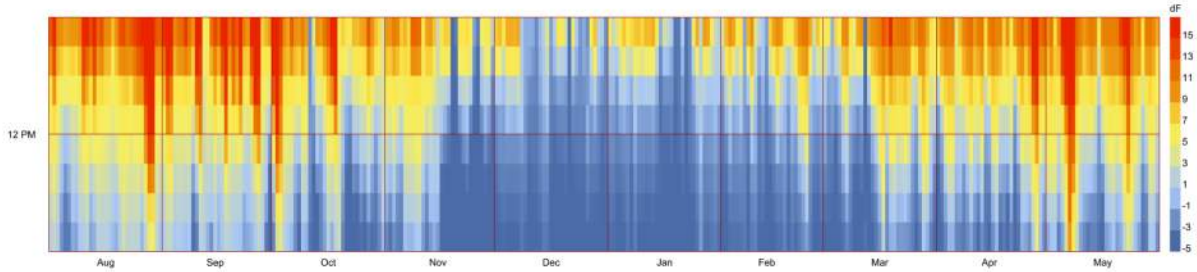


Figure 145: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 711 hours which feel too hot, and the magnitude of the discomfort hours is 6,157 degreeF-hours.

Basic Mitigation

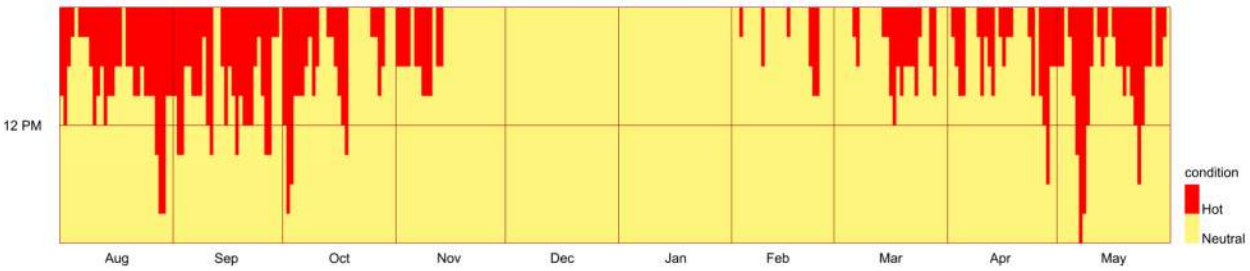


Figure 146: Distribution of hours which are too hot throughout the year

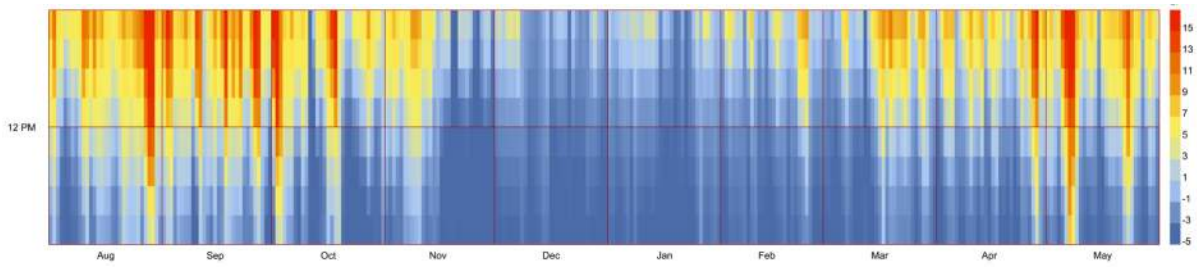


Figure 147: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Basic Mitigation case has 414 hours which feel too hot, and the magnitude of discomfort is 3,212 degreeF-hours.

Passive Mitigation

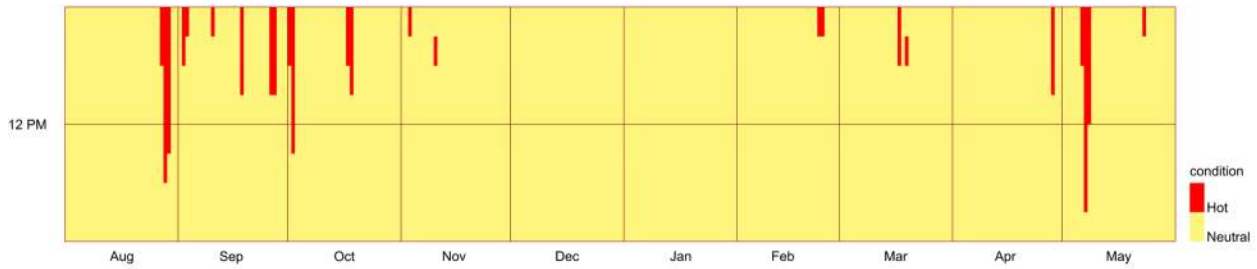


Figure 148: Distribution of hours which are too hot throughout the year

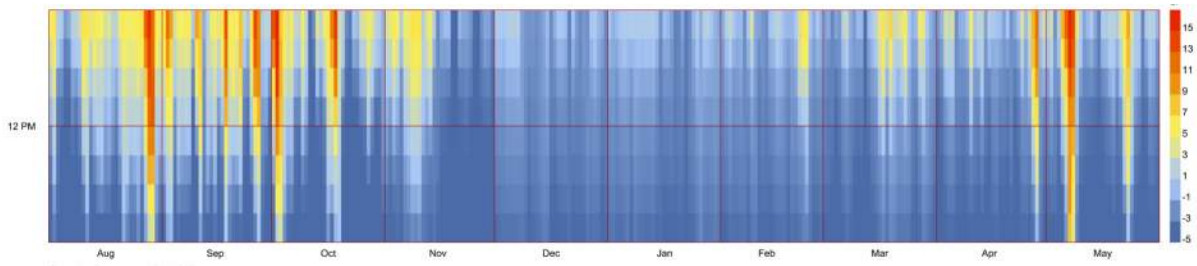


Figure 149: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 62 hours which feel too hot, and the magnitude of discomfort is 638 degreeF-hours.

Air-Conditioning Retrofit

Figure 150: Distribution of hours which are too hot throughout the year

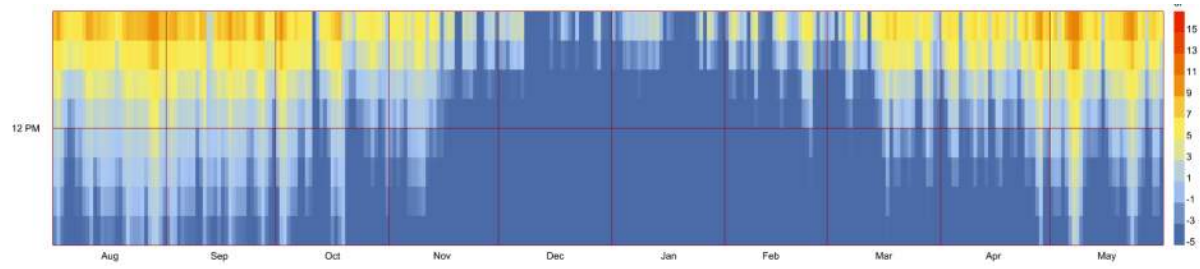


Figure 151: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 231 hours which feel too hot, and the magnitude of discomfort is 1,419 degreeF-hours.

Air-Conditioning Retrofit Plus

Figure 152: Distribution of hours which are too hot throughout the year

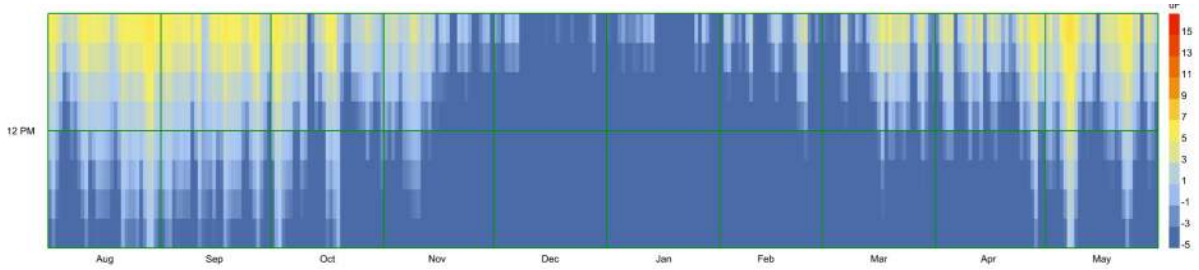


Figure 153: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit Plus case has 23 hours which feel too hot, and the magnitude of discomfort is 119 degreeF-hours.

Model 5 – Gymnasium

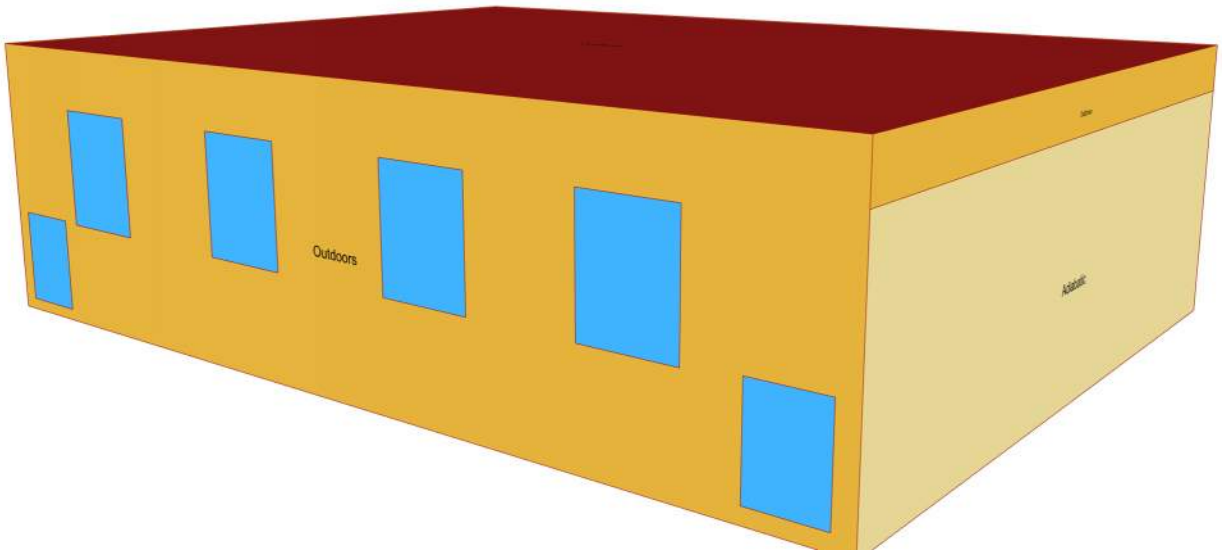


Figure 154: Energy Model Geometry

	Description	Value	Unit
Campus	West Oakland Middle School		

Model	Gymnasium		
Wall Construction	Uninsulated Concrete Wall	1	R-value
Roof Construction	Uninsulated Concrete Roof	4	R-value
Roof Construction (Passive Approach)	Insulation Entirely Above Deck	31	R-value
Space Type	Secondary School Gym		
Space Area	Conditioned Floor Area	5,439	square feet
People	Number of occupants	163.2	People
Lights	Lighting Load Density (Installed)	0.7	Watts
Plug Loads	Plug Load Density (Installed)	0.5	Watts
Heating Setpoint	7am through 4pm	68	Degrees F
Heating Setback	5pm through 6am	59	Degrees F
Cooling Setpoint (for A/C Retrofits)	7am through 4pm	74	Degrees F
Cooling Setback (for A/C Retrofits)	5pm through 6am	80	Degrees F
Windows	Area of all windows	415	square feet
Baseline Window Operability	% of window area that are opened when conditions allow	7	%
Basic Mitigation Window Operability	% of window area opened with a glazing replacement	*N/A*	%
Passive Mitigation Window Operability	% of window area opened with glazing replacement and actuator installation	7	%

Window Opening Thresholds - Baseline	Windows allowed open between 8am through 4pm		
Window Opening Thresholds - Passive Mitigation	Windows allowed open between 8am through 4pm		
Air Speed (Typical)	The air speed experienced by occupants typically	59	fpm
Air Speed - with Ceiling Fans (Passive Approach)	The air speed experienced by occupants with a ceiling fan running	177	fpm

Baseline

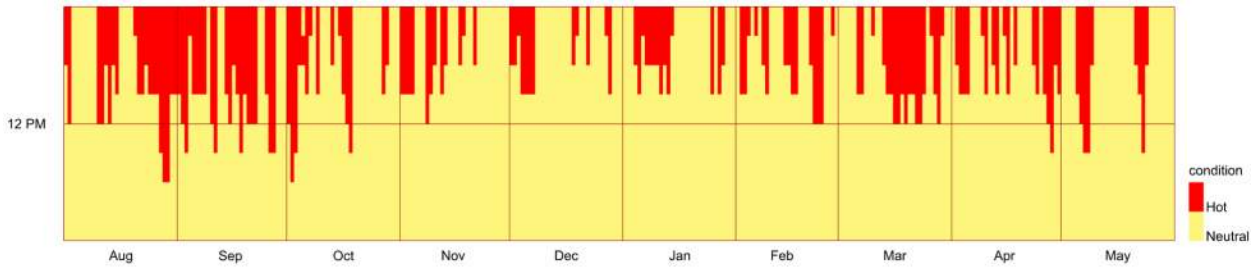


Figure 155: Distribution of hours which are too hot throughout the year

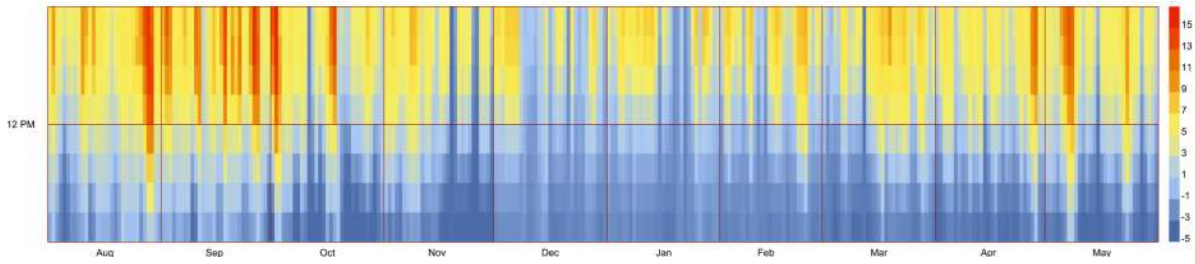


Figure 156: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The baseline case has 451 hours which feel too hot, and the magnitude of the discomfort hours is 3,039 degreeF-hours.

Passive Mitigation

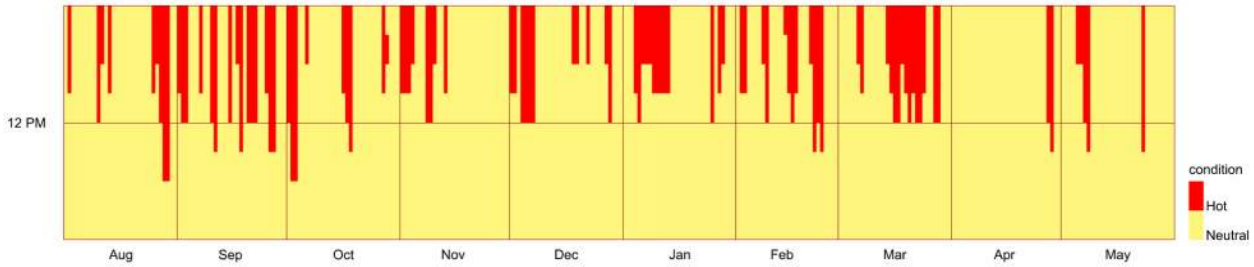


Figure 157: Distribution of hours which are too hot throughout the year

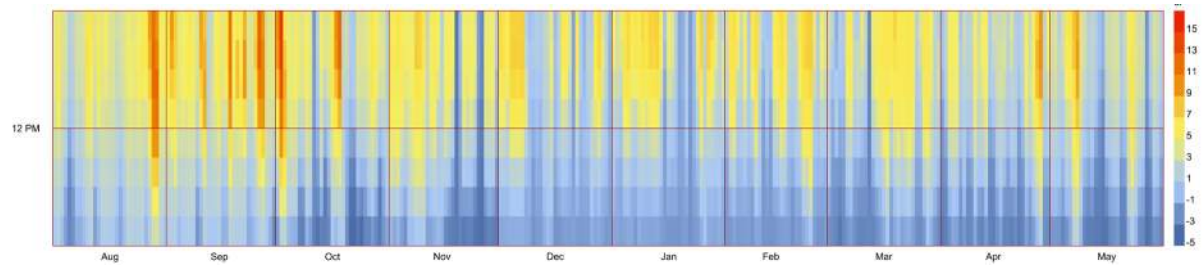


Figure 158: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Passive Mitigation case has 336 hours which feel too hot, and the magnitude of discomfort is 2,116 degreeF-hours.

Air-Conditioning Retrofit

Figure 159: Distribution of hours which are too hot throughout the year

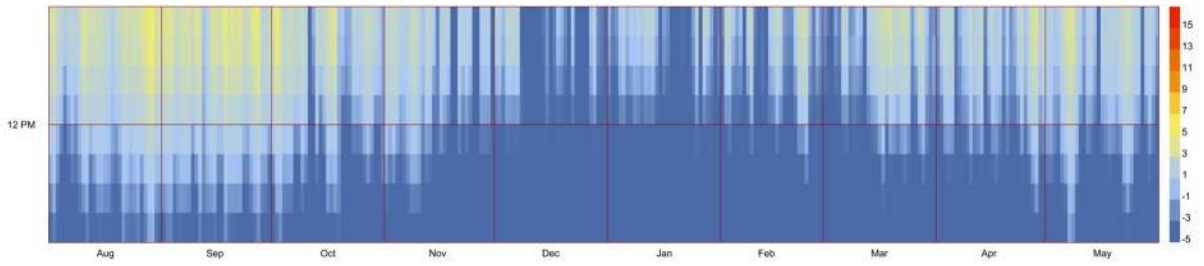


Figure 160: Magnitude of discomfort: the difference between the room operative temperature and optimal temperature

The Air Conditioning Retrofit case has 0 hours which feel too hot, and the magnitude of discomfort is 0 degreeF-hours.

Campus Wide Measures

Passive Approach

1. Provide (1) 20A/1P circuit for each fan. It is assumed that electrical circuits are available in the MPR, Gym, and 3 classrooms.
2. Provide (2) 100A, 120/208V panels, (1) for each 2-story classroom building.
3. Provide (1) Fire Alarm Control Relay for each fan to shut off fan in the event of the fire alarm system going into alarm. The control relay shall connect to the nearest smoke detector with SLC cable.

Air Conditioning Retrofit and Air Conditioning Retrofit Plus

Note that this is an estimated worst-case scenario as PG&E loads were not available for the existing service.

1. Provide a new 3000 amp 120/208V, 3ph, 4W Main Switchboard and backfeed existing 1600 amp 120/208V, 3ph, 4W switchboard. All new panels shown shall be fed from new MSB. This service size will require bus duct.
2. Provide (1) 500 amp 120/208V, 3ph, 4w panel for Classrooms 1-16/Admin building.
3. Provide (1) 500 amp 120/208v, 3ph, 4w panel for Classrooms 17-29/Admin building.
4. Provide (1) 500 amp 120/208v, 3ph, 4w panel for Classrooms 30-32/MPR/Gym building.

WEST OAKLAND MIDDLE SCHOOL ELECTRICAL LOAD CALCULATIONS

NEW SERVICE LOAD CALCULATION

Existing Main Switchboard is 1600 amps at 120/208v, 3 phase, 4 wire
Existing Peak Demand is unknown. 50% Panel capacity has been used for calculations

(E) PEAK DEMAND - ? KW	288.0	KW AT	125%	=	360.0	KVA
NEW CONNECTED LOAD PER BELOW	546.1	KVA AT	100%	=	546.1	KVA
				TOTAL	906.1	KVA

906.1 KVA = **2517.0** **AMPS AT 120/208V, 3 PHASE**

PROVIDE 3000 AMP SWITCHBOARD AT 120/208V, 3 PHASE, 4 WIRE

WEST OAKLAND ADDITIONAL LOADS TO EXISTING SERVICE

BUILDING C/D	VOLTAGE	QTY	KVA EACH	TOTAL		CONNECTED LOAD		PANEL SIZE
RTU-1	208/3	3	16.27	48.8	KVA			
RTU-4	208/3	4	28.1	112.4	KVA			
RTU-5	208/3	1	19.9	19.9	KVA			
			SUBTOTAL	181.1	KVA	503.08	AMPS	800 AMPS

BUILDING E	VOLTAGE	QTY	KVA EACH	TOTAL				
VHP-1	208/3	16	7.3	116.8	KVA			
			SUBTOTAL	116.8	KVA	324.44	AMPS	500 AMPS

BUILDING F	VOLTAGE	QTY	KVA EACH	TOTAL				
VHP-1	208/3	17	7.3	124.1	KVA			
			SUBTOTAL	124.1	KVA	344.72	AMPS	500 AMPS

TOTAL	546.1	KVA
	1,517.0	AMPS
	@120/208V, 3 PHASE	

Cost Benefit Analysis

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	West Oakland MS			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
1	**Basic Mitigation**				
	Remove windows and frames	7,831	sf	20.00	156,620
	New windows and frames	7,831	sf	187.50	1,468,313
	Rough carpentry per window set	31	ea	2,500.00	77,500
	Patching and repairing	1	ls	170,243.25	170,243
	SUBTOTAL				**1,872,676**
	GENERAL CONDITIONS			10.0%	187,268
	BONDS & INSURANCE			2.0%	41,199
	OVERHEAD AND PROFIT			10.0%	210,114
	DESIGN CONTINGENCY			20.0%	462,251
	ESCALATION			6.8%	189,523
	TOTAL CONSTRUCTION COST				**2,963,031**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	West Oakland MS			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
2	**Passive Approach**				
	Remove windows and frames	7,831	sf	20.00	156,620
	New windows and frames	7,831	sf	187.50	1,468,313
	Rough carpentry per window set	31	ea	2,500.00	77,500
	Actuators, complete	31	ea	3,000.00	93,000
	Tie into EMS controls and test	1	ls	23,250.00	23,250
	Patching and repairing	1	ls	181,868.25	181,868
	Window security screens, perforated metal panel	1,566	sf	125.00	195,775
	Roof insulation	26,000	sf	15.00	390,000
	Ceiling fans	38	ea	1,000.00	38,000
	Power and controls to ceiling fans	38	ea	1,437.50	54,625
	100a panel and feeder	2	ea	14,583.33	29,167
	Fire alarm control relay with SLC cable	38	ea	1,250.00	47,500
	Patching and repairing	1	ls	42,322.92	42,323
	SUBTOTAL				**2,797,940**
	GENERAL CONDITIONS			10.0%	279,794
	BONDS & INSURANCE			2.0%	61,555
	OVERHEAD AND PROFIT			10.0%	313,929
	DESIGN CONTINGENCY			20.0%	690,644
	ESCALATION			6.8%	283,164
	TOTAL CONSTRUCTION COST				**4,427,025**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	West Oakland MS			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
3	**Air Conditioning Retrofit**				
	York 10 ton rooftop packaged heat pump unit	3	ea	50,000.00	150,000
	York 4 ton rooftop packaged heat pump unit for Music Room	1	ea	20,000.00	20,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	2	ea	15,000.00	30,000
	York 12.5 ton rooftop packaged heat pump unit	1	ea	62,500.00	62,500
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 6.5 ton rooftop packaged heat pump unit in Music Lab	1	ea	32,500.00	32,500
	York 4 ton rooftop packaged heat pump unit for Music Room	1	ea	20,000.00	20,000
	York 4 ton rooftop packaged heat pump unit	2	ea	20,000.00	40,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	16	ea	15,000.00	240,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	17	ea	15,000.00	255,000
	York 10 ton rooftop packaged heat pump unit	1	ea	50,000.00	50,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	4	ea	15,000.00	60,000
	Ductwork and distribution	70,000	sf	20.00	1,400,000
	Controls	1	ls	63,600.00	63,600
	Testing, adjusting and balancing	70,000	sf	2.50	175,000
	Structural roof upgrade	50,000	sf	25.00	1,250,000
	Mechanical power	53	ea	3,750.00	198,750
	Condensate drainage	53	ea	3,437.50	182,188
	Patching and repairing	50,000	sf	5.00	250,000
	3000a main switchboard	1	ea	200,000.00	200,000
	Back feed existing 1600a switchboard	1	ea	133,333.33	133,333
	500a panel and feeder	2	ea	135,416.67	270,833
	800a panel and feeder	1	ea	216,666.67	216,667
	SUBTOTAL				**5,500,371**
	GENERAL CONDITIONS			10.0%	550,037
	BONDS & INSURANCE			2.0%	121,008
	OVERHEAD AND PROFIT			10.0%	617,142
	DESIGN CONTINGENCY			20.0%	1,357,712
	ESCALATION			6.8%	556,662
	TOTAL CONSTRUCTION COST				**8,702,931**

ESTIMATE SUMMARY					
PROJECT:	OUSD IAQ Cost Benefit Analysis			DATE:	3/27/2023
LEVEL:	Conceptual			ESTIMATOR:	Javier Silva
CLIENT:	HY Architects			SCHEDULE:	12 Months
LOCATION:	West Oakland MS			AREA (SF):	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT
4	**Air Conditioning Retrofit Plus**				
	Remove windows and frames	7,831	sf	20.00	156,620
	New windows and frames	7,831	sf	187.50	1,468,313
	Rough carpentry per window set	31	ea	2,500.00	77,500
	Patching and repairing	1	ls	170,243.25	170,243
	York 10 ton rooftop packaged heat pump unit	3	ea	50,000.00	150,000
	York 4 ton rooftop packaged heat pump unit for Music Room	1	ea	20,000.00	20,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	2	ea	15,000.00	30,000
	York 12.5 ton rooftop packaged heat pump unit	1	ea	62,500.00	62,500
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 10 ton rooftop packaged heat pump unit	2	ea	50,000.00	100,000
	York 6.5 ton rooftop packaged heat pump unit in Music Lab	1	ea	32,500.00	32,500
	York 4 ton rooftop packaged heat pump unit for Music Room	1	ea	20,000.00	20,000
	York 4 ton rooftop packaged heat pump unit	2	ea	20,000.00	40,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	16	ea	15,000.00	240,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	17	ea	15,000.00	255,000
	York 10 ton rooftop packaged heat pump unit	1	ea	50,000.00	50,000
	In-room vertical heat pump unit with outside air connection and barometric relief through the wall	4	ea	15,000.00	60,000
	Ductwork and distribution	70,000	sf	20.00	1,400,000
	Controls	1	ls	63,600.00	63,600
	Testing, adjusting and balancing	70,000	sf	2.50	175,000
	Structural roof upgrade	70,000	sf	25.00	1,750,000
	Mechanical power	53	ea	3,750.00	198,750
	Condensate drainage	53	ea	3,437.50	182,188
	Patching and repairing	70,000	sf	5.00	350,000
	3000a main switchboard	1	ea	200,000.00	200,000
	Back feed existing 1600a switchboard	1	ea	133,333.33	133,333
	500a panel and feeder	2	ea	135,416.67	270,833
	800a panel and feeder	1	ea	216,666.67	216,667
	SUBTOTAL				**7,973,047**
	GENERAL CONDITIONS			10.0%	797,305
	BONDS & INSURANCE			2.0%	175,407
	OVERHEAD AND PROFIT			10.0%	894,576
	DESIGN CONTINGENCY			20.0%	1,968,067
	ESCALATION			6.8%	806,907
	TOTAL CONSTRUCTION COST				**12,615,308**

To estimate the campus-wide performance of the different strategies, a weighted average of the energy modeling results is applied. Each room at the campus is assigned an energy model representation, based on the building's space type, orientation, etc. The total discomfort hours for each building on campus are added up. For the different mitigation strategies, we can consider the amount that the discomfort hours are reduced by.

The total discomfort hours for each campus are shown in the table below:

Campus-wide discomfort hours	Baseline	Basic Mitigation	Passive Mitigation	Air Conditioning Retrofit	Air Conditioning Retrofit Plus
West Oakland Middle School	26,389	11,905	2,465	6,874	434

The total reduction percentage of discomfort hours is shown in the table below:

Scenario Improvement %	Basic Mitigation	Passive Mitigation	Air Conditioning Retrofit	Air Conditioning Retrofit Plus
West Oakland Middle School	55%	91%	74%	98%

LIFE CYCLE COSTING SUMMARY

LCC-1

Project Name: *West Oakland Campus*

Date: *4/28/2023*

ANNUAL ENERGY USE AND COST

Option	Description	Electricity			Natural Gas		Simple Payback (years)
		Consumption (kWh)	Demand (kW)	Cost ($)	Consumption (therms)	Cost ($)	
Base	Baseline (Existing Conditions)	38,601	0	$5,202	432	$1,101	N/A
1	Basic	38,992	0	$5,255	710	$1,807	N/A
2	Passive	38,434	0	$5,180	314	$801	3,104.5
3	AC Retrofit	55,609	0	$7,494	0	$0	N/A
4	AC Retrofit+	54,571	0	$7,354	0	$0	N/A

LIFE CYCLE COST PRESENT VALUE

Option	Initial Cost	Utility Incentive	Annual Recurring Costs	Electricity Costs	Natural Gas Costs	Non Annual Recurring OM&R Cost	Replacem. Costs	Residual Value	Total LCC	Additional Costs
Base	$0	$0	$0	$93,328	$23,229	$0	$0	$0	$116,557	$0
1	$349,203	$0	$0	$94,279	$38,124	$0	$0	$0	$481,606	$365,049
2	$999,654	$0	$0	$92,933	$16,899	$0	$0	$0	$1,109,487	$992,930
3	$1,965,185	$0	$0	$134,448	$0	$0	$0	$0	$2,099,633	$1,983,077
4	$2,279,310	$0	$0	$131,937	$0	$0	$0	$0	$2,411,247	$2,294,690

Study Parameters

Study Period: 25 years

Real Discount Rate: 3.0%

☑ DOE/FEMP Escalation Rates

Region: Western US

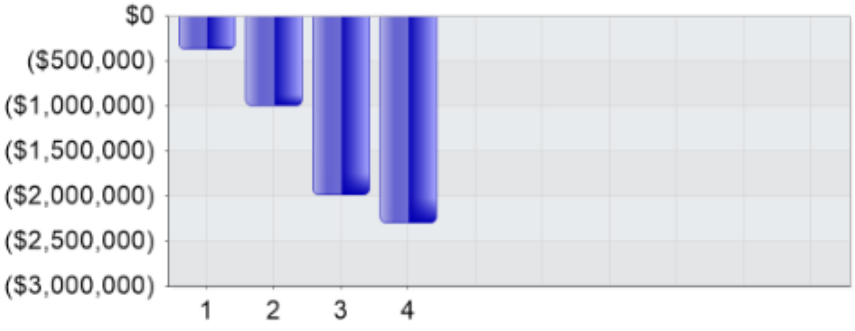
Fuel Sector: Commercial

☐ Uniform Escalation Rates

Electricity: N/A

Natural Gas: N/A

LIFE CYCLE COST SAVINGS



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How to Read a Lifecycle Cost Analysis

Based on the "Baseline" or existing conditions, this column represents number of years required for energy cost savings to pay for the initial investment

Annual Consumption & Cost Data for the 5 rooms included in the study

LIFE CYCLE COSTING SUMMARY

Project Name
Laurel Campus

4/28/2023

ANNUAL ENERGY USE AND COST

Option	Description	Electricity Consumption (kWh)	Electricity Demand (kW)	Electricity Cost ($)	Natural Gas Consumption (therms)	Natural Gas Cost ($)	Simple Payback (years)
Base	*Baseline (Existing Conditions)*	*38,913*	*0*	*$13,755*	*314*	*$782*	*N/A*
1	*Basic*	*38,964*	*0*	*$13,773*	*350*	*$872*	*N/A*
2	*Passive*	*38,836*	*0*	*$13,728*	*259*	*$645*	*3,316.9*
3	*AC Retrofit*	*72,257*	*0*	*$25,542*	*0*	*$0*	*N/A*
4	*AC Retrofit+*	*72,055*	*0*	*$25,471*	*0*	*$0*	*N/A*

This study assumes increase in outside costs to maintain the mitigation recommendations is negligible based on the scale of implementation. If measures are applied district wide, annual recurring costs should be evaluated.

Based on study period (25 years) and discount rate (3%). Applies to 5 classrooms included in study.

Information not available. Energy consumption analysis is based on reported kWH and therms.

Total Life Cycle Cost (LCC) is the sum of the initial cost, and electricity and natural gas costs, represents total cost to install and run the 5 rooms in the study over a 25 year period

Relative cost to implement the selected mitigation measure compared with maintaining the existing conditions (baseline).

Normalized value based on the cost estimate and applicable area: Initial cost to upgrade 5 rooms in the study

LIFE CYCLE COST PRESENT VALUE

Option	Initial Cost	Utility Incentive	Annual Recurring Costs	Electricity Costs	Natural Gas Costs	Non Annual Recurring OM&R Cost	Replacem. Costs	Residual Value	Total LCC	Additional Costs
Base	*$0*	*$0*	*$0*	*$246,776*	*$16,498*	*$0*	*$0*	*$0*	*$263,274*	*$0*
1	*$149,174*	*$0*	*$0*	*$247,099*	*$18,397*	*$0*	*$0*	*$0*	*$414,670*	*$151,396*
2	*$543,966*	*$0*	*$0*	*$246,291*	*$13,608*	*$0*	*$0*	*$0*	*$803,865*	*$540,591*
3	*$1,527,664*	*$0*	*$0*	*$458,244*	*$0*	*$0*	*$0*	*$0*	*$1,985,908*	*$1,722,634*
4	*$1,639,151*	*$0*	*$0*	*$456,970*	*$0*	*$0*	*$0*	*$0*	*$2,096,121*	*$1,832,847*

Equipment replacement costs for equipment were not evaluated in this study

Study Parameters

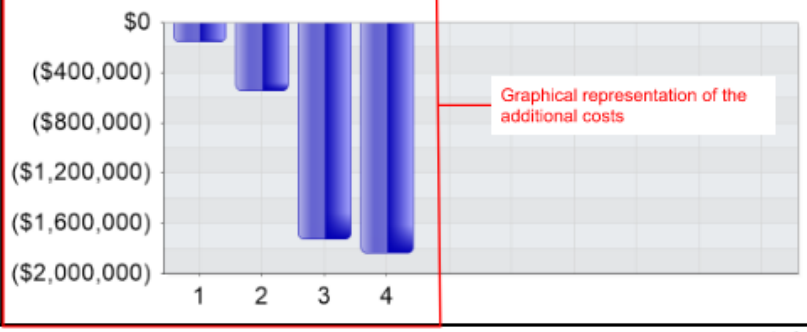
Study Period: *25* years

Real Discount Rate: *3.0%*

☑ DOE/FEMP Escalation Rates
Region: *Western US*
Fuel Sector: *Commercial*

☐ Uniform Escalation Rates
Electricity: *N/A*
Natural Gas: *N/A*

LIFE CYCLE COST SAVINGS



Graphical representation of the additional costs

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