University of Hawaii at Manoa

Building Design and Performance Standards

MODELING AddENDUM

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INTRODUCTION

Early design decisions often have the largest impact on a building's energy use. These decisions are often made without the benefit of quantitative analysis. Later in the design process, when energy and possibly thermal comfort analyses become available, changing these large-scale decisions can be difficult.

For this reason, these UHM BDP Standards include a Modeling Addendum with combined climate and program analysis for classroom, offices and laboratory buildings. This is a "pre-design information package" to be handed out to the design team, outlining critical climate and program issues that need to be Addressed throughout the design process. The goal of this pre-design information is two-fold: first, it presents a process for developing useful quantitative energy analysis for a site and program before detailed project design actually begins. Second, it gives a context for the metrics required by these Standards and confirms that they are both ACHievable and reasonable in this climate.

This information was generated for the Standards and is grounded in scientific principles, rather than less precise rule-of-thumb measures and general guidelines often employed at these early project stages. The Project Development Report (PDR) provided to the architectural design team at the beginning of the design phase of the project could also include or refer to these studies to give an example of what is expected of the design teams in terms of analysis process and submittal documentation. The studies will allow the design to commence strategically with regard to daylight, comfort, energy and will be useful in moving projects progressively towards the mandated zero net energy goal by 2035.

This information is specific to each building type on UHM campus and includes a weather data analysis, daylighting and shading studies, HVAC autonomy and thermal comfort studies, and energy studies. These provide a reference for design teams to pursue similar analysis to evaluate building performance against the metrics required in these Standards. Some examples of efficient electric lighting designs for classrooms, offices and laboratories are also included, to support assumptions included in thermal comfort and energy models.

Add/ Introduction (Continued)

The UHM BDP Standards require multiple updates to energy models during the design process on new construction projects and significant building renovations (Group 1) to ensure that appropriate measures are being tested at every stage of design. Energy modeling allows in-depth comparative analysis of potential building systems and design strategies to optimize energy performance. Modeling is to be used as a design tool first and a compliance tool second. Building performance modeling as a design tool enables the team to make integrated design decisions based on a full understanding of cost and how systems interact.

The following pages present a process for developing comparative quantitative daylight, energy and comfort analysis for an existing building and program before actual design begins. The classroom, which is repeated many times in buildings on campus, was the starting point for investigation.

Shading and daylighting are both primary tools to increase occupant comfort and lower energy use, but they are often in conflict. In order to determine the potential for maximizing visual comfort, lighting levels and solar control while reducing use of electric lighting, the daylight studies focused on a typical existing classroom. These studies generated balanced design solutions that then served as input in terms of shading strategies (recommended profile angles) and window sizes (minimum and maximum window to wall ratio) for the comfort and energy models.

The next step towards understanding the potential for existing buildings on UHM campus to reduce energy use, as mandated by both State and University policies, and also move towards net zero performance by 2035, focused on the passive potential for each building type and each orientation.

The goal of zero-net-energy performance requires maximum hours of comfort delivered passively through building envelope design and control without mechanical conditioning. The most energy is saved if comfort is Achieved passively, without active systems. Using comfort load factor diagrams and parametric simulations we identified suites of passive strategies that minimize need for mechanical conditioning. Simulations of various envelope configurations quantify the impact of natural ventilation, thermal mass, roof and wall insulation, glazing specification, efficient

Add/ Introduction (Continued)

lighting design and daylighting controls on both the annual energy use and the hour-by-hour thermal comfort of occupants.

Once a set of suites representing the potential new and retrofit projects for existing UHM buildings were identified, an appropriate mechanical system was included in the models. Assumptions for ceiling fans and smart controls were also made. Energy use was then studied and compared between the different suites.

In most integrated, sustainable design practices, energy analyses beyond a baseline model do not come into the process until after an initial design has been proposed. Working without a preliminary design and instead using conceptually defined “ideal” design characteristics for repeated units on campus sets a high bar for the design teams. This strategy is well suited to any program with repeated or dominant elements.

Providing the design team with detailed analysis of the energy potential of the climate and program allows the design teams to move in a direction conducive to passive strategies immediately in their design process. Access to light and air become primary informants to program locations and orientations on the site at the onset. Typical space studies allow the design team to understand the passive needs of each project so they can immediately negotiate these with other needs of the project including mitigating outdoor air quality and acoustics.

Finally, a preliminary basic net zero feasibility study assuming potential PV output for both typical and high performance PV panels in this climate was developed to establish how far from Achievingthe net zero performance goal each building type is.

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Add/A. CLIMATE AND WEATHER DATA ANALYSIS

The climatic conditions have a strong influence on the optimal design of a high performance building and can reveal potential design opportunities and limitations. Culturally, local climate knowledge such as local winds is already used in everyday decision-making. Thus, climate issues need to be one of the key drivers throughout the design process. In this section, we provide a detailed data analysis of the TMY3 weather data from Honolulu Airport. We highlighted and identified the information that is critical for building performance in order to identify conditions and periods that might affect the modeling results and, as a consequence, the building designs.

A typical meteorological year (TMY) is a collation of selected weather data for a specific location, generated from a data bank derived from a 1973-2005 period of record. It is selected so that it presents the range of weather phenomena for the location in question, while still giving annual averages that are consistent with the long-term averages. In other words, these data were selected because they did not contain extremes.

Some of the variables that are used as input in building performance models include:

- Sky conditions (Global Horizontal Radiation, Diffuse horizontal radiation, Direct normal irradiation and Cloud Cover)
- Wind conditions (Wind Speed and Direction)
- Air Conditions (Dry bulb Temperature, Relative Humidity)

We compared the weather data from the Honolulu Airport to the weather data collected by several weather stations on UHM campus to understand the effect of microclimate impacts on building performance.

There is general meso-climatic knowledge, if not data, regarding the location of the campus. The trade winds are typically funneled down the valley. They can run parallel to the valley walls and have up-slope edges along the East ridge. Weather stations on the campus should confirm historic wind directions that may vary from the airport. The

Add/A. Climate and Weather Data Analysis (Continued)

confirmation of this data would also help at a planning scale in siting buildings as well as developing strategies to ventilate them.

However, in the campus data for air and sky conditions, microclimatic differences are either not evident or show that the UHM campus is minimally cooler than the airport. University of Hawaii at Manoa Campus is higher in altitude and further away from the ocean than the Honolulu airport. The temperature tends to be generally lower, which will make interior comfortable conditions easier to Achieve in buildings. Thus, the weather data from the Honolulu Airport provides a useful conservative assumptions and is valid for building performance prediction purposes.

As the weather stations on campus only collected reliable information for certain variables, a complete weather data set to be used in energy modeling was not available, and thus daylight, comfort and energy models results could not be compared between using typical meteorological data sets (TMY) and actual meteorological year (AMY) data sets.

In order to simulate conditions under actual peak conditions (such as heat waves), it is critical to compare building performance under this typical meteorological data set (TMY) to an actual meteorological year (AMY) data that might be more representative of the future conditions buildings will need to endure in the next 20 years. This should be included in an update of the Standards when possible.

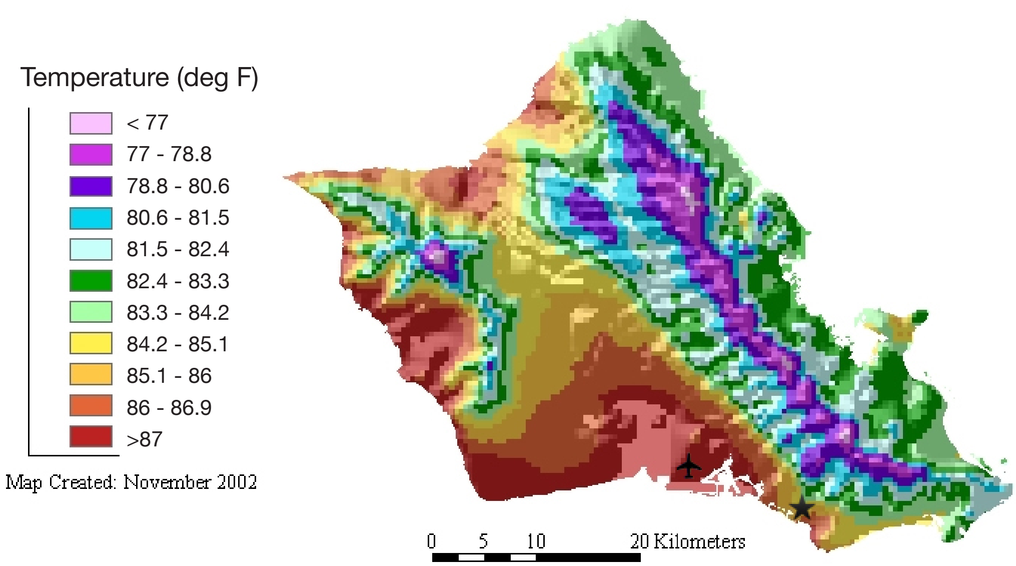
The design team should review available weather data in order to select or build a dataset that is representative of the weather expected on site. Review any available site-specific data to determine if any adjustments from airport (TMY or AMY) data are required to account for differences in microclimate, especially regarding wind conditions and opportunities for naturally ventilated spaces.

Add/A. CLIMATE AND WEATHER DATA ANALYSIS

1. CLIMATE ANALYSIS

The Hawaiian climate zones can be grouped into four types according to air temperature, precipitation, cloud cover, wind and elevation. Honolulu, Oahu is a representative example of a leeward, dry site at low elevation while Manoa is higher in elevation and closer to the mountains.

Climate includes other variables like humidity and solar radiation. To assess the climate of Honolulu, Typical Meteorological Year (TMY) data was used. This type of data is standard for performance evaluation and highly useful for simulations because it includes a large number of variables (60). The TMY data sets are based on measured data for every hour over the course of the year. The data set also does not simply, average all the years together, but tries to accurately portray a typical year, including storms, heat spells, dry spells,etc.



Add/A.1 Climate Analysis (Continued)

1. **TEMPERATURE**

Temperature in Hawaii is strongly correlated to elevation, distance from the coast and the influence of trade winds. However, the diurnal temperature change is fairly consistent among locations and is generally limited to a 10F swing. Throughout the Hawaiian islands, the temperature band is typically between 60F-80F. Temperature affects the comfort of the occupants, and is directly related to the potential performance of natural ventilation to provide comfort, as well as to the demand on the cooling system.

Honolulu experiences a tropical semi-arid climate, with a mostly dry summer season, due to a rain shadow effect. Temperatures vary little throughout the months, with average high temperatures of 80–90 °F (27–32°C) and average lows of 65–75 °F (18–24 °C) throughout the year. Temperatures reach or exceed 90 °F (32 °C) on an average 38 days annually, with lows in the upper 50s °F (14–15 °C) occurring once or twice a year. The highest recorded temperature was 95 °F (35 °C) during a heat wave in September 1998. According to the National Weather Service, high temperatures in Honolulu are more frequently tying the record set for each date in the past. The lowest recorded temperature was 52 °F (11 °C) on February 16, 1902, and January 20, 1969. In 2014, the record high was 94°F on September 5th and the record low was 53°F on February 9th.

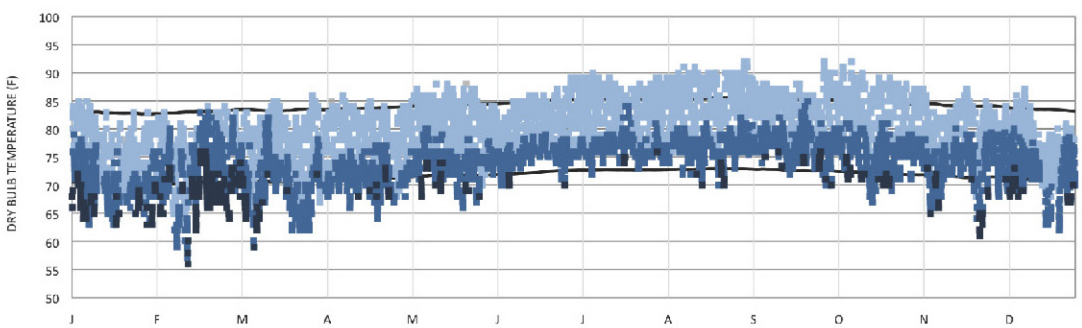
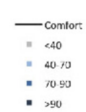


Fig 4.2. Honolulu Annual Outdoor Dry bulb Temperature and Humidity



Add /A.1 Climate Analysis (Continued)

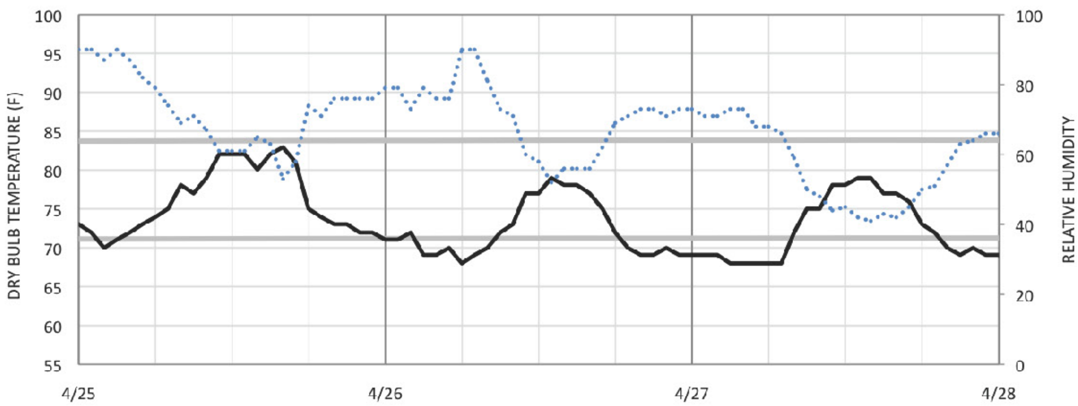
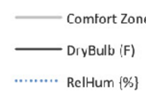


Fig 4.3. Honolulu Outdoor Dry Bulb Temperature and Humidity During A Typical Three Day Period
(April 25th Thru April 28th)



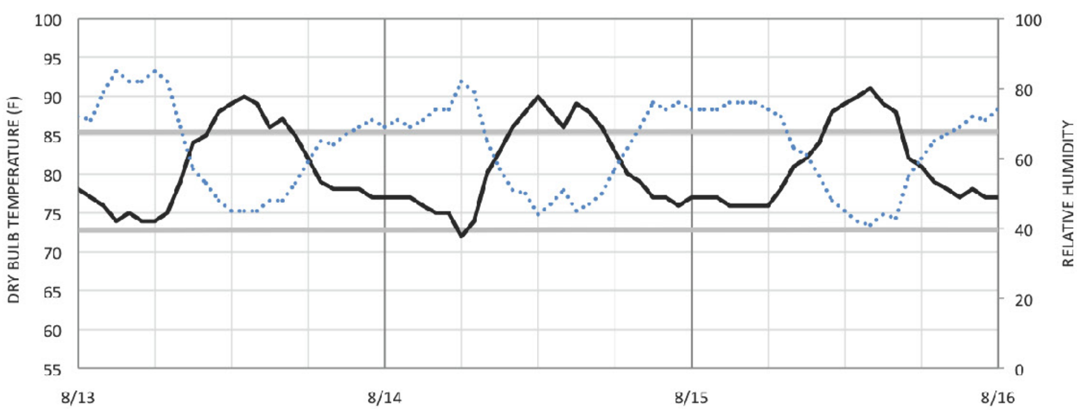


Fig 4.4. Honolulu Outdoor Dry Bulb Temperature and Humidity During A Hot Three Day Period
(Aug 13th Thru Aug 16th)

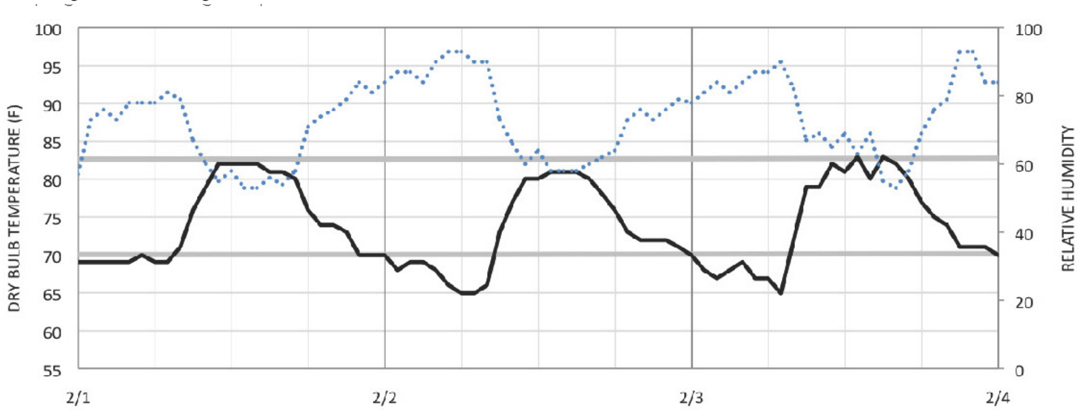
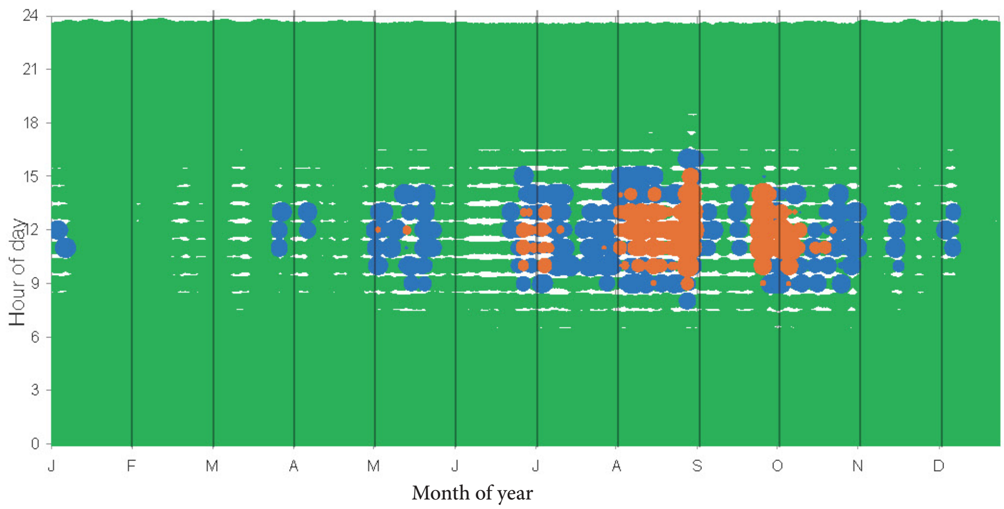


Fig 4.5. Honolulu Outdoor Dry Bulb Temperature and Humidity During A Three Day Period with Cold Nights
(Feb 1St Thru Feb 4Th)

Add/A.1 Climate Analysis (Continued)



Outside in Shade (with 1 m/s air speed) : **131** Hours of Discomfort Per Year

more comfortable → comfortable

borderline (within 1°C or 1.8°F of uncomfortable)

more uncomfortable → uncomfortable

Fig 1. Honolulu Outdoor Conditions

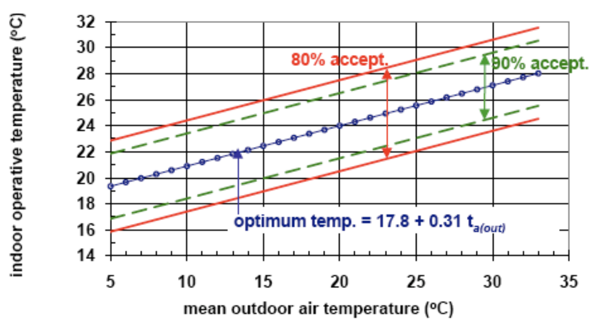


Fig 2. The ASHRAE Std 55 2010 Adaptive Comfort Standard in naturally ventilated spaces as a function of prevailing outdoor temperature. To (out) is simply an arithmetic average of the mean monthly minimum and maximum daily air temperatures for the month in question. The optimum indoor temperature is expressed in terms of operative temperature (approximately the average of air and mean radiant temperatures).

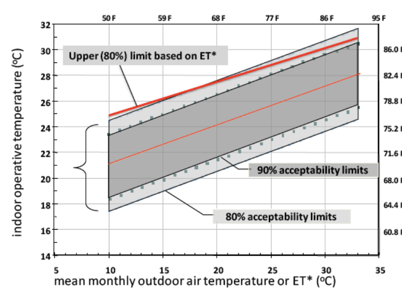


Fig 3. The ASHRAE Std 55 2010 Adaptive Comfort Standard in naturally ventilated spaces showing upper (80% acceptability) limit based on mean monthly ET*.

Add /A.1 Climate Analysis (Continued)

2. THERMAL COMFORT

A comfort analysis of outdoor conditions in Honolulu identifies when people feel comfortable throughout the year, and what they need to feel comfortable (in the shade with a breeze of 1m/sec).

The comfort criteria were set by collectively reviewing ASHRAE comfort standards. The upper limit for comfort is currently defined by an operative temperature of:

Upper 80% Acceptable Limit = 18.9 °C + 0.255 * outdoor mean ET* of past 15 days + 3.5 °C + 2 (°C) increase from a mean air speed of about 1 m/s

Operative Temperature (OT) = 1/2 * MRT + 1/2 * DBT
MRT = Mean radiant temperature DBT = Dry bulb temperature

ET-Star (ET) is defined as the temperature at 50% relative humidity which would cause the same sensible plus latent heat exchange from a person as would the actual environment. This combines temperature and humidity into a single index, so two environments with the same ET* should provide the same thermal response even though they have different temperatures and humidities, as long as they have the same air velocities.*

The results showed that both being in the shade and having a 1m/s air movement, with no collected internal gains, provide comfort during most of the year. In other words, someone sitting under a tree with a breeze would feel comfortable most of the time.

Fig 1 shows hourly comfort conditions outdoors. The horizontal axis gives each day of the year and the vertical axis shows each hour of the day with noon in the middle and midnight at the bottom and top. Green dots represent hours when people would feel comfortable; the “warm” dots (orange) represent hours warmer than comfortable; and light blue dots represent hours within 1degree C (1.8F) hotter than comfortable, meaning borderline of comfort conditions. The size of the dot represents the comparative intensity of comfort or discomfort.

In Fig 1, outdoors, the uncomfortable hours are only 131 per year and the bulk of them occurs between 9am and 3pm (when classes are in session), especially in August. There are also times of discomfort at the end of September/ beginning of October and end of July/ beginning of June, also between 9am and 3pm.

Add/A.1 Climate Analysis (Continued)

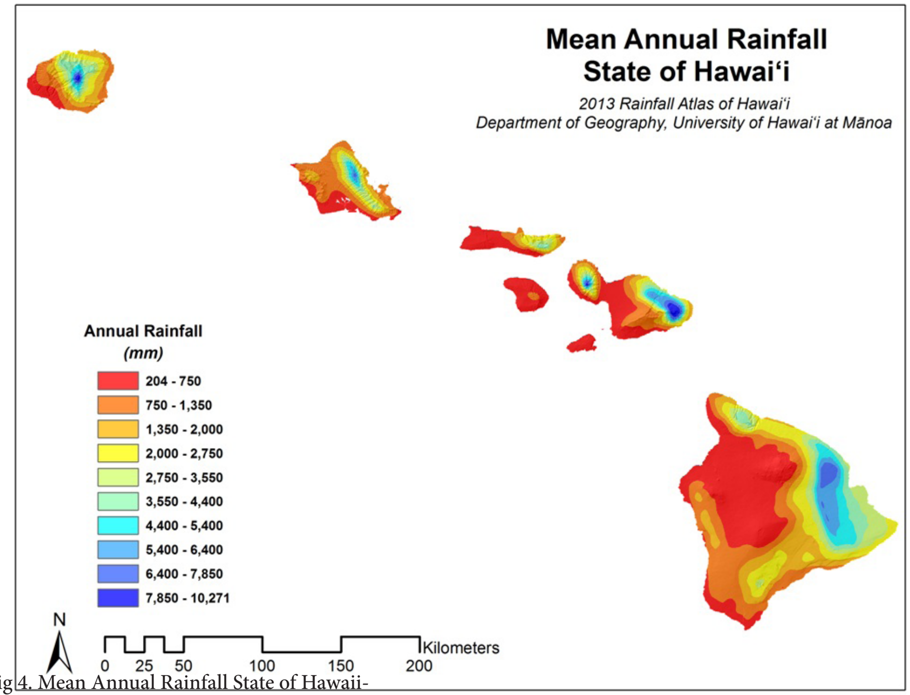


Fig 4. Mean Annual Rainfall State of Hawaii-
Source : 2013 Rainfall Atlas of Hawaii- UHM Dept of Geography

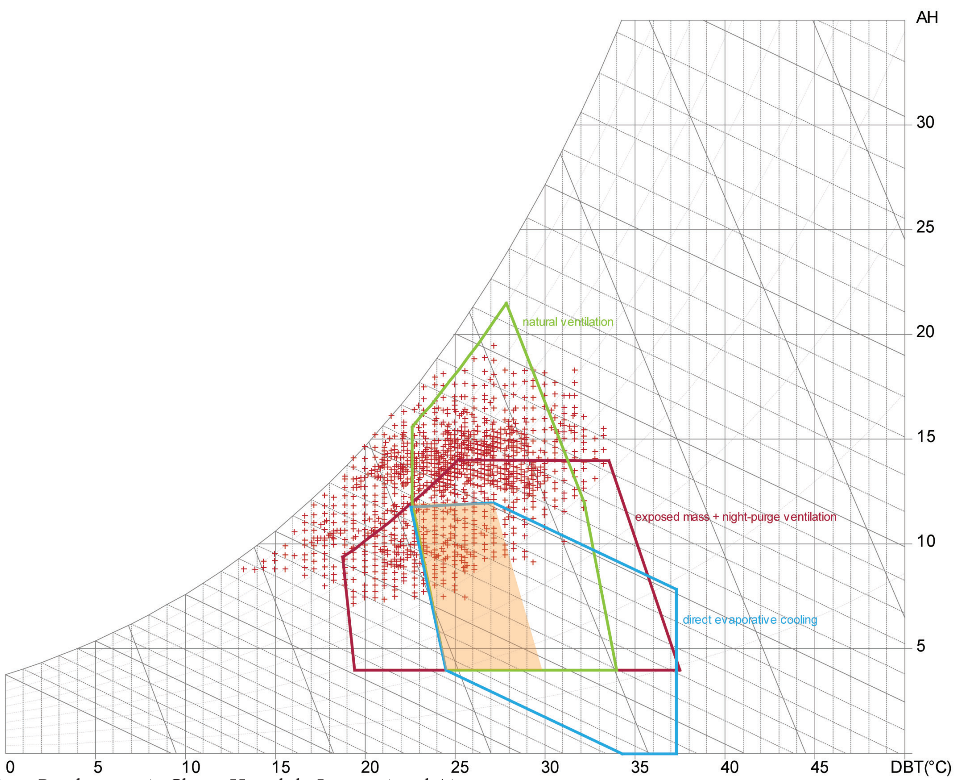


Fig 5. Psychormetric Chart- Honolulu International Airport

Add /A.1 Climate Analysis (Continued)

3. PRECIPITATION AND HUMIDITY

Annual rainfall is influenced by location and elevation. Sites on the windward side of the islands can be very wet, as the tradewinds hit the higher elevations and drop precipitation, while those on the leeward side can be extremely dry. In Addition, as clouds rise up in elevation following volcanoes, they tend to release more of their moisture at the higher elevations. Precipitation levels affect the design of the envelope, the materials used in the structure and the amount of rainwater that the site can harvest. Relative humidity throughout the Hawaiian islands tends to be high which impacts the comfort of the occupants and the design of the envelope, the heating/cooling systems and the operation of the facility.

Relative humidity and dry bulb temperature move in opposite direction, making hot and relatively dry days and cool and humid nights. Because of the higher altitude and distance away from the ocean, the cold days at University of Hawaii are likely to be more temperate than that at the airport.

A psychometric chart helps to initially define the distribution of energy in the outdoor environment between “latent” energy carried by the moisture in the air, and “sensible” energy carried into he air molecules at a particular site. Figure 5 shows this distribution for Honolulu by plotting one point for each hour of the year, with daytime conditions in orange (gray box) shown on the chart is one of the main functions of a facility and its conditioning system. Temperature is along the x-axis and relative humidity along the y-axis. The orange box marks the comfort zone.

The combination of high humidity (close to upper curve) and high temperature (toward the right side of the chart) is the most challenging, as only compressive cooling can remove moisture and its energy from the air to make the internal environment comfortable. Compressive mechanical systems such as air conditioners reduce the relative humidity of the air in the facility as well as cooling the air, delivering comfort to occupants by making the interior conditions quite different than exterior conditions. A less energy intensive means of providing comfort under high humidity is to provide air movement across the skin with cross ventilation or ceiling fans.

Add/A.1 Climate Analysis (Continued)

With the conditions described above for temperature, relative humidity and outdoor thermal comfort, conditioning strategies such as mixed mode buildings will become critical in this climate. A well-designed mixed-mode building allows spaces to be naturally ventilated during periods of the day or year when it is feasible or desirable, and uses mechanical cooling only as necessary for supplemental cooling when natural ventilation is not sufficient. The goal is to maximize comfort while minimizing the significant energy use and operating costs of air conditioning.

4. <u>WIND</u>

Wind direction, frequency and velocity can have a significant effect on the potential to naturally ventilate a space, as well as the potential for wind power.

Regular trade winds are a key feature of the climate in the Hawaiian Islands. Mauka (mow-kah) means on the mountain side and Makai (mah-kigh) means on the ocean side. Moa'e, a'e, a'e loa, Moa'e Lehua, or Moa'e pehu are the names for the tradewind. Trade winds, which blow from a NE and ENE direction, account for 70% of all winds in Hawaii and are the most common winds over Hawaiian waters. During the summer, trades used to prevail more than 90% of the time, sometimes persisting throughout an entire month (see *section B. Impact of Climate Change*). However, in the winter (January through March), trade winds may occur only 40% to 60% of the time.

It is important to note that winds also change direction throughout the day (from Mauka to Makai) as highlighted in Figure 6 below. Buildings should be designed to accomodate such varying wind directions.

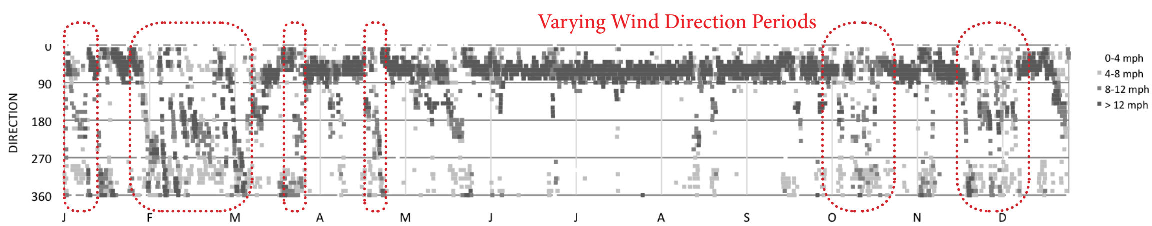


Fig 6. Honolulu Wind Speed and Direction

Add /A.1 Climate Analysis (Continued)

5. CLOUD COVER AND SOLAR RADIATION

Cloud cover is tied closely to solar radiation, which is important when designing for renewable solar energy, as well as to daylight design and performance. The amount of direct solar radiation influences the type of solar panels that can be used. In Addition, the amount of direct solar radiation influences the envelope design, such as shade length, insulation level, radiant barrier use and fenestration pattern, as well as orientation.

Overcast skies deliver daylight optimally through the horizontal plane (roof) since the sky is brighter at the zenith than the horizon. In contrast, clear skies deliver daylight effectively through the vertical plane (walls) as long as the direct sun

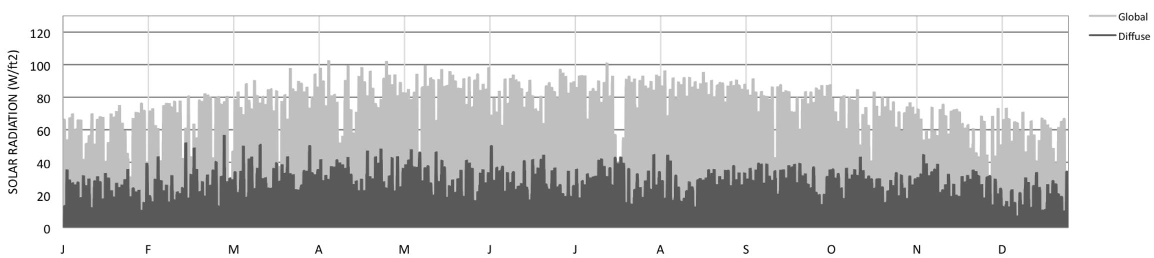


Fig 7. Honolulu Solar Radiation

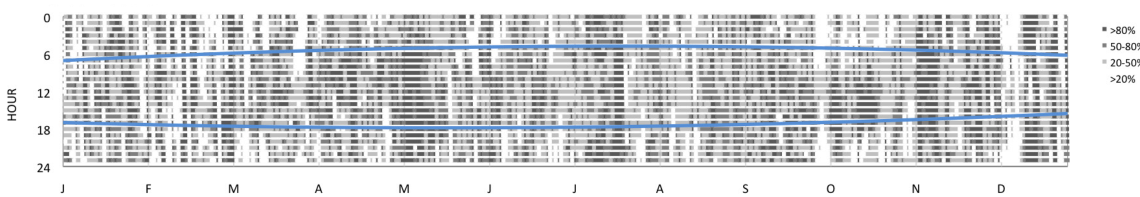


Fig 8. Honolulu Cloud Cover

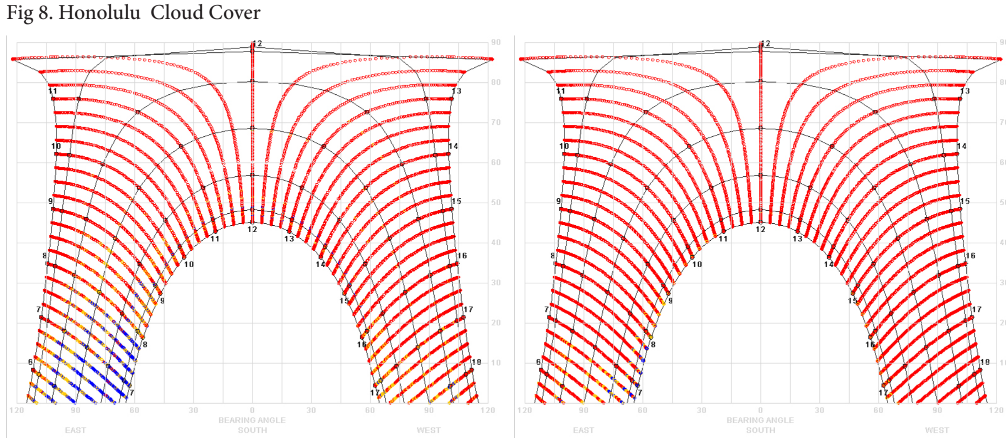


Fig 9. Honolulu Sun Shading Chart

WARM/HOT (SHADE NEEDED) > 75 degrees F

COMFORT (SHADE HELPS) > 70 degrees F

COOL/COLD (SUN NEEDED)

Add/A.1 Climate Analysis (Continued)

penetration can be controlled. This is usually the cause for conflicts between the design of facade shading devices and daylight needs inside the buildings.

Another aspect of the Hawaii climate is that the sky conditions change from overcast to clear very frequently throughout the same day. Therefore, static shading devices often prove inadequate for these changeable conditions.

In summary, design teams for buildings in the UHM Campus need to be aware of the following:

- Mixed mode conditioning strategies are critical. Thermal comfort is achievable: being outdoors, sitting on the shade and having a 1m/s air movement, provides comfort during most of the year.
- Sky and wind conditions change frequently throughout the day, impacting daylighting and shading designs.

Add /A.1 Climate Analysis (Continued)

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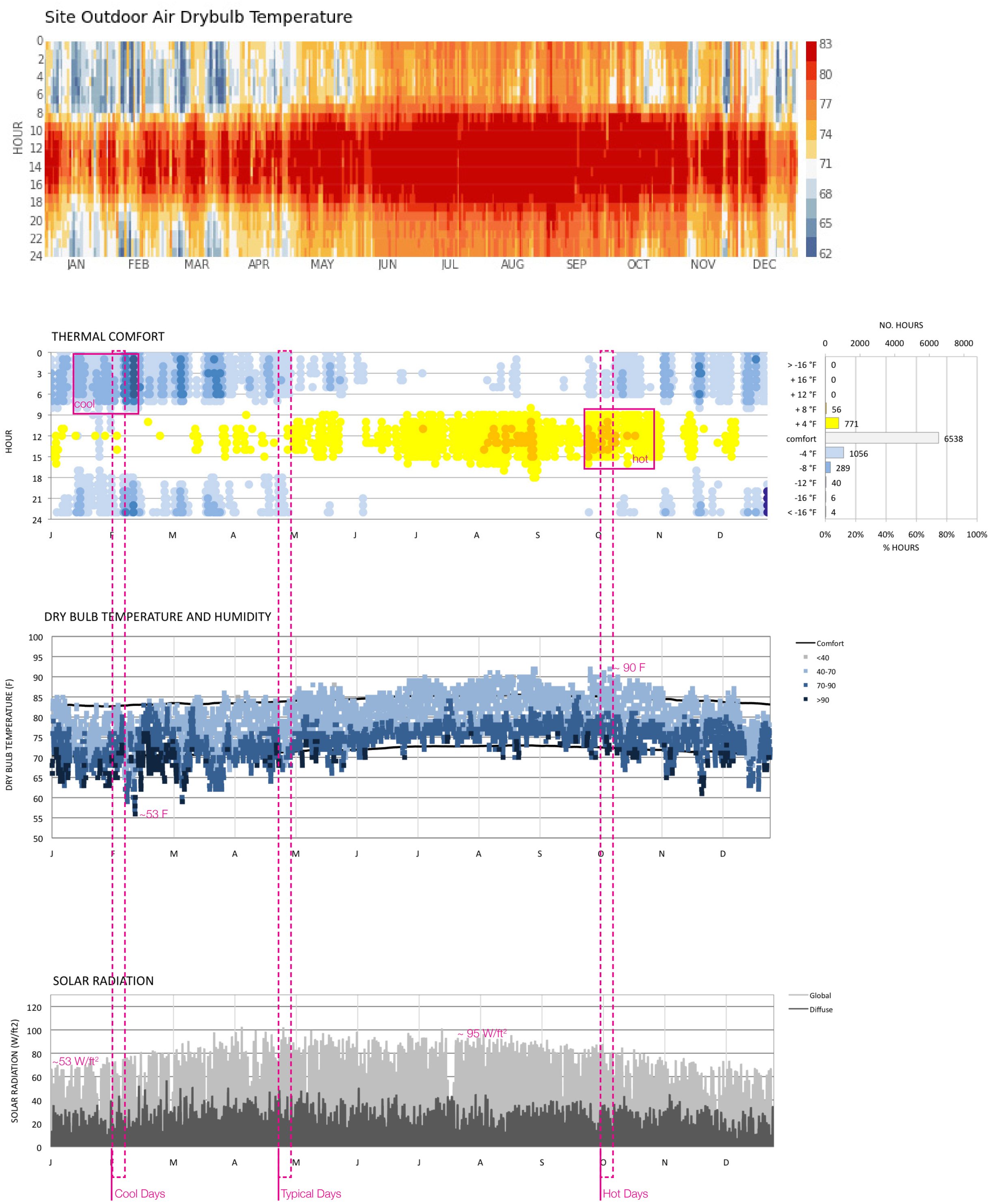
Add/A.1 Climate Analysis (Continued)



Add/A CLIMATE AND WEATHER DATA ANALYSIS

2. TMY 3 FROM HONOLULU INTERNATIONAL AIRPORT

Temperature in Hawaii is closely tied to elevation, distance from the coast and the trade winds. The prevailing wind comes mostly from northeast. Wind direction influence the precipitation and humidity distribution among the islands. Sites on the windward side of the islands can be wet, while places on the leeward side, can be relatively dry. Also, as clouds rise up to higher elevation, they tend to release moisture to the air. Relative humidity tends to be high which can impact occupants comfort and the design of the heating and cooling system.

To read the two first graphs on the left, locate the day of the year along the horizontal axis (January to December) and locate the time of day along the vertical axis (morning at the top and evening at the bottom). In this example here, the color of the point represents the outdoor temperature at that time of day and year.

The first graph shows the outdoor dry bulb temperature.

The second graph was made based on the adaptive comfort model, and it shows that the Honolulu climate is moderate for most of the time. The yellow dots in the thermal comfort graph represent the hot time of the year, and they account for about 10% of the year. The situation is different during the night time, of which the air is cooled down.

The third graph shows again the outdoor dry bulb temperature but highlights the daily temperature swings, which is about 15 degrees F, It also overlays data for relative humidity (color of the dot) which is high at night and low during the daytime.

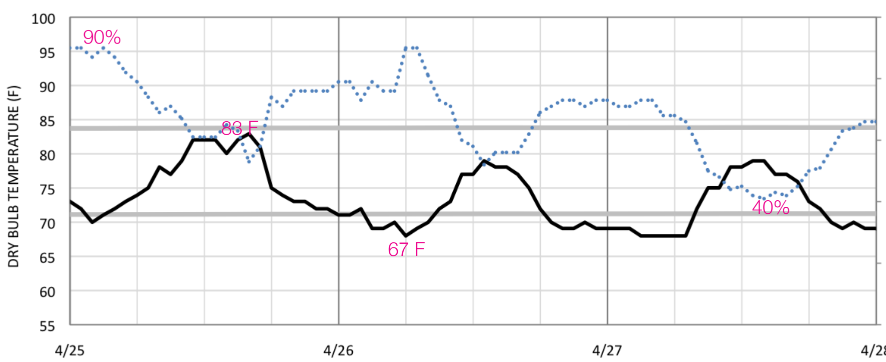
The fourth chart shows the solar radiation throughout the year, where indicates that the direct radiation is dominant.

Three sets of days were picked to represented the typical cool, hot and average days throughout the year.

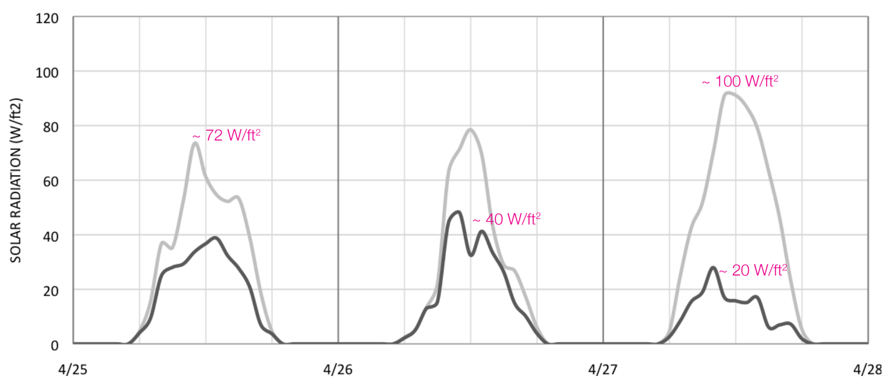
Add/A.2 TMY 3 From Honolulu International Airport (Continued)

Relative humidity and dry bulb temperature move in opposite direction, making hot and relatively dry days and cool and humid nights. Again, because of the higher altitude and distance away from the ocean, the cold days at University of Hawaii is more temperate than that at the airport.

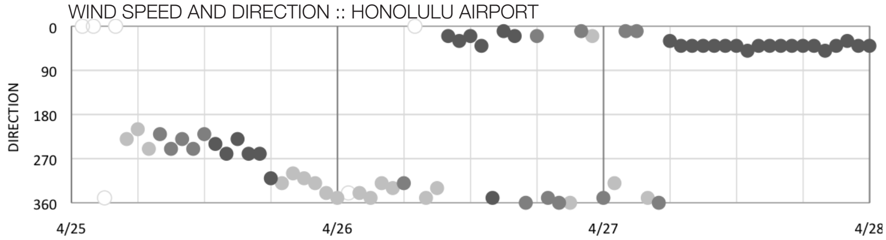
Typical Days



SOLAR RADIATION :: HONOLULU AIRPORT

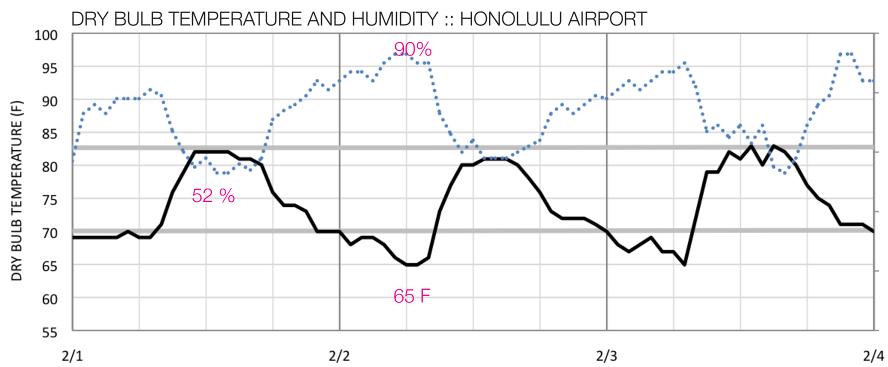


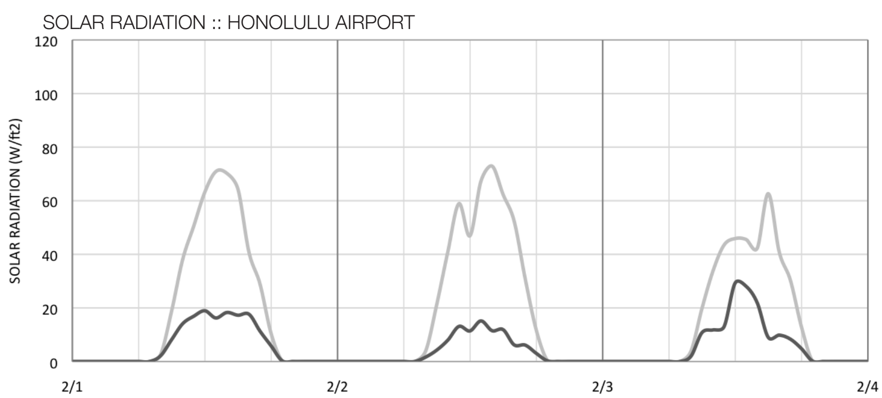
WIND SPEED AND DIRECTION :: HONOLULU AIRPORT



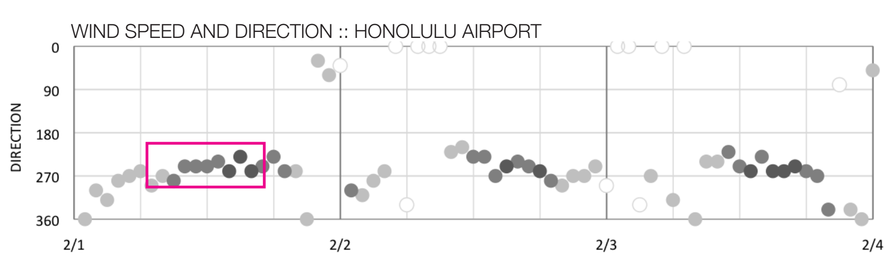
Add/A.2 TMY 3 From Honolulu International Airport (Continued)

Cool Days



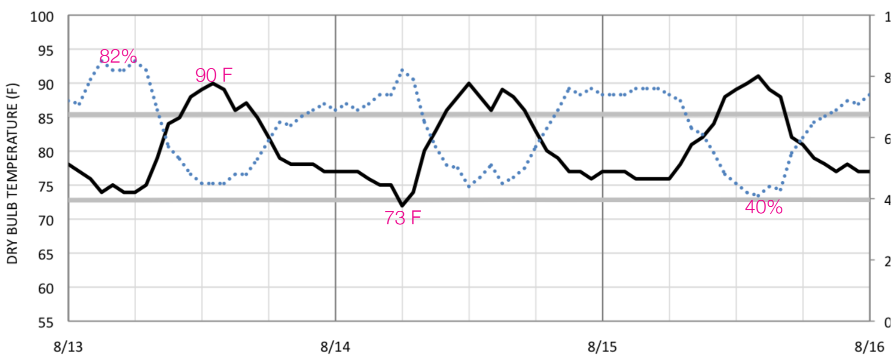


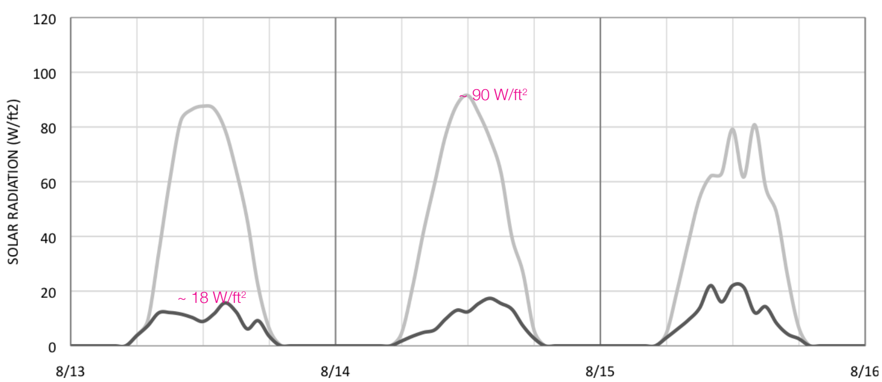
The solar radiation graph indicates that there are more direct solar radiation at the airport and there are more diffusive skies at Kuykendall during the colder days.



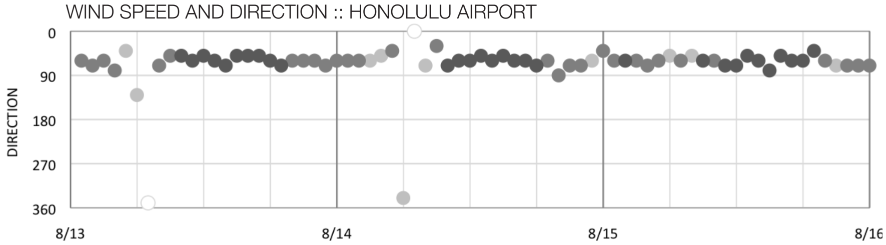
Add/A.2 TMY 3 From Honolulu International Airport (Continued)

Hot Days





The solar radiation pattern is rather consistent at the airport, while at Kuykendall, as the dry bulb temperature rises, the skies become less diffusive than during the colder days.



At the airport, strong southwest wind brings down the relative humidity level, and UHM cooler days happen when the consistence northeast wind is dominant, which induce a more tempered humidity and temperature level.

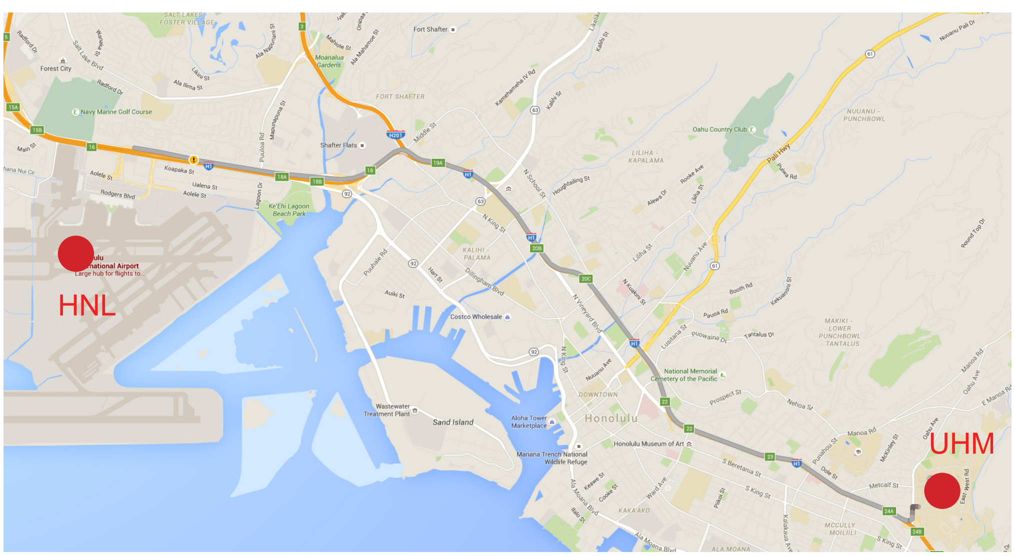
Add/A CLIMATE AND WEATHER DATA ANALYSIS

3. WEATHER DATA FROM UHM CAMPUS

Typical Meteorological Year (TMY) weather data are published and available for Honolulu airport (HNL), which is located about 7 miles to the northwest of the UHM campus. In modeling trying to predict building performance, especially to accurately assume microclimatic differences in wind conditions, this TMY weather file needs to be adjusted to account for differences in weather conditions at HNL compared to the weather conditions on UHM sites.

We were provided with weather data collected from two weather stations located on campus: one station is located at Holmes Hall, and the other is located at Kuykendall Hall. The Holmes Hall data include 31,296 timestamps on a 60 minure interval from September 1, 2011 through December 31, 2015. The Kuykendall Hall weather data include 106,338 timestamps on a 15 minute interval from July 16, 2011 through January 21, 2015. Both data sets include occasional gaps in the data.

Weather from HNL was downloaded from Weather Underground for 2011 through 2015. Data were hourly and included air temperature, wind speed and wind direction among other variables. The analysis in the following pages compares conditions at HNL with simultaneous conditions at UHM. Some comparisons were studied as dependent on wind direction. We present the comparisons below in order for UHM personnel to review the data for quality assurance.



Add/A.3 Weather Data from UHM Campus (Continued)

a. Wind Direction

First we reviewed wind direction variation between HNL and UHM. Due to the turbulent nature of boundary layer wind conditions, we expect wind measurements to vary significantly between each weather station for any particular pair of simultaneous measurements. We compare the full set of simultaneous measurements to see if the general relationship between wind directions at each site exhibits systematic inconsistency.

For Holmes Hall, we note that the wind data appear to be unusable, as wind data show no data points for wind directions between 90° and 270°. For Kuykendall hall, we note generally corresponding wind directions, with a cluster of points showing similar variation of trade wind wind directions between 0° and 90°. We also note clusters where wind directions at Kuykendall of around 30° to 60° for HNL wind directions of around 130°, 220°, and 340°. These clusters indicate inconsistencies between airport and site for which we don't yet have an explanation.

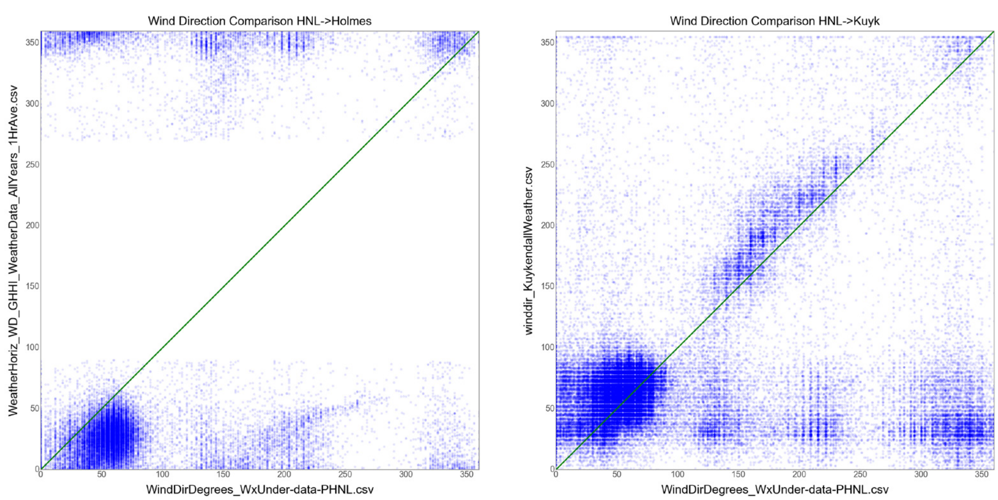


Figure 1. Wind direction relationships for Holmes Hall (left) and Kuykendall Hall (right) vs the HNL airport.

Add/A.3 Weather Data from UHM Campus (Continued)

b. Wind Speed

We reviewed wind speed variation between HNL and UHM. Due to the turbulent nature of boundary layer wind conditions, we expect wind measurements to vary significantly between each weather station for any particular pair of simultaneous measurements. We compare the full set of simultaneous measurements to see if the general relationship between wind speeds at each site exhibits a systematic relationship that can be used for adjustment.

We also anticipate that this relationship may be dependent upon the wind direction, so we examine the relationship by wind direction, in bins of 10°. For each bin, we plotted a scatterplot of simultaneous measurements of wind speed at UHM vs HNL (ie, measurements taken within an hour). We also calculated the line of best fit using OLS regression (see Figure 2 below). Finally, we plotted the frequency of measurements and the wind speed scale factor calculated for Holmes and Kuykendall (See Figure 3 below). The results for Kuykendall Hall show an adjustment factor of around 80%. The results for Holmes are suspect since the scale factor is so low, and because the wind direction variation exhibited erroneous data.

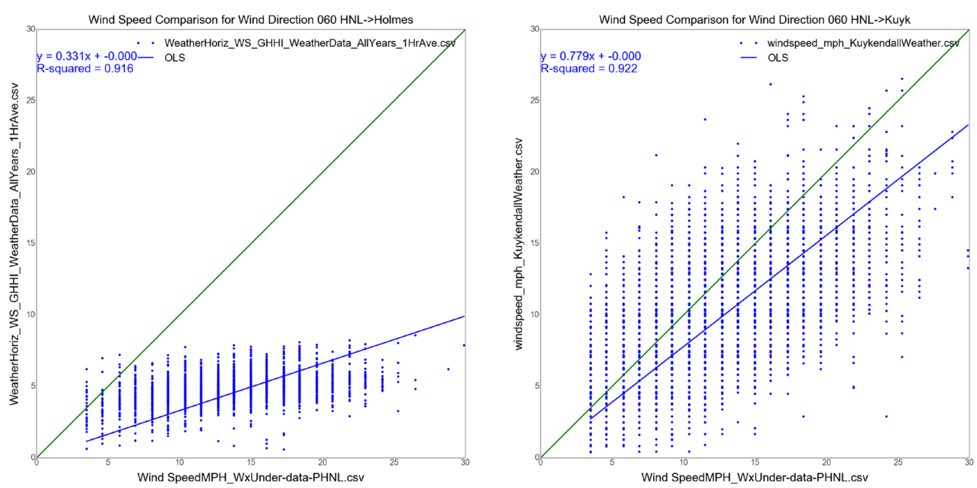


Figure 2. Scatter plots of wind speeds for 60° wind direction bin

Add/A.3 Weather Data from UHM Campus (Continued)

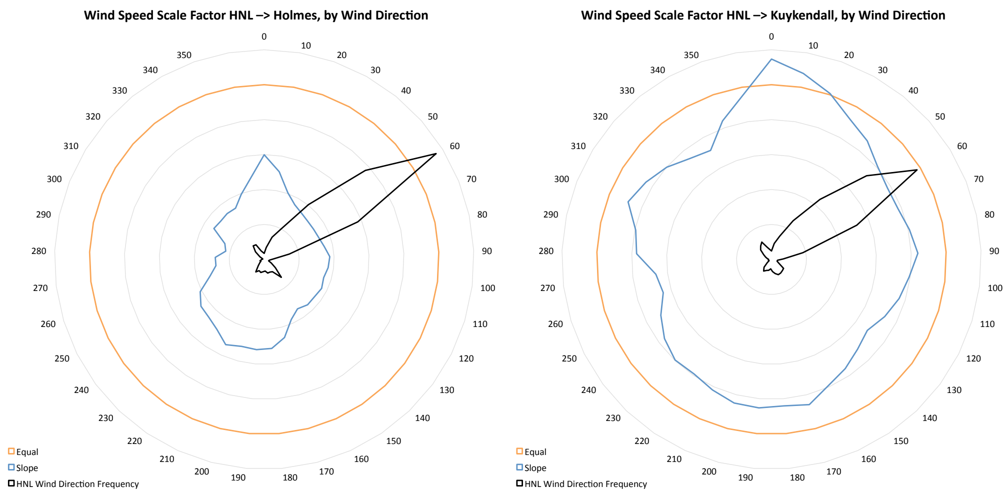


Figure 3. Wind speed adjustment factor and frequency by wind direction

c. Air Temperature

Last, we reviewed air temperature variation between HNL and UHM. As opposed to wind data, we expected to see more consistency between patterns of air temperature at HNL vs UHM. Similarly, we compared the full set of simultaneous measurements to see if the general relationship between wind speeds at each site exhibits a systematic relationship that can be used for adjustment.

We also anticipate that this relationship may be dependent upon the wind direction, so we examine the relationship by wind direction, in bins of 10°. For each bin, we plotted a scatterplot of simultaneous measurements of air temperature at UHM vs HNL (ie, measurements taken within an hour). We also calculated the line of best fit using OLS regression (see Figure 2 below). Finally, we plotted the frequency of measurements and the linear air temperature correction equation calculated for Holmes and Kuykendall (See Figure 4 below). The results for Kuykendall Hall show a lower slope than the relationship for Holmes. We also plot the predicted temperatures on campus HNL temperatures of 74°F and 81°F for Holmes Hall and Kuykendall Hall by wind direction.

Add/A.3 Weather Data from UHM Campus (Continued)

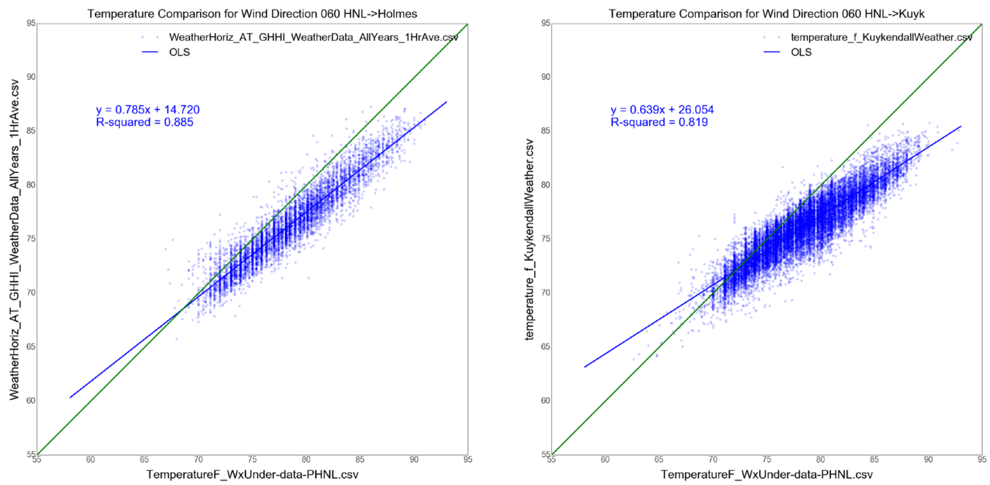


Figure 4. Scatter plots of air temperatures for 60° wind direction bin

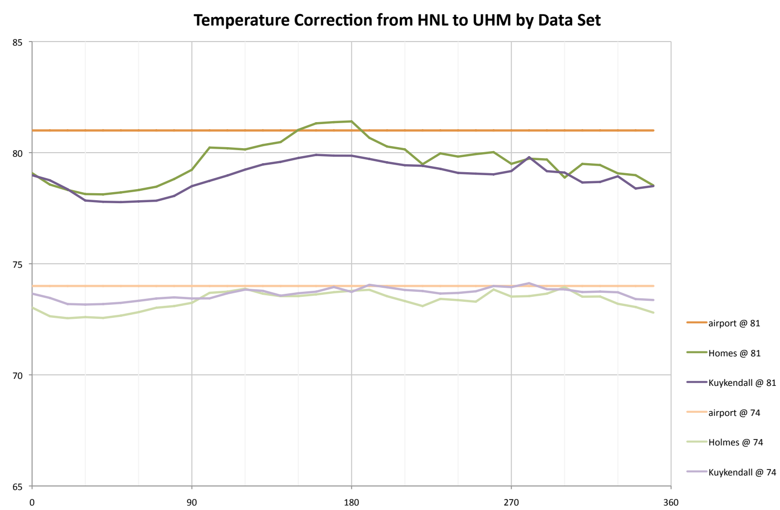


Figure 5. Air temperature adjustment factor by wind direction, showing more variation for the temperatures predicted by Holmes Hall data.

Note that during trade winds, the temperatures on site are generally lower than at the airport, especially for warmer weather. On the other hand, air temperatures are more similar between HNL and UHM for wind directions from the south.

Using the Holmes hall data, the adjusted UHM campus temperature variation will be greater than the adjustment derived from the Kuykendall data. We will average the correction equations for these two UHM datasets, unless we are provided reasons for relying upon one dataset more than another.

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Add/B. DAYLIGHTING AND SHADING STUDIES

1. EXECUTIVE SUMMARY

The first round of daylighting studies focused on optimizing solar control. The performance of different exterior shading strategies was evaluated in terms of the amount of useful daylight (percentage of the space that achieve between 30 and 300 FC with fractional credit for values below 30 FC) inside the space for each orientation. The Profile Angle is the angle between a vector normal to the window and the rays of the sun, measured perpendicular to the window plane.

Fixed, single overhang solutions were compared to other shading strategies such as fixed louvers, tilting louvers or automated louvers.

- For south facades, fixed or tilting louvers perform the best (fixed louvers outperform the single overhang as they produce a redirecting effect). The horizontal overhang is better at preventing excessive lighting near the window, but has less penetration in deeper spaces. Recommended Profile Angle is between 45 and 65 degrees.
- For east facades, fully automated louvers outperform all other options. Fixed strategies are less effective near the window because of low sun angles. Recommended Profile Angle is between 45 and 65 degrees.
- For west facades, fully automated louvers outperform all other options. Fixed strategies are less effective near the window because of low sun angles. Recommended Profile Angle is between 45 and 65 degrees.
- For north facades, a small horizontal overhang performs best. Larger overhangs only marginally reduce sun penetration at the expense of daylight deeper in the space. Recommended Profile Angle is 65 degrees.

This Addendum also includes a series of graphs showing actual hourly data over the whole year for:

- Horizontal overhang effectiveness (percentage of the window that is shaded) for different overhang depths for each orientation.
- Automated louver protocols: Schedules based on sun penetration for different orientations of operable louvers. Tilt only simulates with 5 positions, retractable has an Additional 6th position (fully open),
- Hourly Useful Daylight Performance (percentage of the space that achieve between30 and 300 FC with fractional credit for values below 30 FC)
- Hourly excessive illuminance (percentage of the space that exceeds 300 FC.)

Add/B.1 Executive Summary (Continued)

The next round of daylighting studies analyzed visual comfort in the Hawaiian climate and how to prevent glare from direct views to the horizon and low altitude sky.

The sky conditions in Hawaii pose some unique challenges to meeting these demands. The latitude and local climate conditions lead to periods of very bright skies (even at the horizon) mixed with rapidly changing and sometimes quite dark skies. In order to maintain visual comfort inside the building the window wall needs a response the reduces the brightness of the view to the sky, but still allows enough daylight during darker sky conditions.

In cases where the view to the sky is obstructed by vegetation, topography and surrounding buildings (except those with large high reflectance surfaces that receive direct sun), a fixed horizontal overhang or fixed louvers that effectively block direct sun on the window works alone to create a visually comfortable interior.

In all other cases where there is a direct view to the horizon and low altitude sky some dynamic response is necessary. Two Preferred options:

- Option 1:: Automated Interior fabric roller shades. This is a compliment to fixed exterior overhangs that meet the profile angle requirements for the orientation. Fabric on East and West facades where a direct view out the window is unavoidable for people seated at desks should have an openness of 1% and a visible light transmittance > 5%. North and South facades, as well as East and West facades where desks are arranged facing perpendicular to the window should have an openness of 3% and visible light transmittance > 10%.
- Option 2:: Automated exterior louvers. Louvers should be light in color and matte rather than specular or glossy. They should be capable of adjusting the profile angle for light penetration between 10 (mostly closed) and 45 degrees (1:1 ratio between louver spacing and louver depth).

This Addendum also includes a series of graphs showing actual hourly data over the whole year for Automated shade protocols by orientation (when the shades would be deployed), human response renderings, falsecolor luminance maps (shows the rendered view on a color scale to communicate surface brightness) and image contour maps (contour map shows changes in elevation, these show changes in illuminance levels throughout the space, showing illuminance levels in footcandles).

2. MODEL ASSUMPTIONS

We modeled and ran simulations using Radiance, a research grade lighting simulation tool developed by Lawrence Berkeley Laboratory that is based on the physics of light and material properties.

Geometry is based on existing classrooms in Kuykendall Hall. Window size was optimized to maximize daylight (50% window to wall ratio). The space is assumed to be located on the third floor, surrounded by medium density 3-4 story buildings and landscape.

Geometry:
- Sill 3.66' high
- Head 10.5' high
- Ceiling: 13' high
- Depth of room: 28'

Materials and finishes are based on assumptions that match the UHM Building Design and Performance Standards.

Visual Light Reflectances (VLR):
- Floor 20%
- Walls 50%
- Ceiling 80%
- Shades 14% VLT
- Glazing 64% VLT
- Site 15%
- Trees 8%
- Overhang 50%

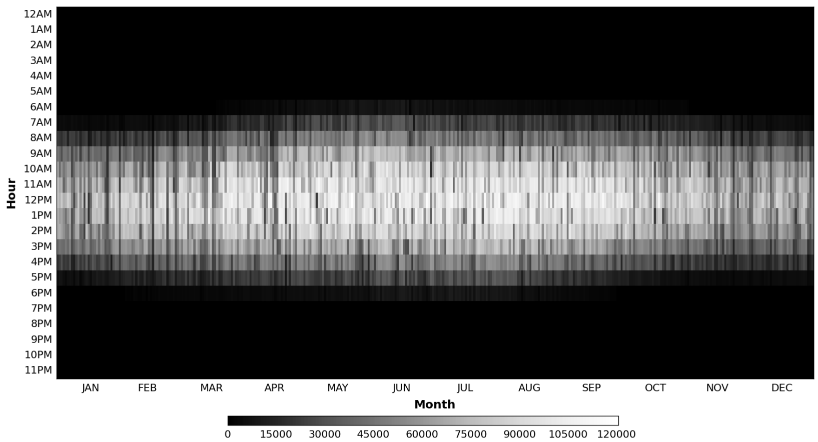
Sky and Climate Data: Weather data is the TMY2 dataset from the Honolulu airport, The TMY3 dataset appears to have hourly values for some columns shifted in certain months, so does not appear to be reliable. The final analysis should be repeated with the UHM weather data if it is substantially different.

Clear sky data is generated using stats from the TMY3 dataset and is in good agreement with the TMY2 direct normal values.

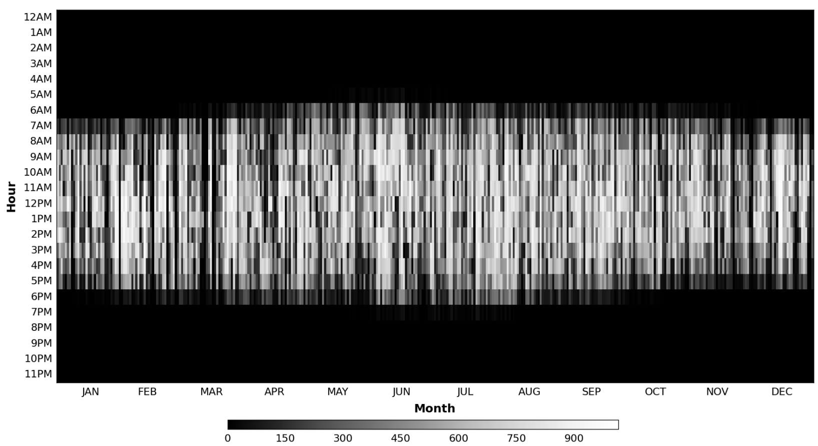
VLR - visible light reflectance, VLT - visible light transmittance

Add/B.2 Model Assumptions (Continued)

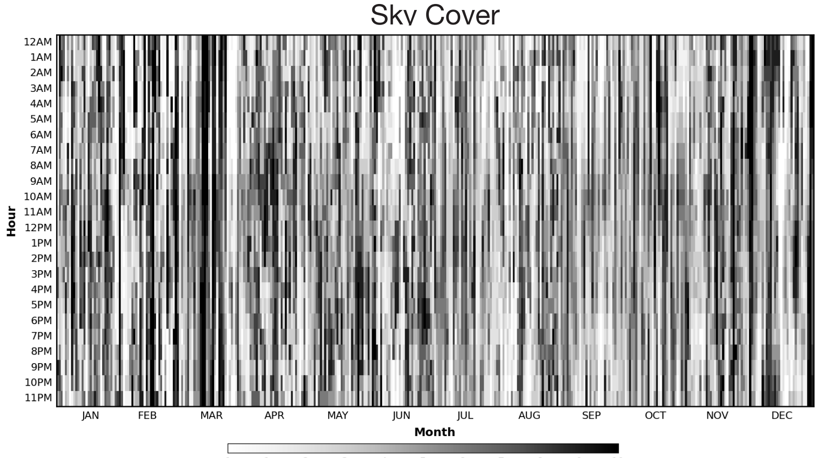
Global Horizontal Illuminance



Direct Normal Radiation

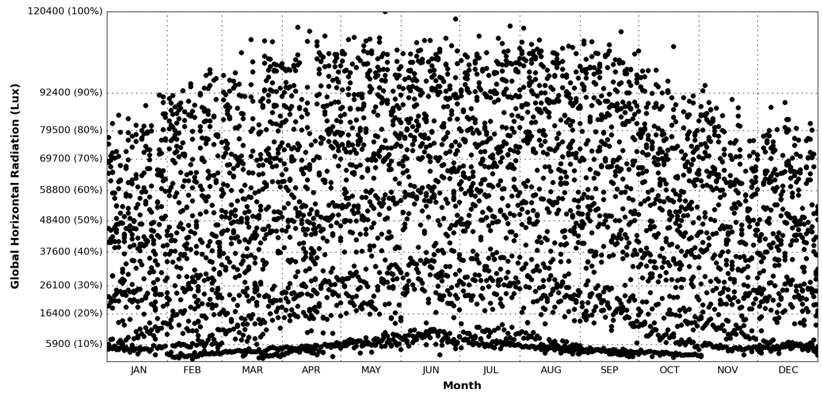


Sky Cover

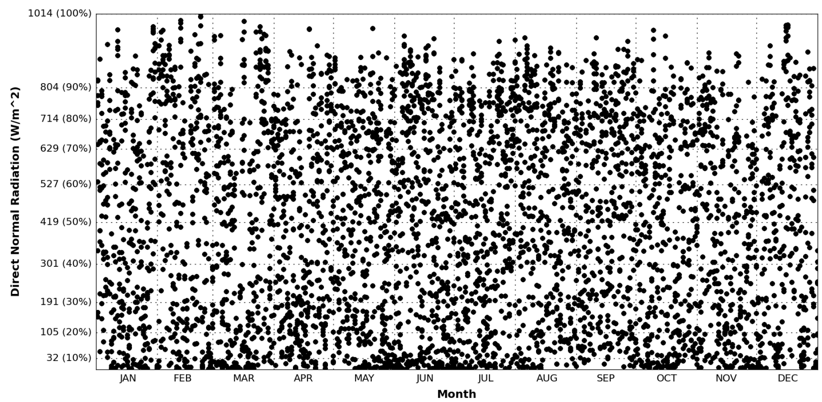


Add/B.2 Model Assumptions (Continued)

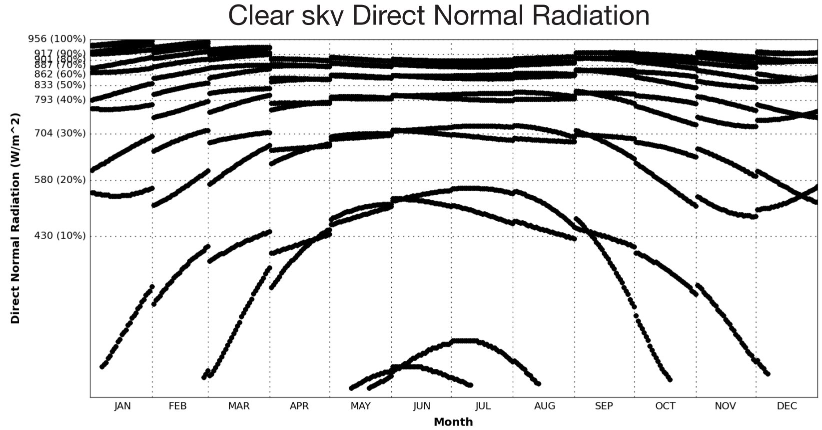
Global Horizontal Illuminance



Direct Normal Radiation



Clear sky Direct Normal Radiation



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Add/B DAYLIGHTING AND SHADING STUDIES

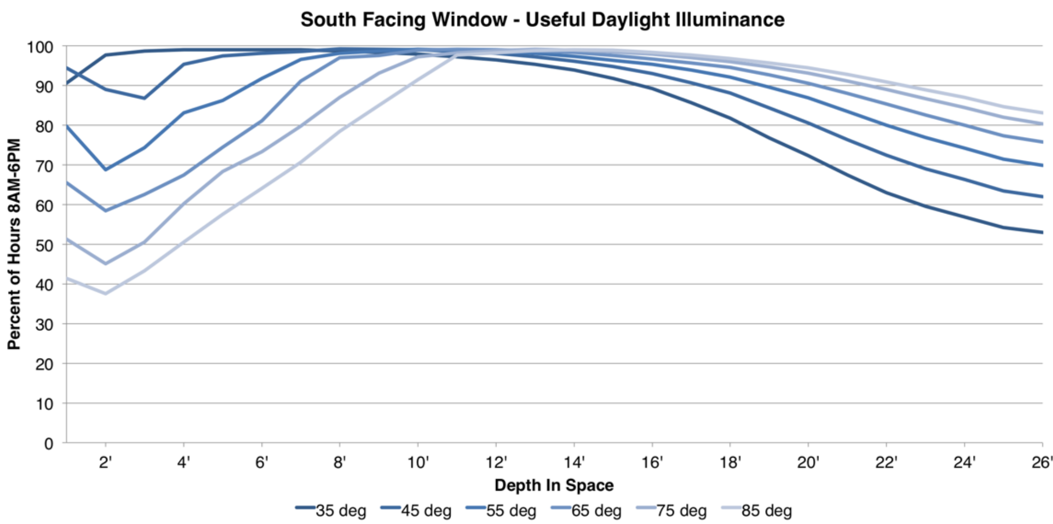
3. OPTIMIZING SOLAR CONTROL

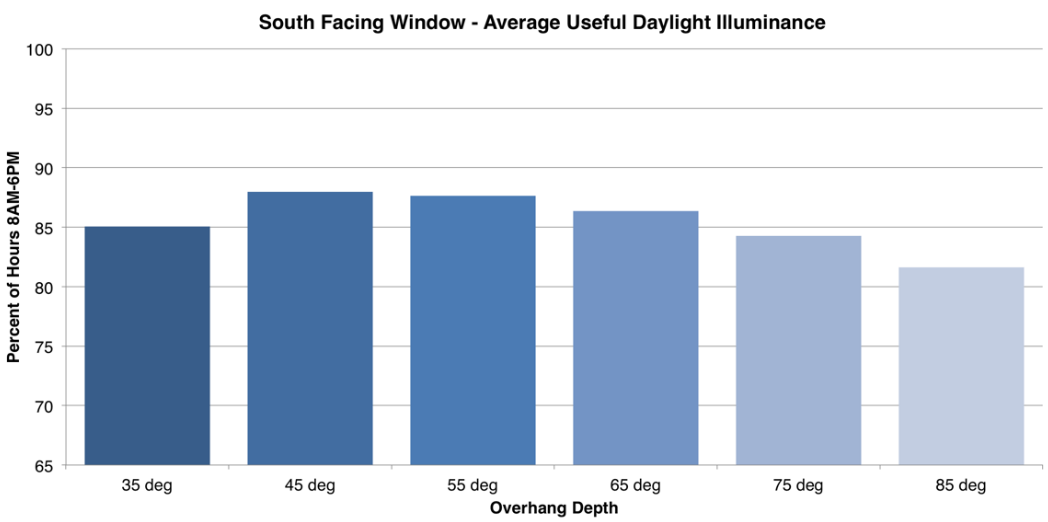
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

3.1. SUMMARY OF RESULTS

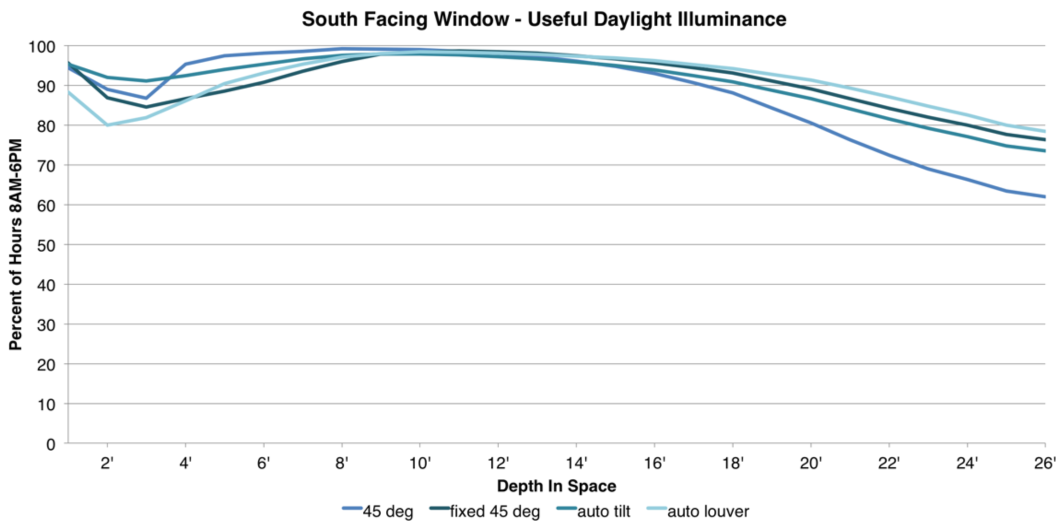
3.1.1 South Facing

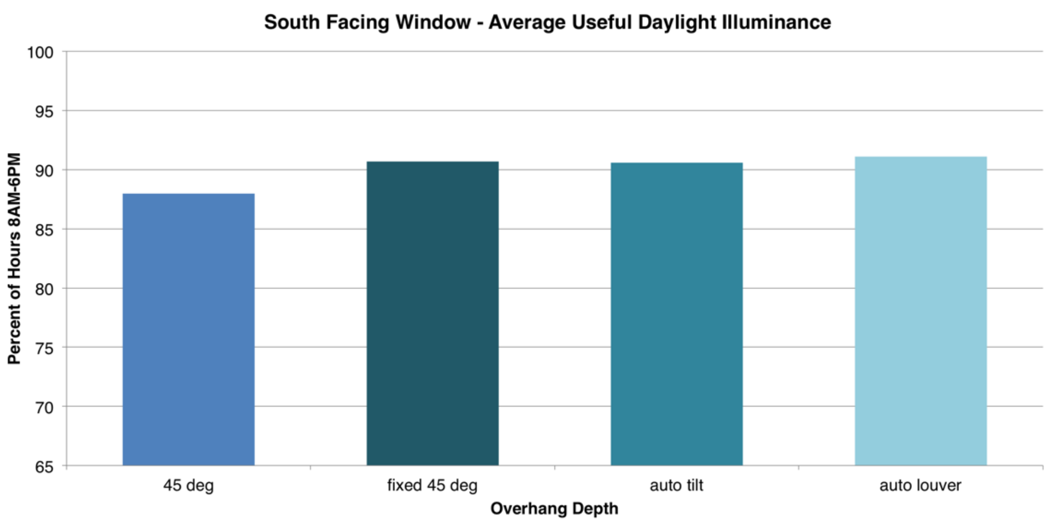




Graphs show the percentage of hours a point receives between 30 and 300 footcandles, with fractional credit for values below 30FC. Graphs on this page show average and point by point performance across the room of different horizontal overhang depths. Graphs on the next page show average and point by point performance for the optimal horizontal overhang compared with smaller fixed louvers, tilting louvers and retractable tilting louvers.

Add/B. 3.1.1 Summary of Results:: South Facing (Continued)





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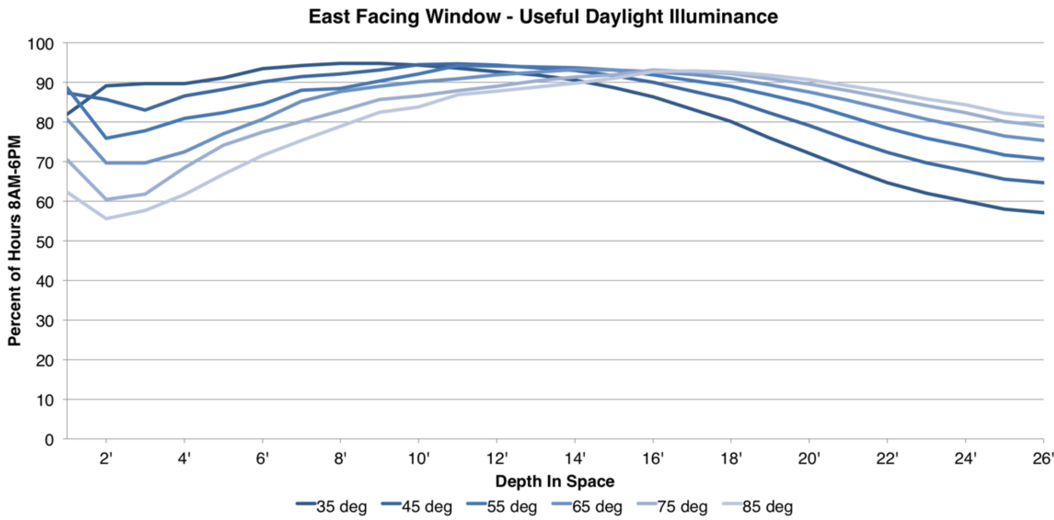
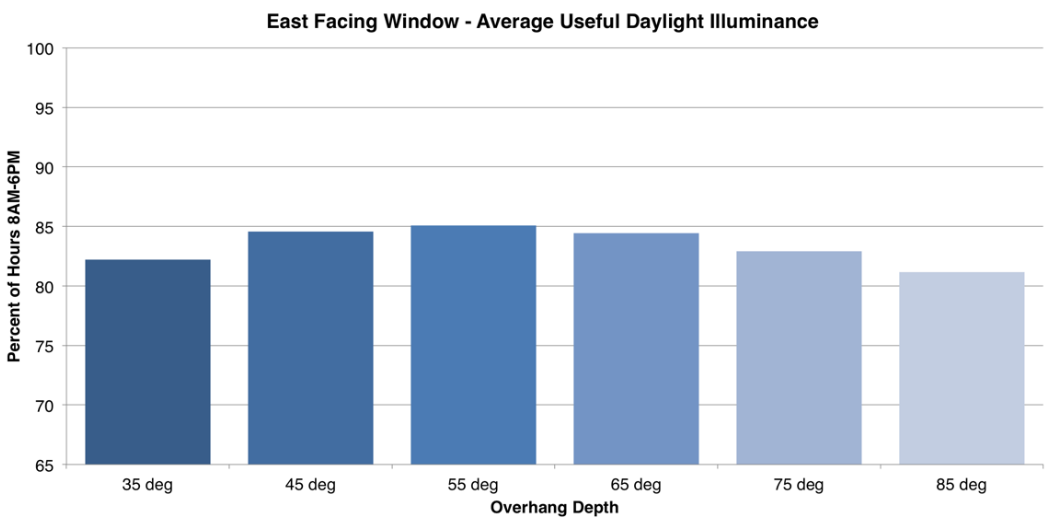
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

3.1. SUMMARY OF RESULTS

3.1.2 East Facing





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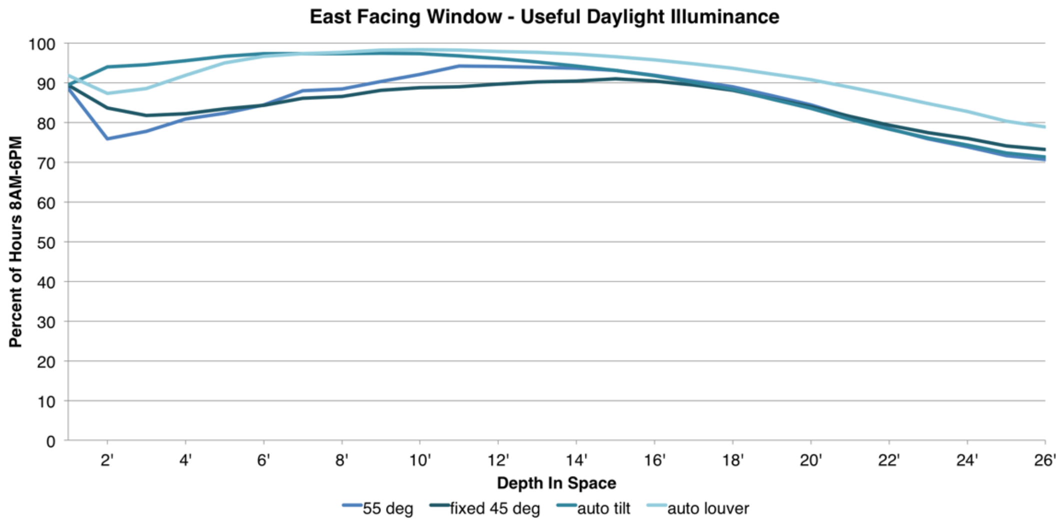
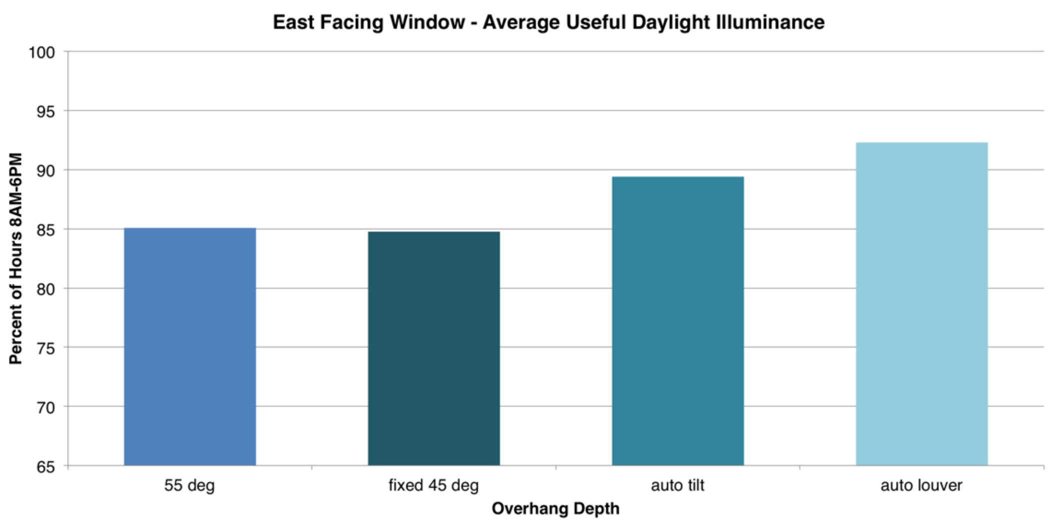
Add/B. 3.1.2 Summary of Results:: East Facing (Continued)





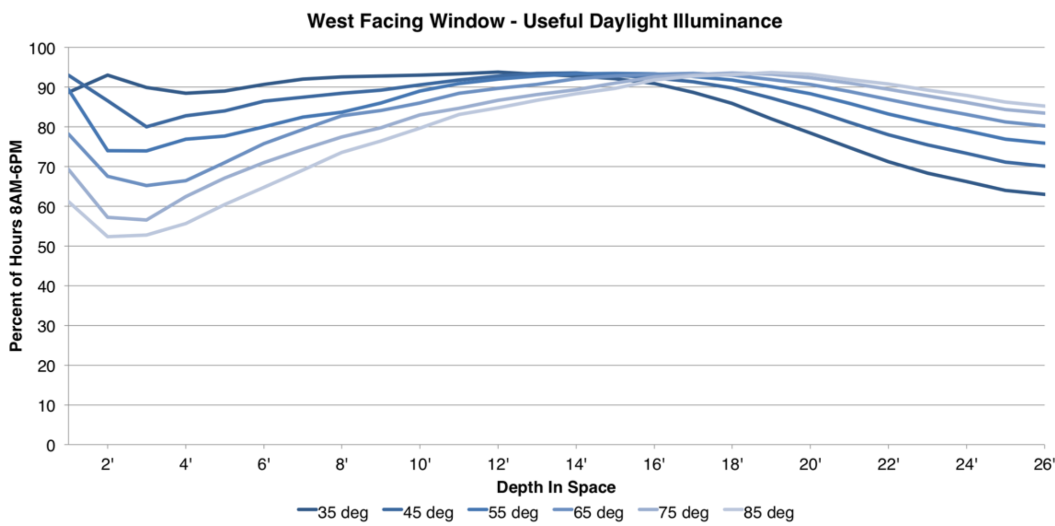
For east facades, fully automated louvers outperform all other options. Fixed strategies are less effective near the window because of low sun angles.

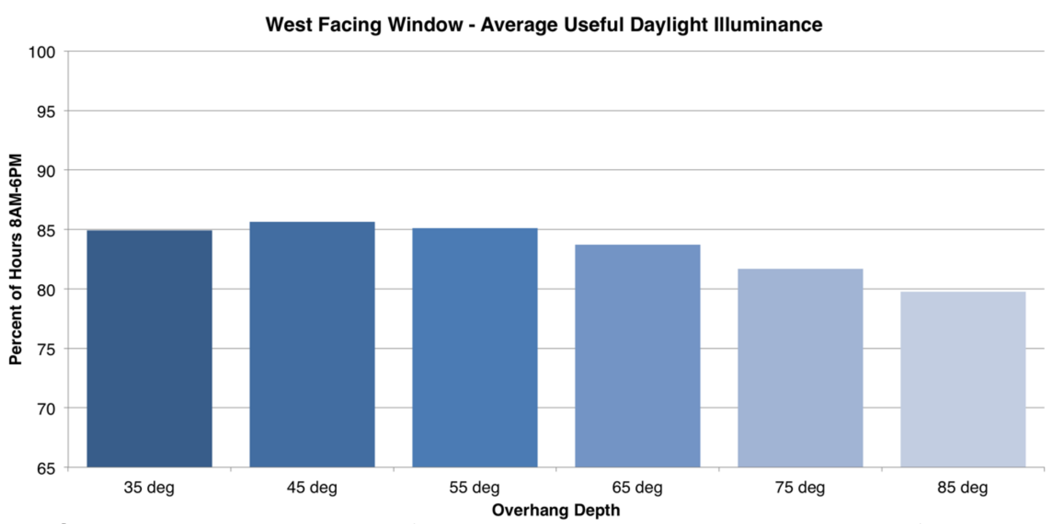
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

3.1. SUMMARY OF RESULTS

3.1.3 West Facing





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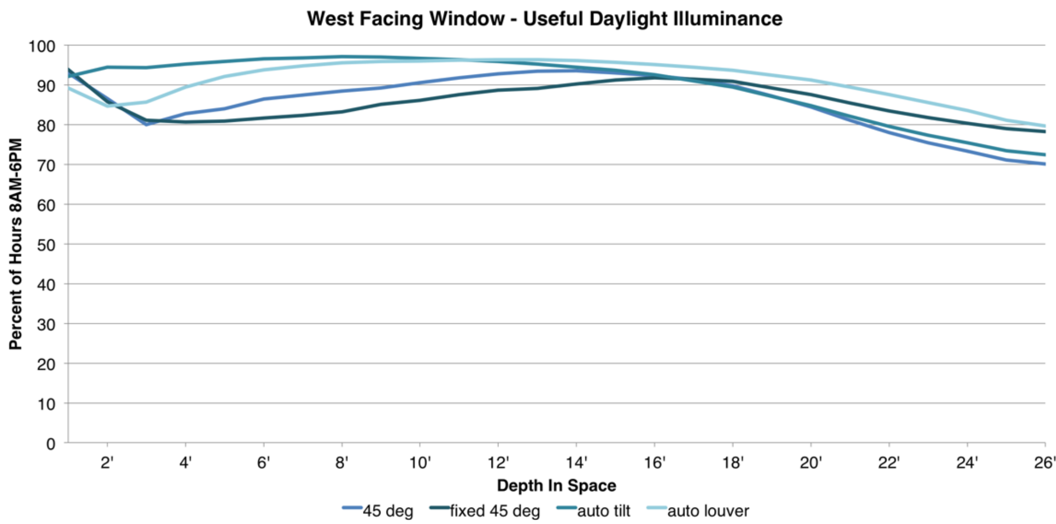
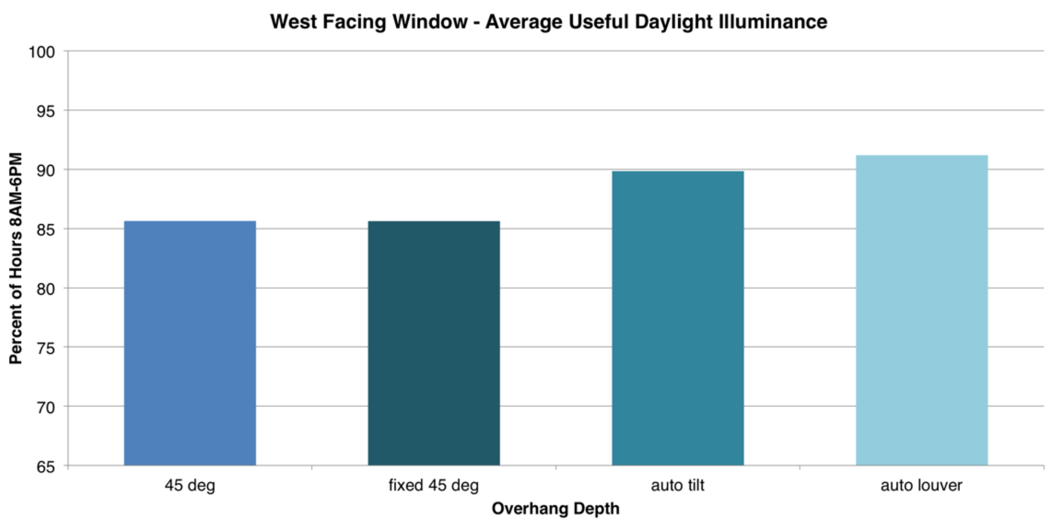
Add/B. 3.1.3 Summary of Results:: West Facing (Continued)





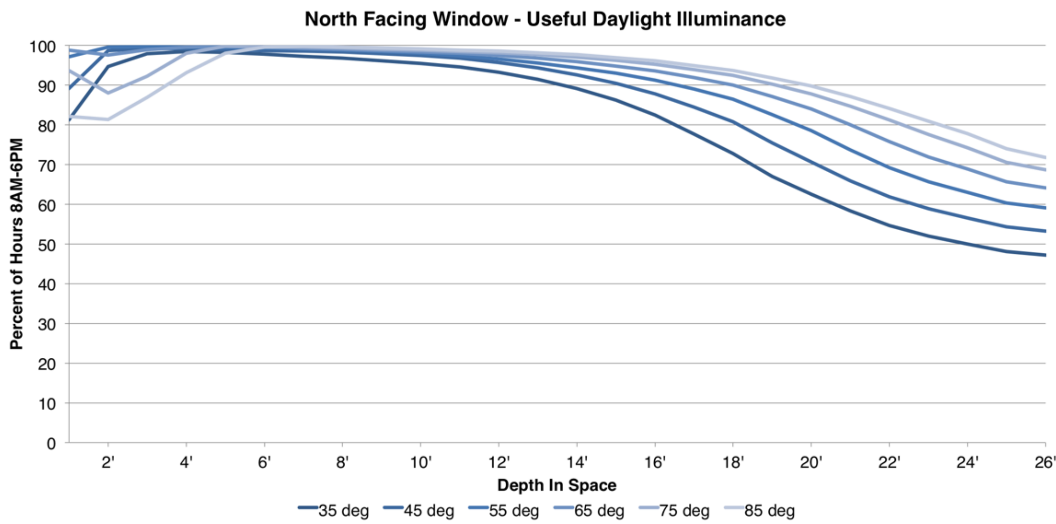
For west facades, fully automated louvers outperform all other options. Fixed strategies are less effective near the window because of low sun angles.

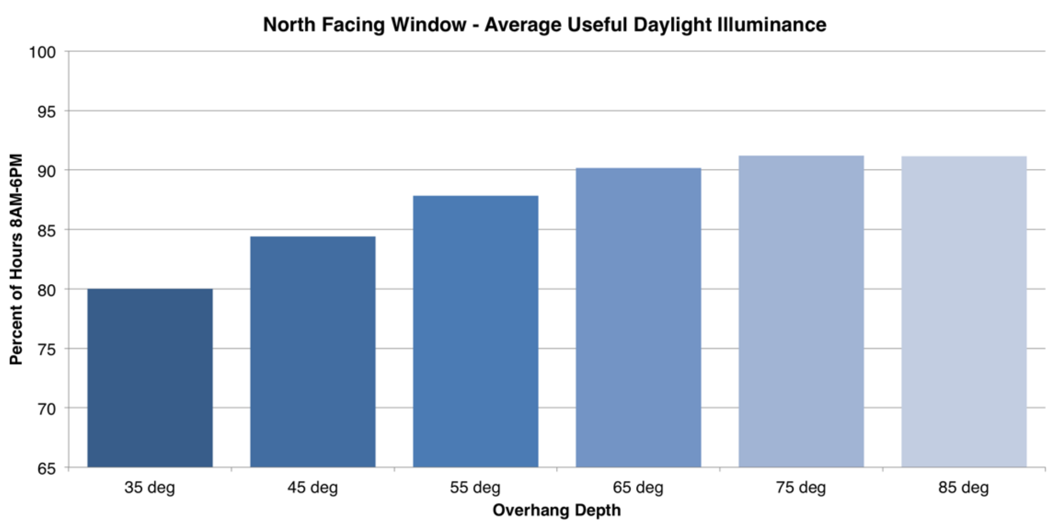
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

3.1. SUMMARY OF RESULTS

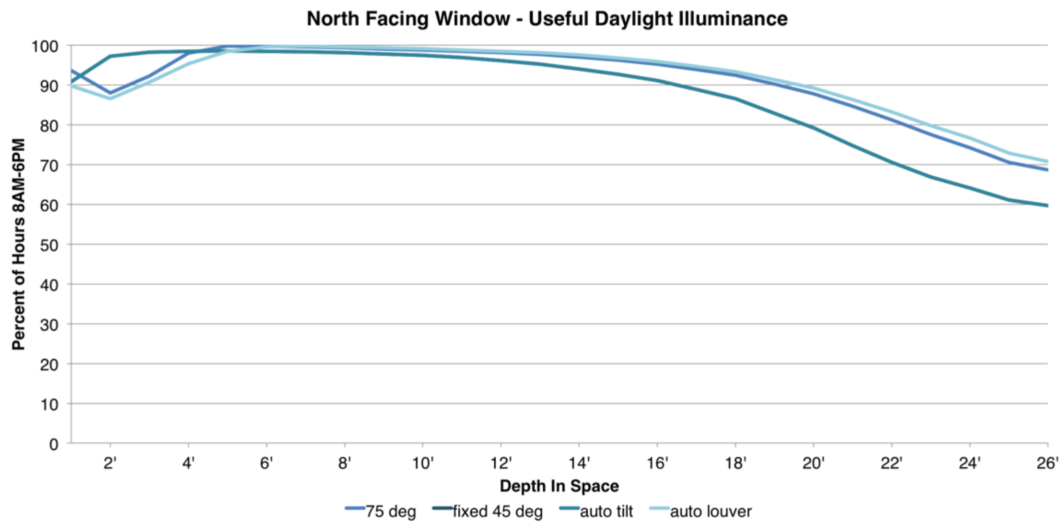
3.1.4 North Facing

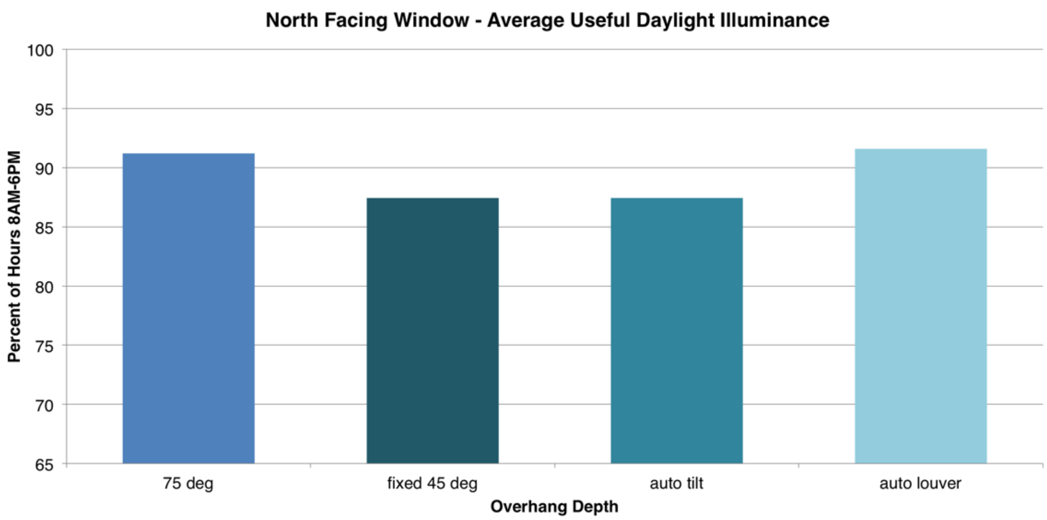




Graphs show the percentage of hours a point receives between 30 and 300 footcandles, with fractional credit for values below 30FC. Graphs on this page show average and point by point performance across the room of different horizontal overhang depths. Graphs on the next page show average and point by point performance for the optimal horizontal overhang compared with smaller fixed louvers, tilting louvers and retractable tilting louvers.

Add/B. 3.1.4 Summary of Results:: North Facing (Continued)





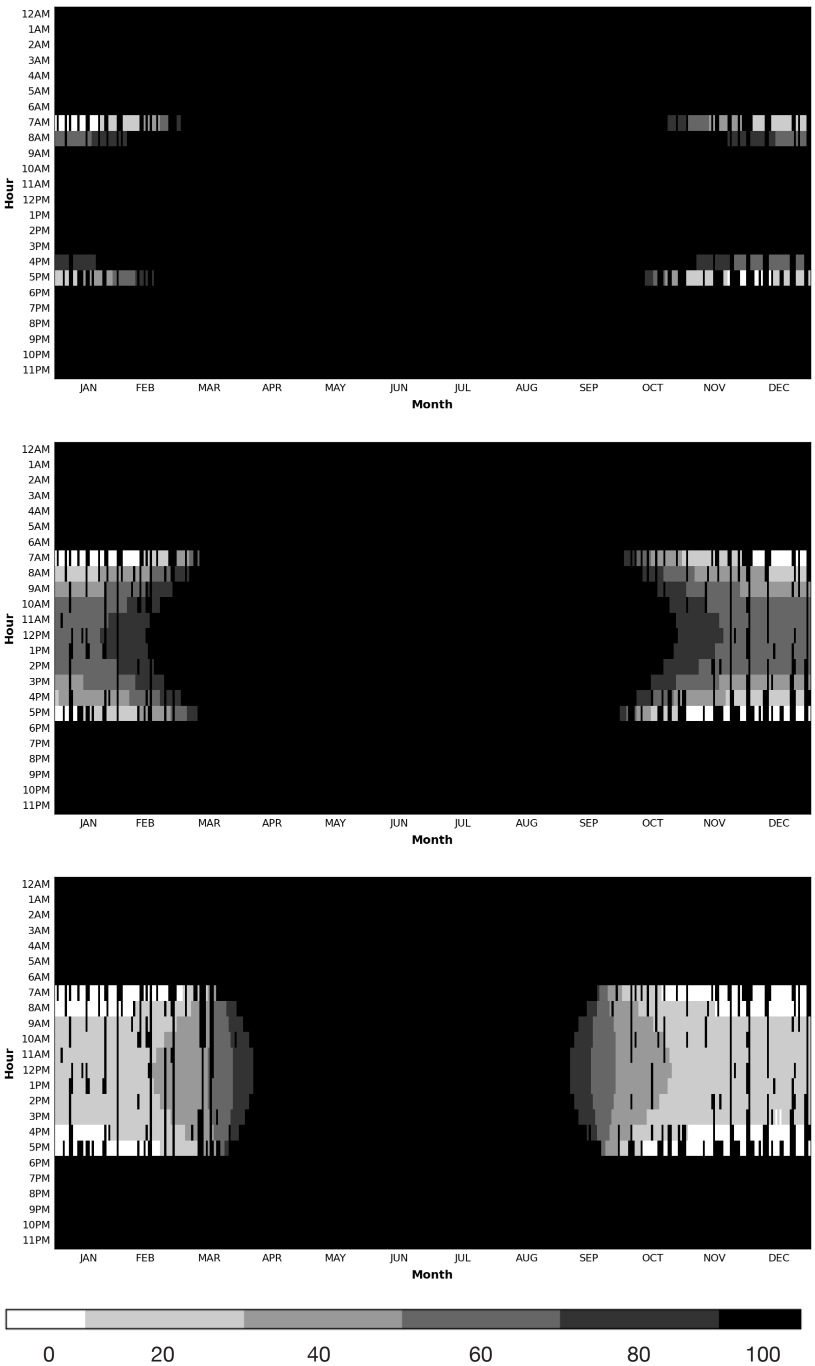
For north facades, a small horizontal overhang performs best. Larger overhangs only marginally reduce sun penetration at the expense of daylight deeper in the space.

Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

3.2. HORIZONTAL OVERHANG EFFECTIVENESS

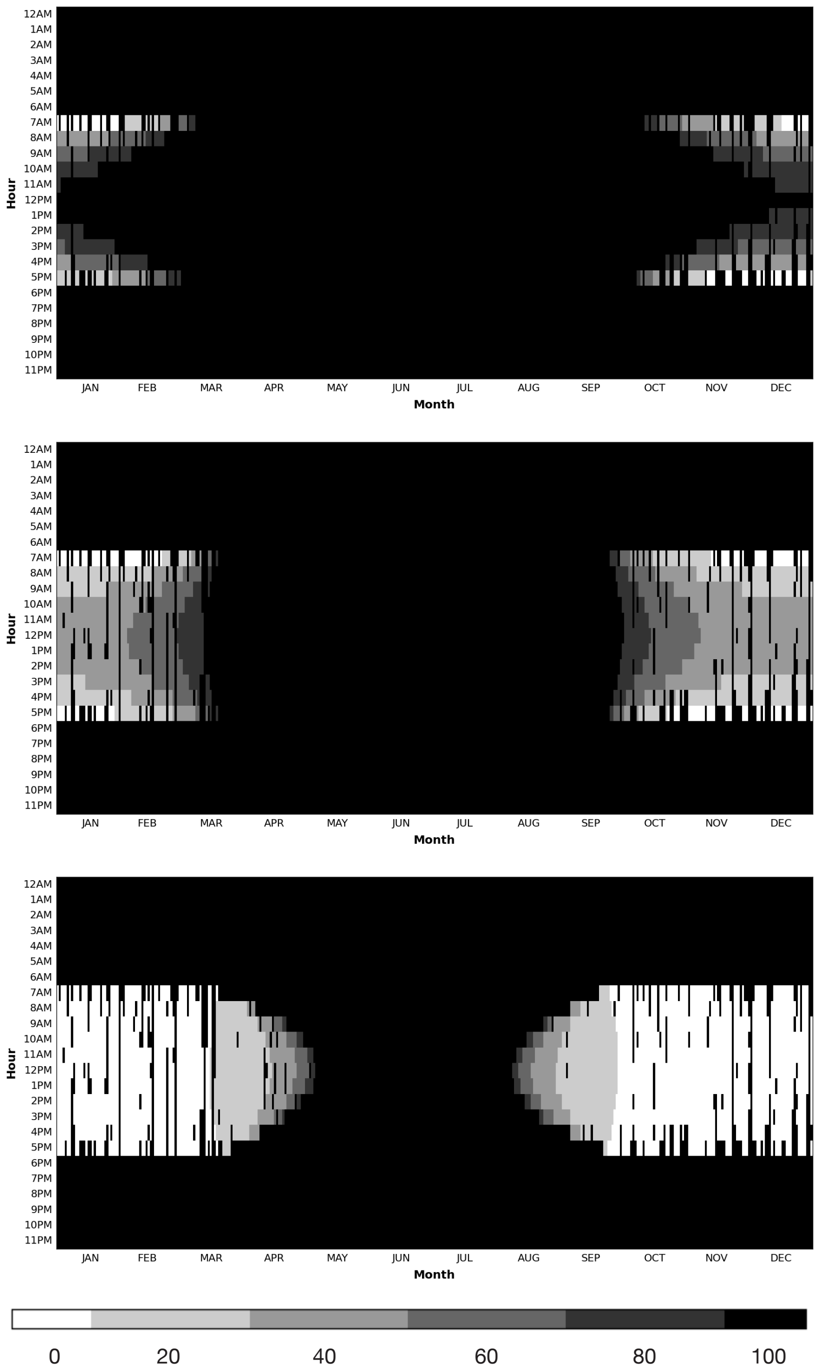
3.2.1 South Facade



LOISOS + UBBELOHDE

Add/B. 3.2.1 Horizontal Overhang Effectiveness:: South Facade(Continued)

Hourly graphs below show the percentage of the window that is shaded for various depths of horizontal overhangs.

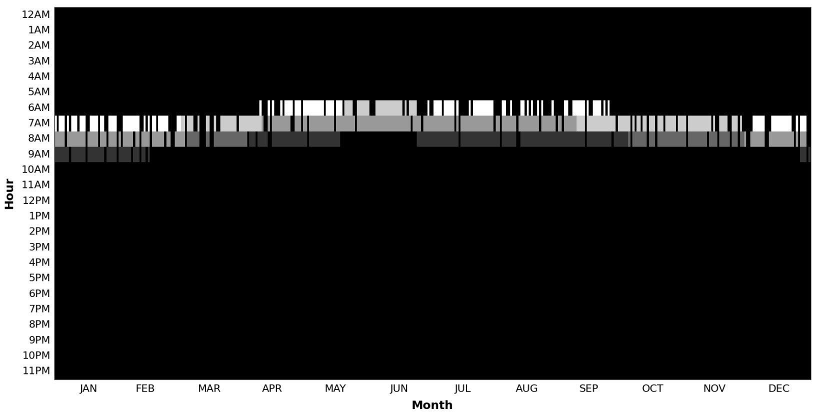


Add/B. DAYLIGHTING AND SHADING STUDIES

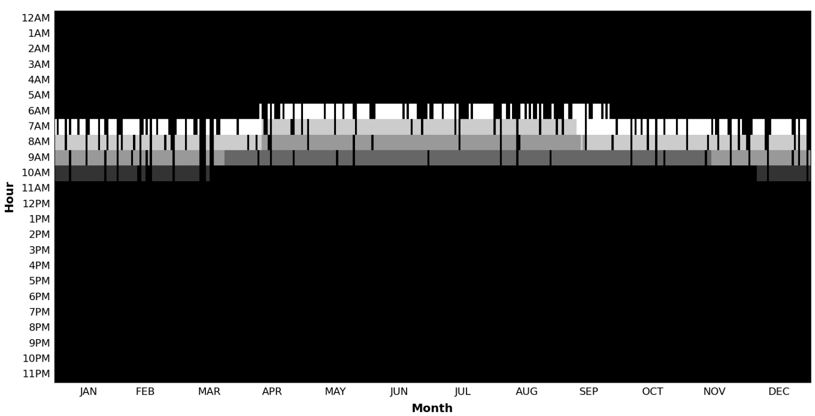
3. OPTIMIZING SOLAR CONTROL

3.2. HORIZONTAL OVERHANG EFFECTIVENESS

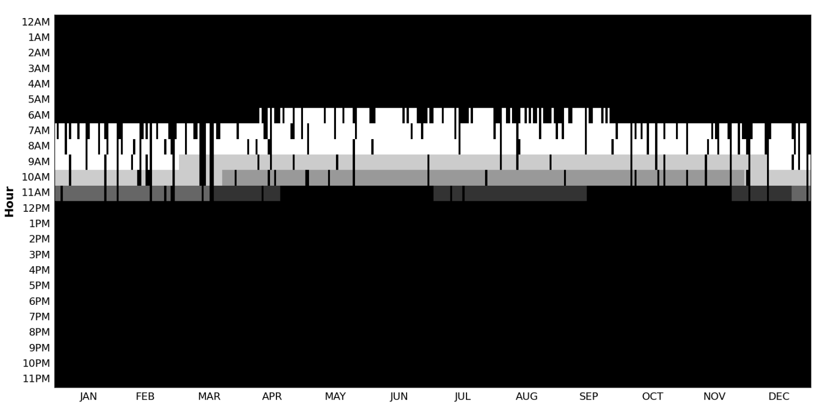
3.2.2 East Facade



35 degree Profile Angle



55 degree Profile Angle

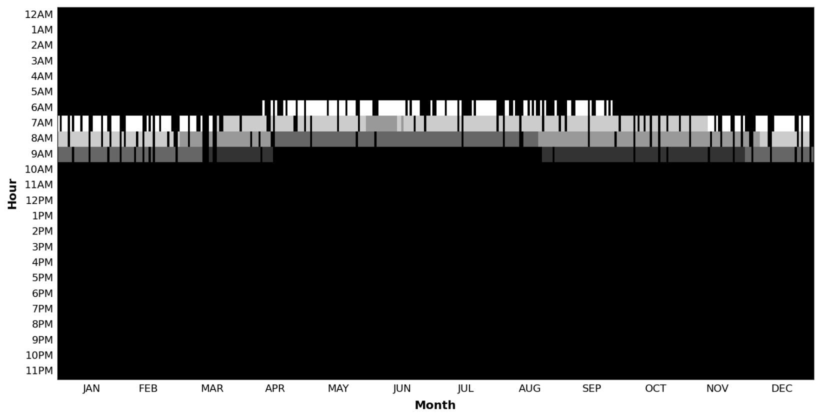


75 degree Profile Angle

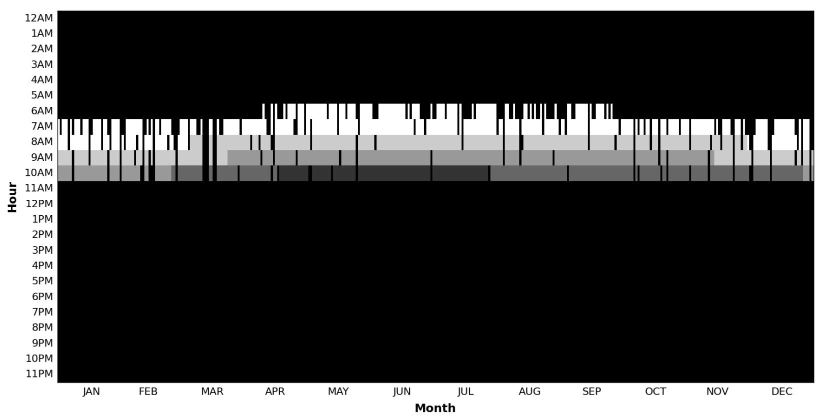
Add/B. 3.2.2 Horizontal Overhang Effectiveness:: East Facade(Continued)

Hourly graphs below show the percentage of the window that is shaded for various depths of horizontal overhangs.

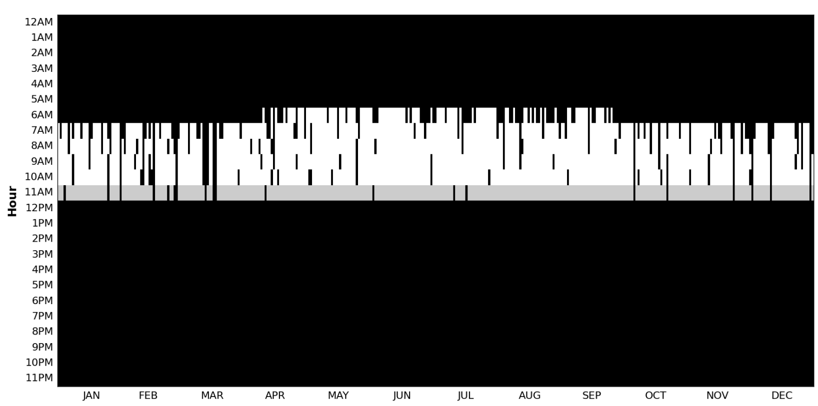
45 degree
Profile Angle



65 degree
Profile Angle



85 degree
Profile Angle

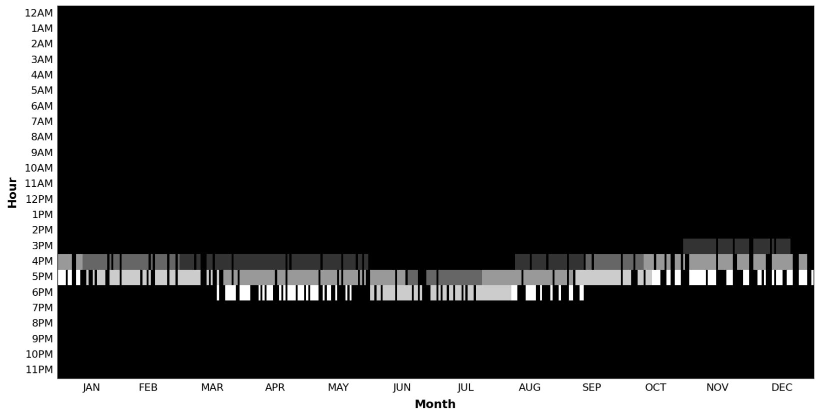


Add/B. DAYLIGHTING AND SHADING STUDIES

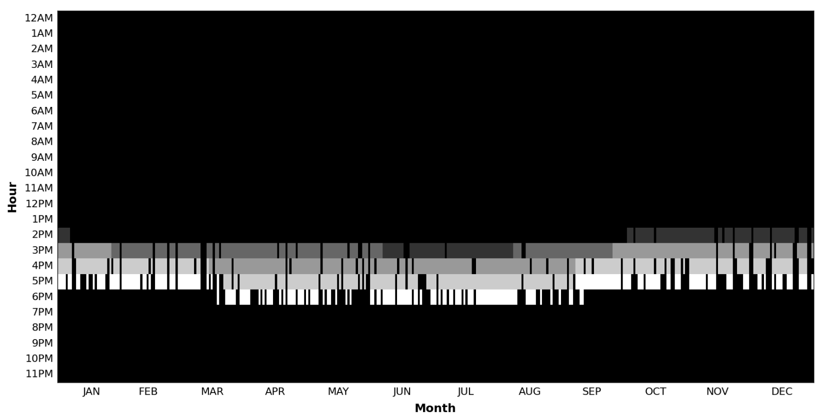
3. OPTIMIZING SOLAR CONTROL

3.2. HORIZONTAL OVERHANG EFFECTIVENESS

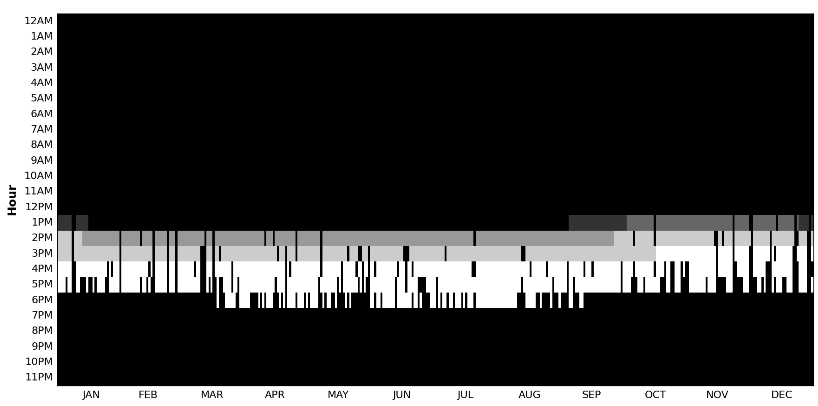
3.2.3 West Facade



35 degree
Profile Angle



55 degree
Profile Angle

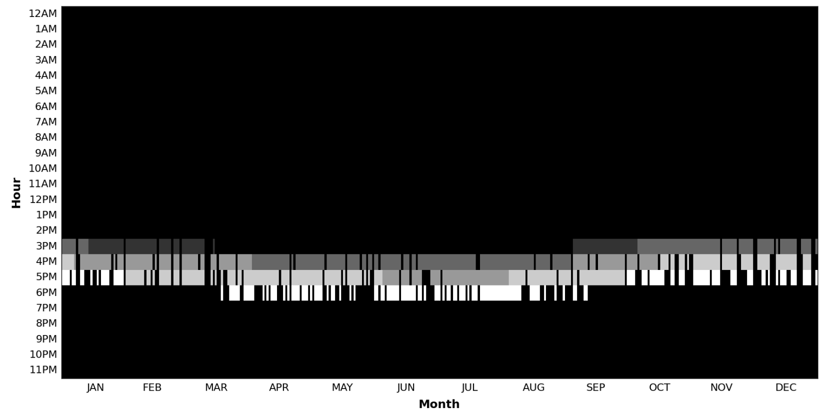


75 degree
Profile Angle

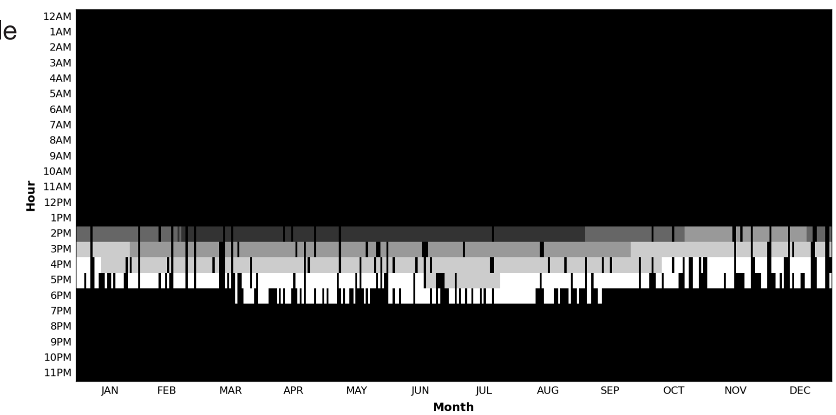
Add/B. 3.2.3 Horizontal Overhang Effectiveness:: West Facade(Continued)

Hourly graphs below show the percentage of the window that is shaded for various depths of horizontal overhangs.

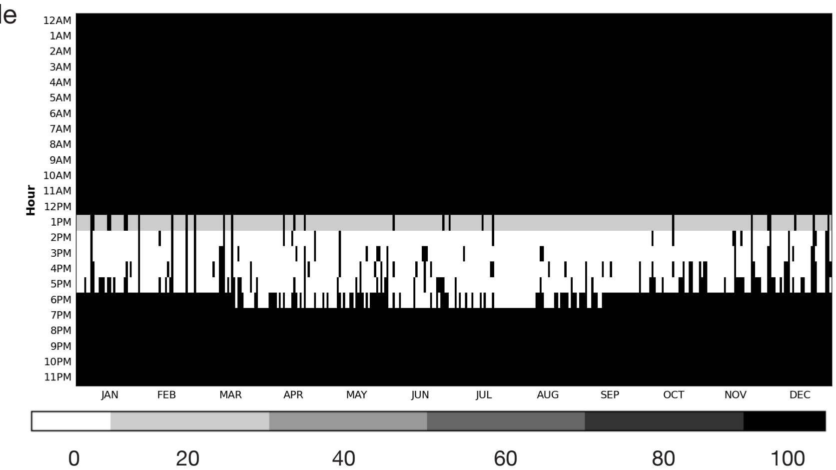
45 degree
Profile Angle



65 degree
Profile Angle



85 degree
Profile Angle

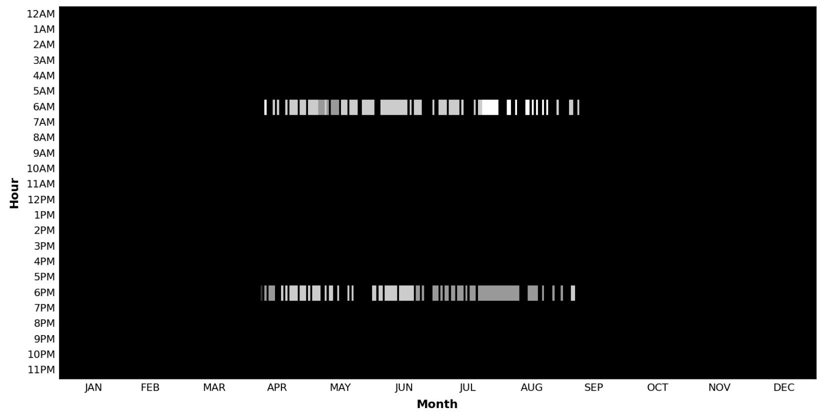


Add/B. DAYLIGHTING AND SHADING STUDIES

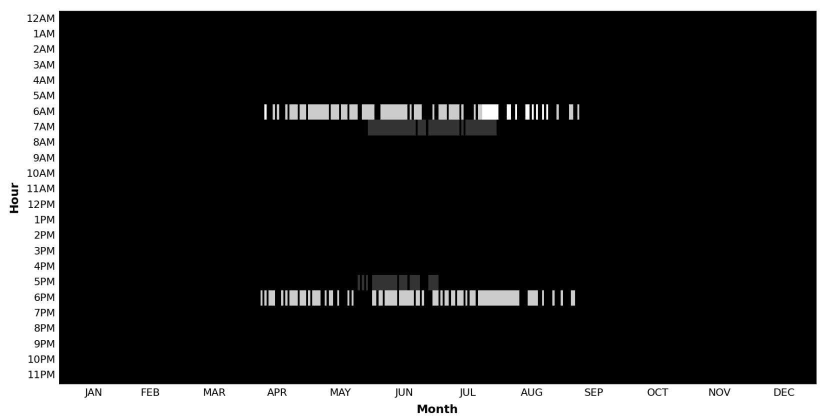
3. OPTIMIZING SOLAR CONTROL

3.2. HORIZONTAL OVERHANG EFFECTIVENESS

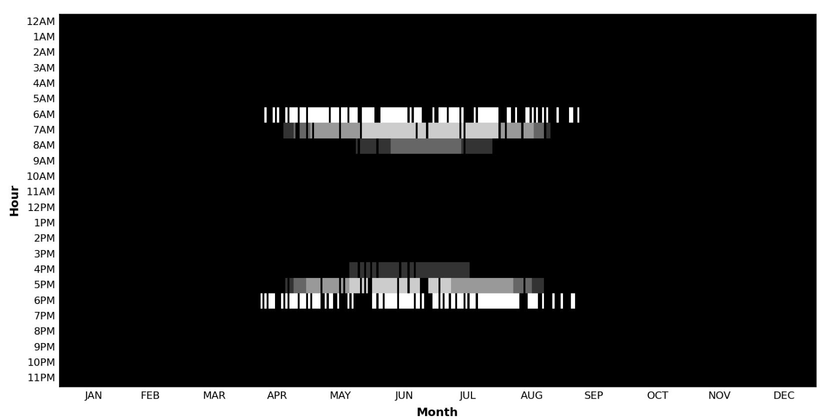
3.2.4 North Facade



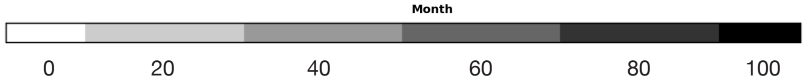
35 degree
Profile Angle



55 degree
Profile Angle



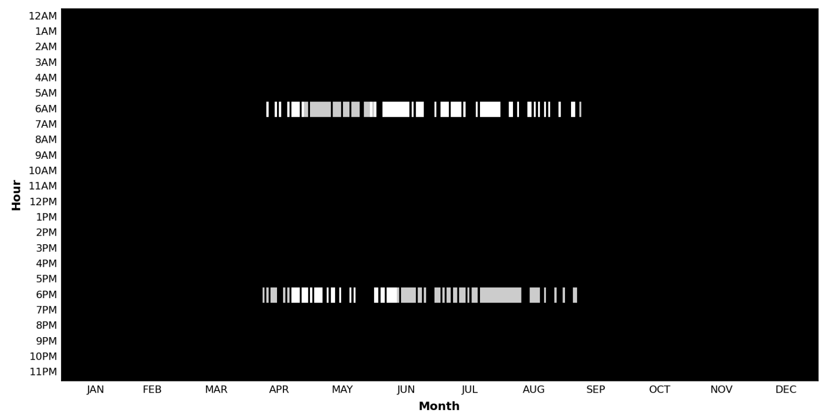
75 degree
Profile Angle



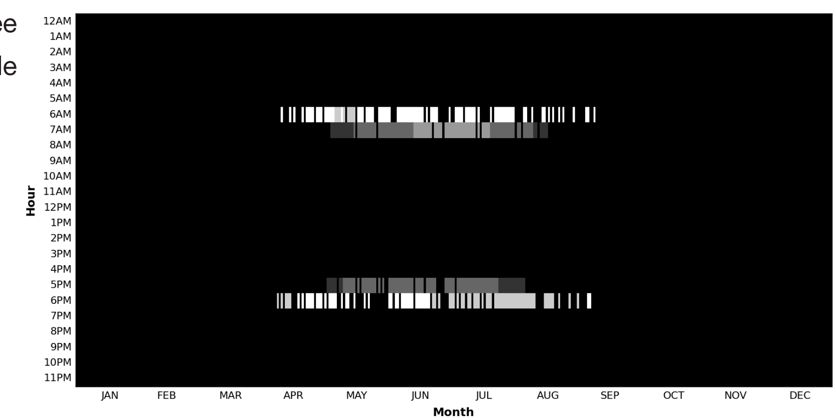
Add/B. 3.2.4 Horizontal Overhang Effectiveness:: North Facade(Continued)

Hourly graphs below show the percentage of the window that is shaded for various depths of horizontal overhangs.

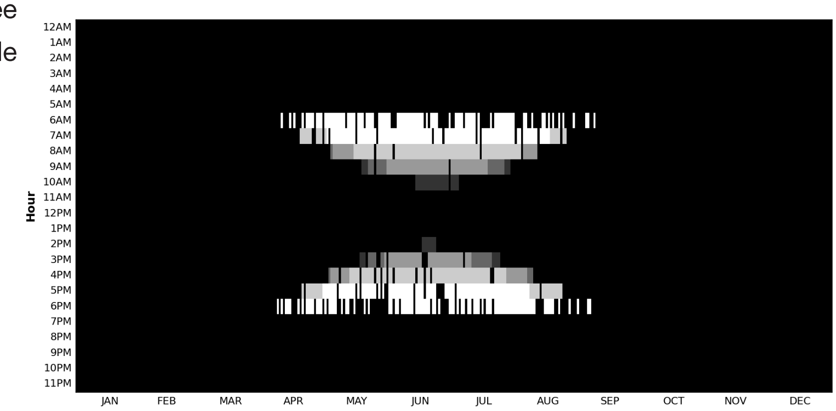
45 degree
Profile Angle



65 degree
Profile Angle



85 degree
Profile Angle



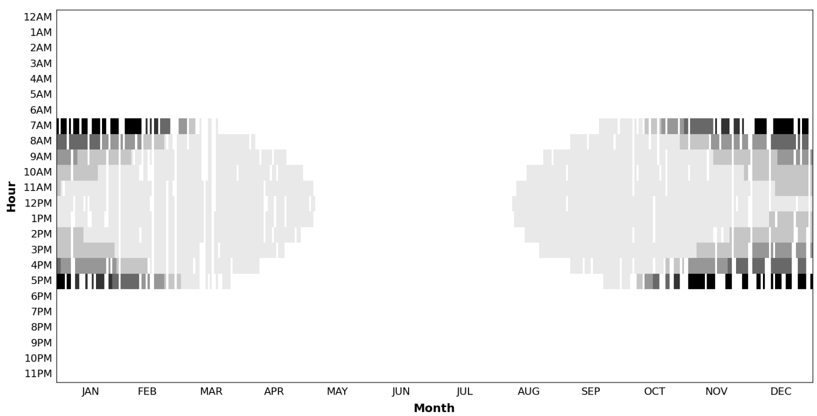
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

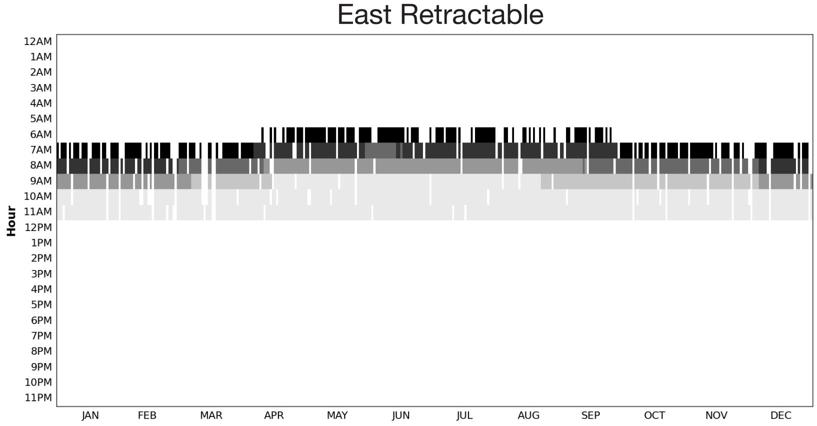
3.3. AUTOMATED LOUVER PROTOCOLS

3.3.1 Retractable

South Retractable



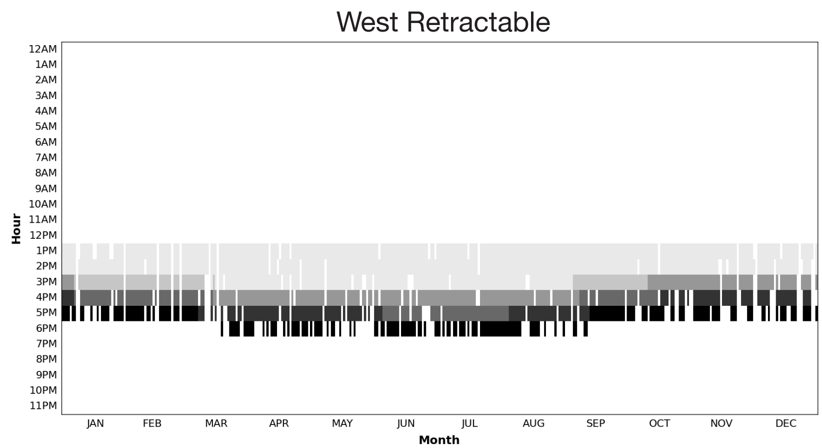
East Retractable

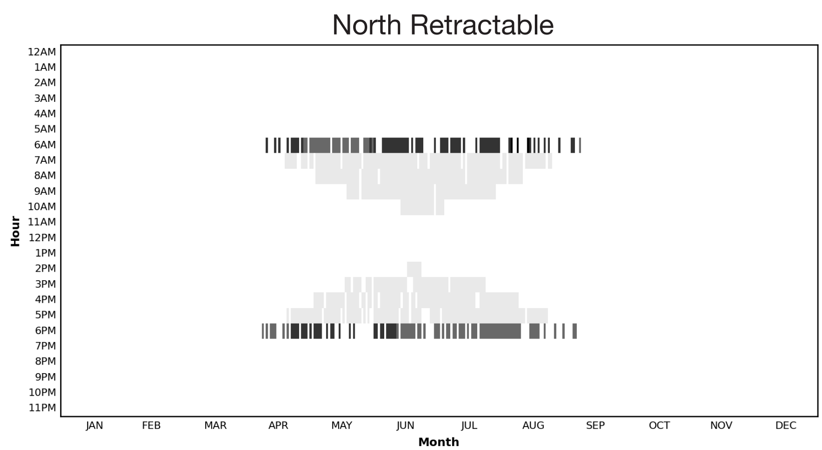


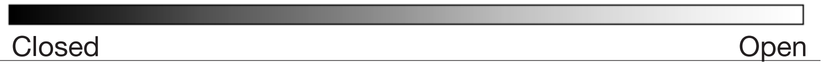
Closed Open

Add/B. 3.3.1 Automated Louver Protocols:: Retractable (Continued)

Schedules based on sun penetration for different orientations of operable louvers. Tilt only simulates with 5 positions, retractable has an Additional 6th position (fully open),





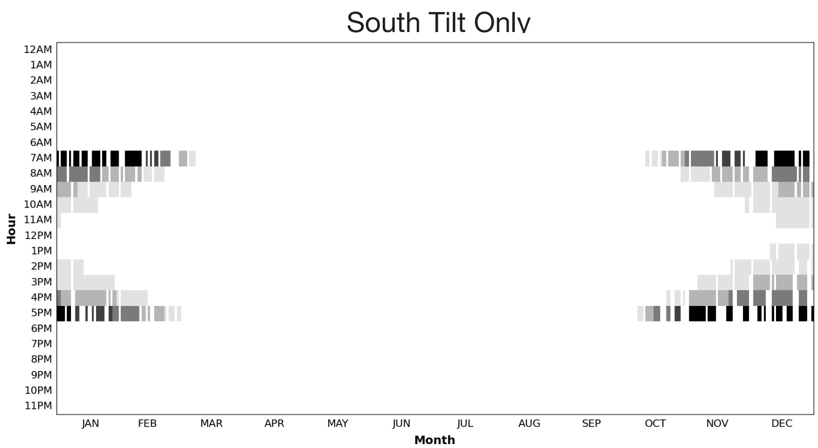


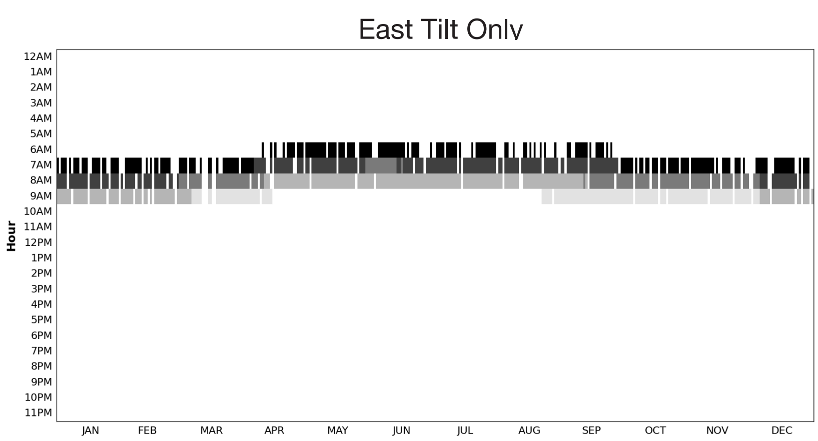
Add/B. DAYLIGHTING AND SHADING STUDIES

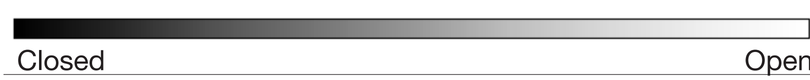
3. OPTIMIZING SOLAR CONTROL

3.3. AUTOMATED LOUVER PROTOCOLS

3.3.2 Tilt Only

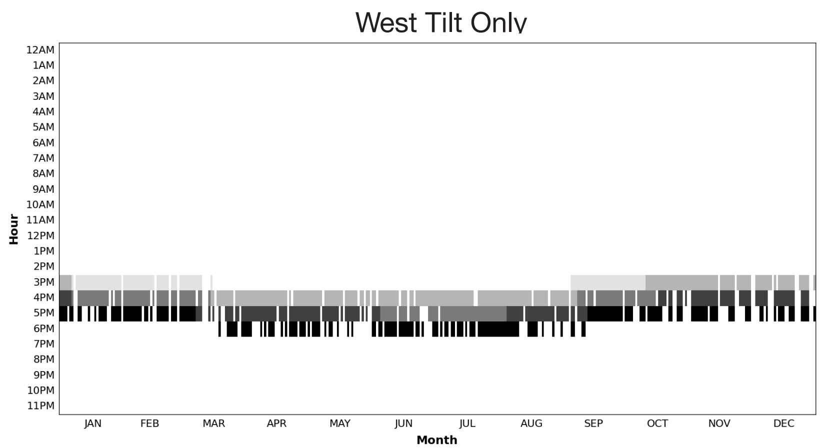


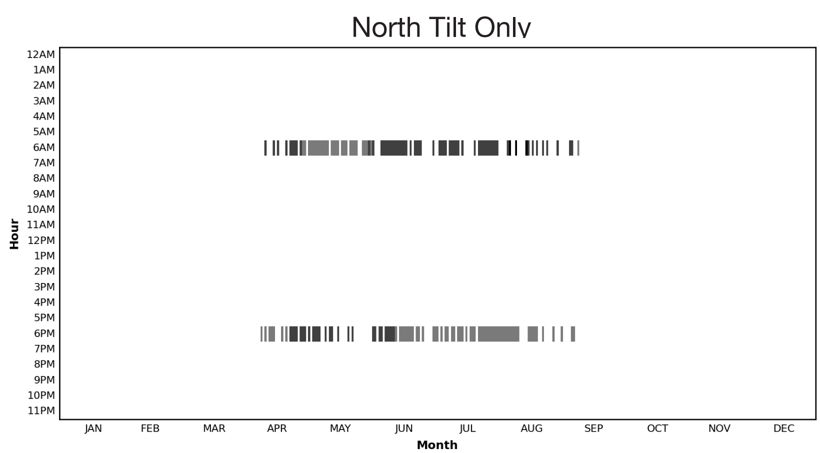


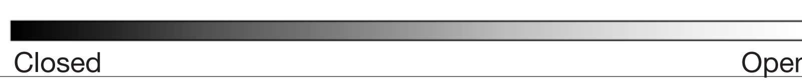


Add/B. 3.3.2 Automated Louver Protocols:: Tilt Only (Continued)

Schedules based on sun penetration for different orientations of operable louvers. Tilt only simulates with 5 positions, retractable has an Additional 6th position (fully open),







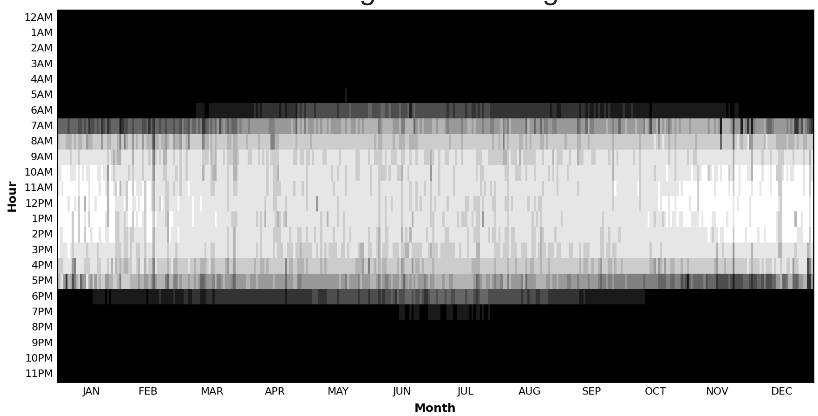
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

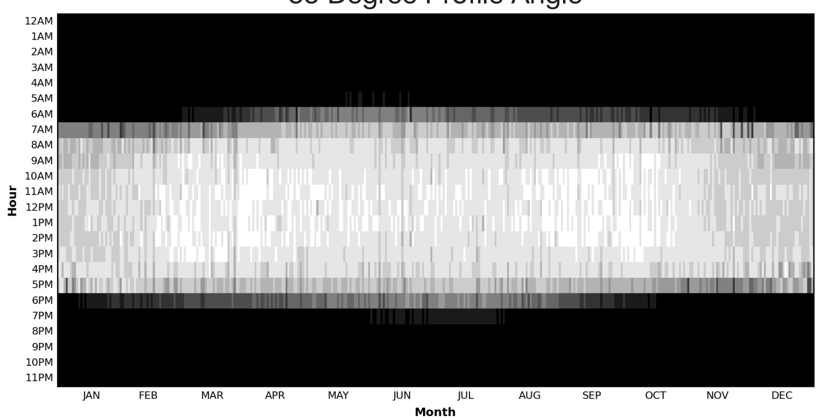
3.4. HOURLY USEFUL DAYLIGHT ILLUMINANCE

3.4.1 South Facade

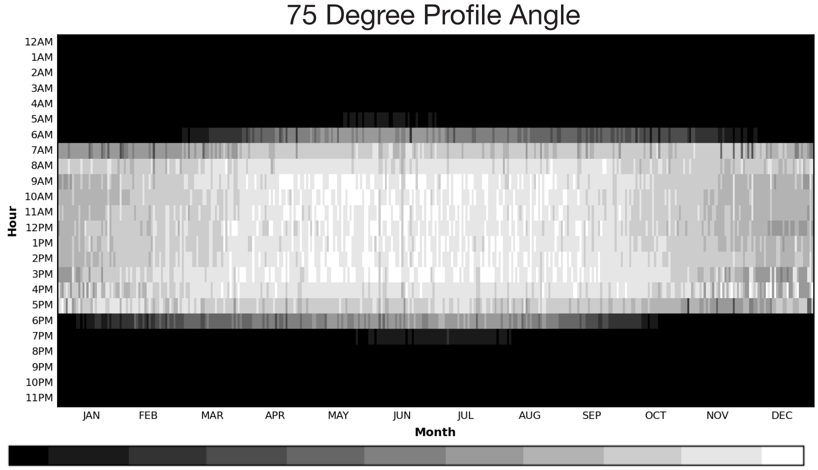
35 Degree Profile Angle



55 Degree Profile Angle



75 Degree Profile Angle

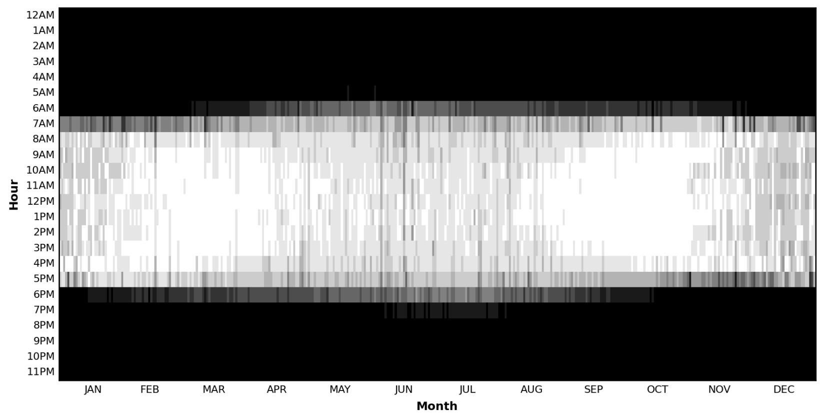


Percent Useful Illumination

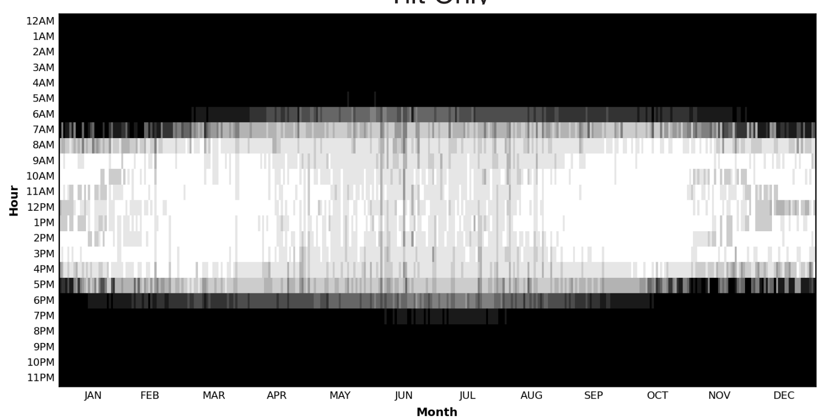
Add/B. 3.4.1 Hourly Useful Daylight Illuminance:: South Facade (Continued)

These Hourly graphs below show the percentage of the space that Achieve between 30 and 300 FC with fractional credit for values below 30 FC.

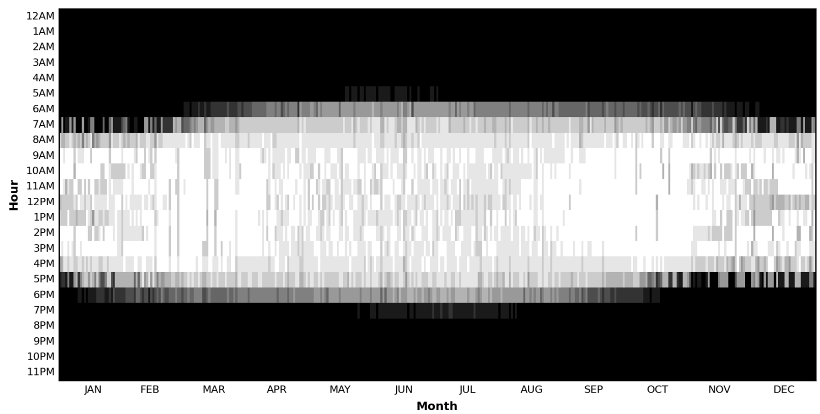
Fixed 45 Degree



Tilt Only



Auto Louver



Percent Useful Illumination

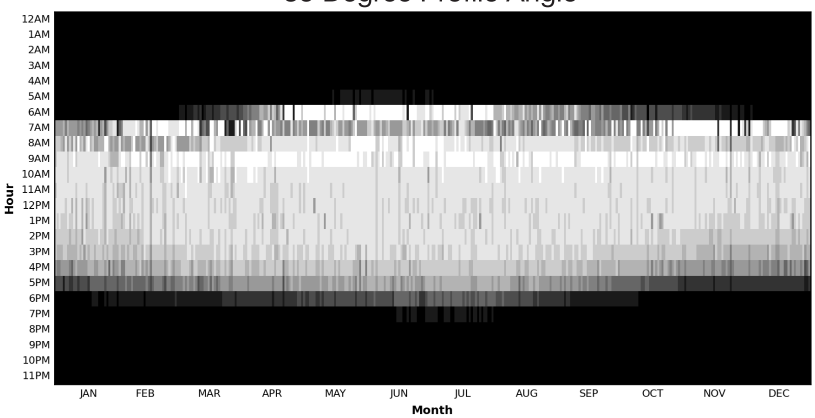
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

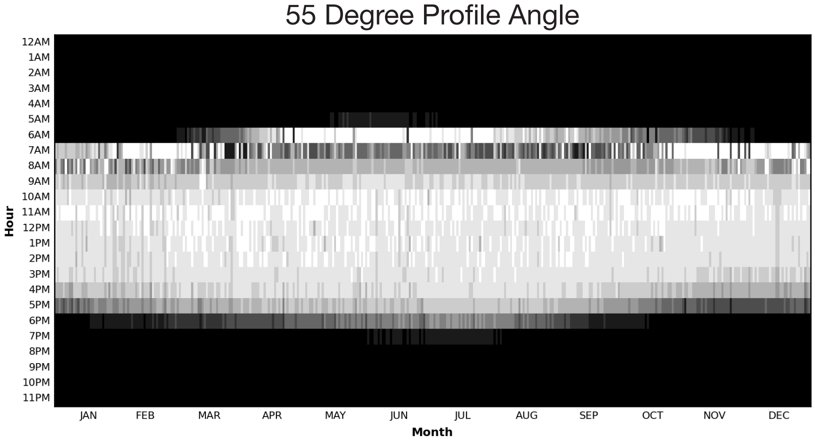
3.4. HOURLY USEFUL DAYLIGHT ILLUMINANCE

3.4.2 East Facade

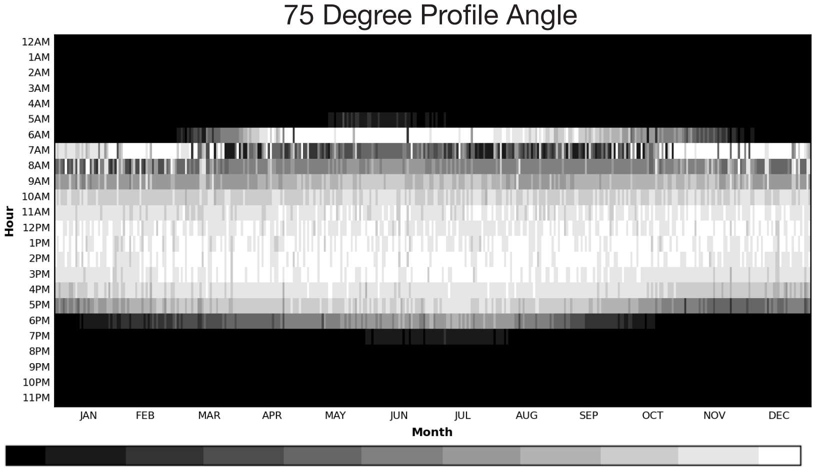
35 Degree Profile Angle



55 Degree Profile Angle



75 Degree Profile Angle

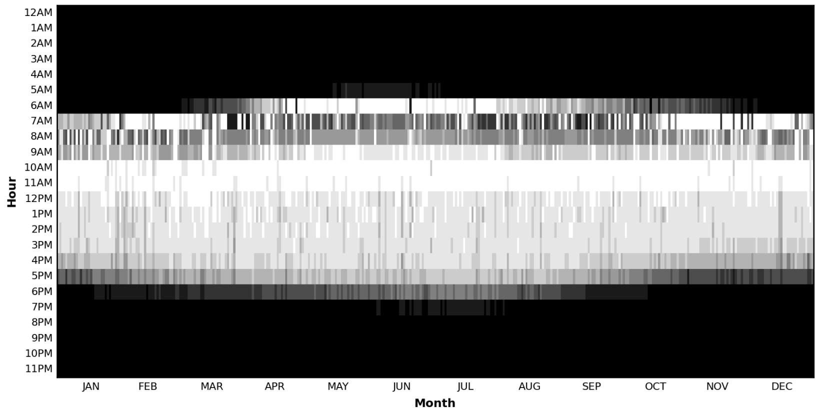


Percent Useful Illumination

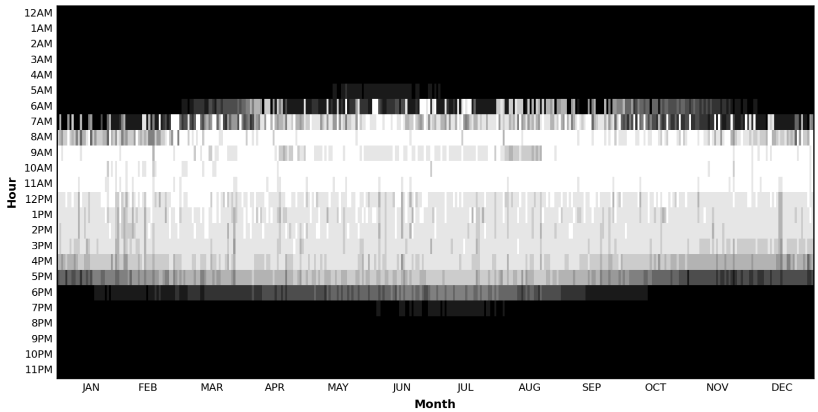
Add/B. 3.4.2 Hourly Useful Daylight Illuminance:: East Facade (Continued)

These Hourly graphs below show the percentage of the space that Achieve between 30 and 300 FC with fractional credit for values below 30 FC.

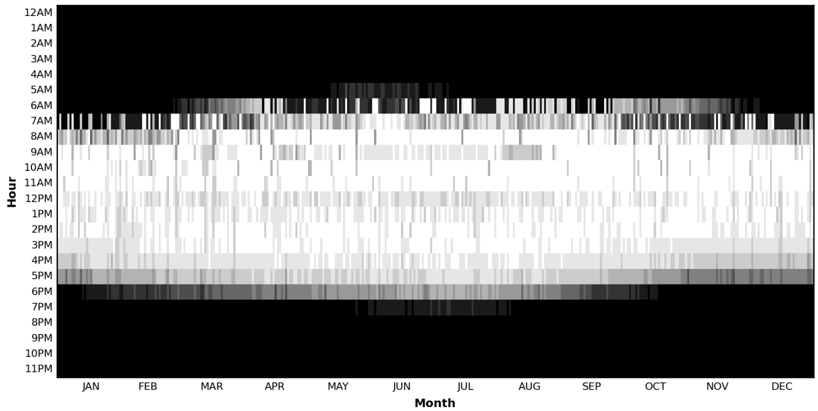
Fixed 45 Degree



Tilt Only



Auto Louver



Percent Useful Illumination

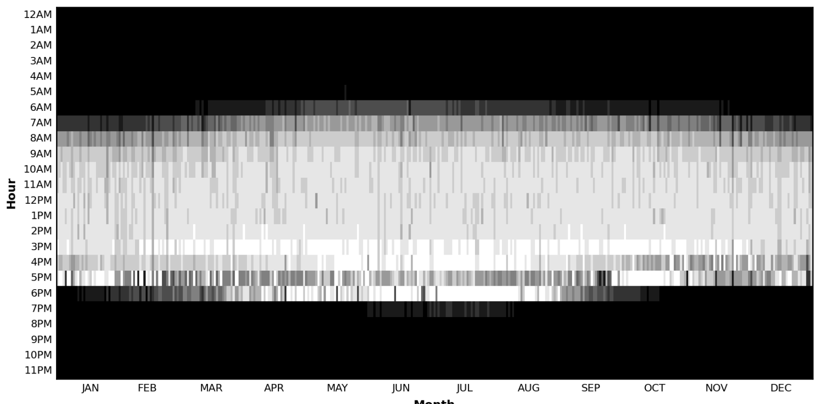
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

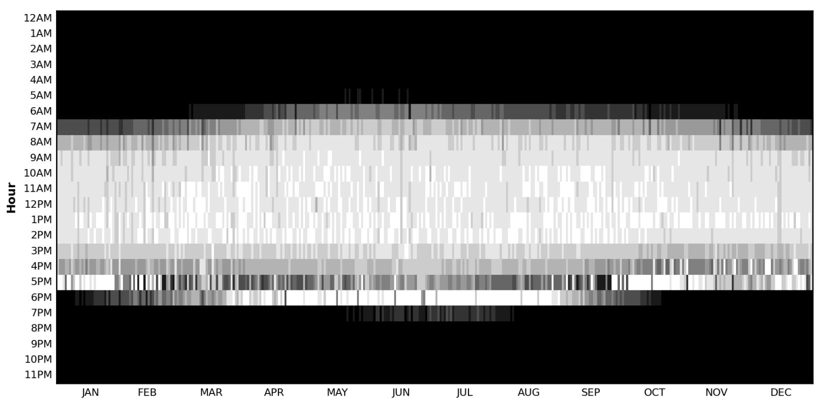
3.4. HOURLY USEFUL DAYLIGHT ILLUMINANCE

3.4.3 West Facade

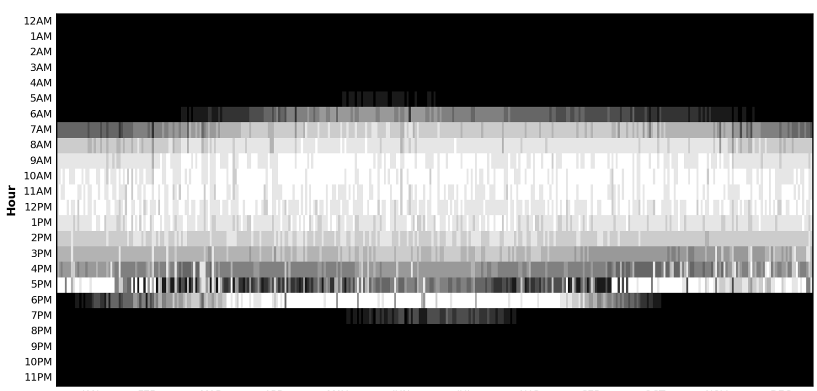
35 Degree Profile Angle

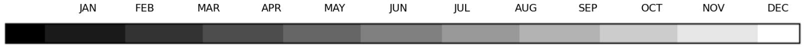


55 Degree Profile Angle



75 Degree Profile Angle

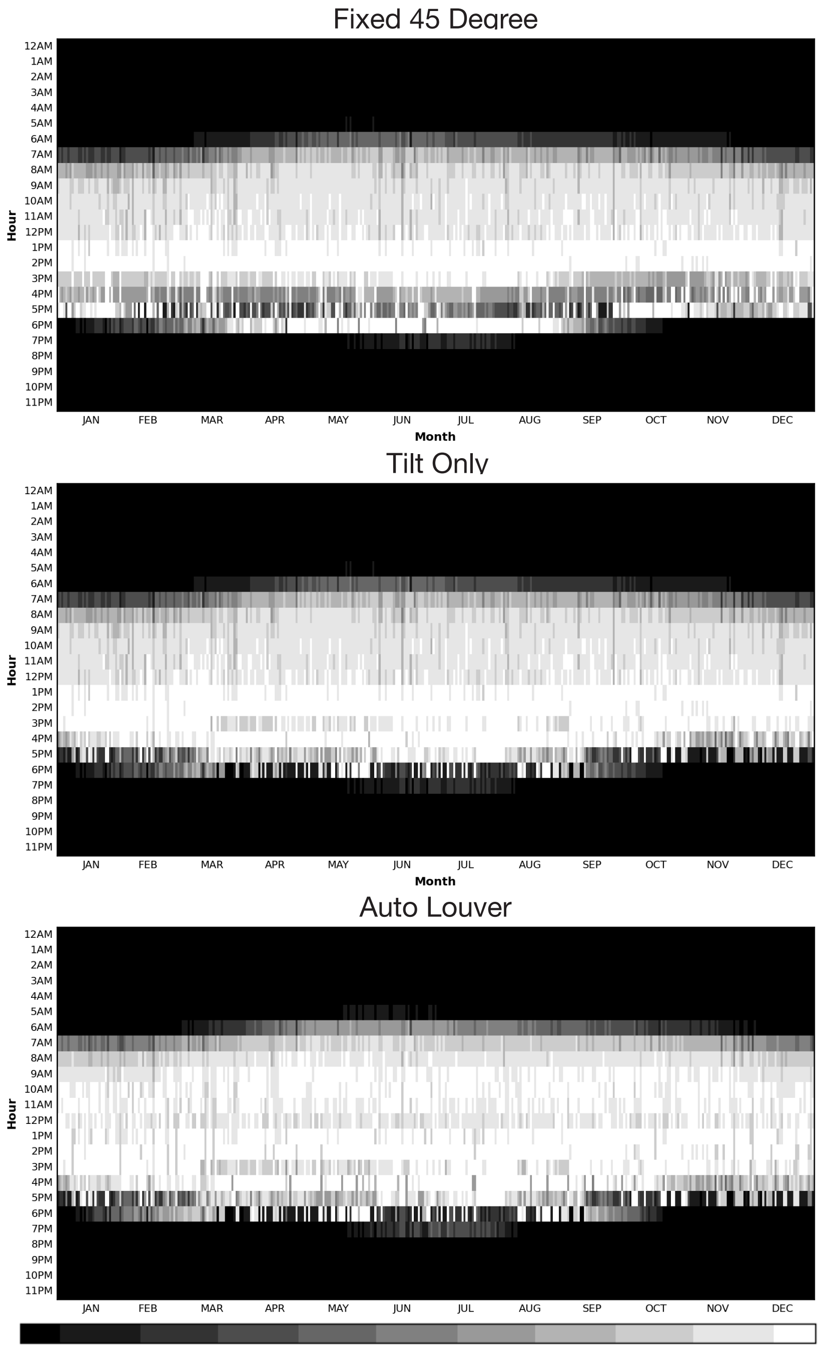




Percent Useful Illumination

Add/B. 3.4.3 Hourly Useful Daylight Illuminance:: West Facade (Continued)

These Hourly graphs below show the percentage of the space that Achieve between 30 and 300 FC with fractional credit for values below 30 FC.



Percent Useful Illumination

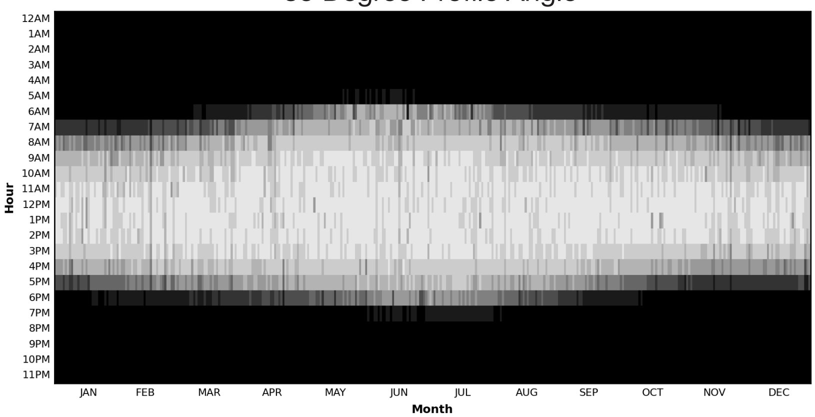
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

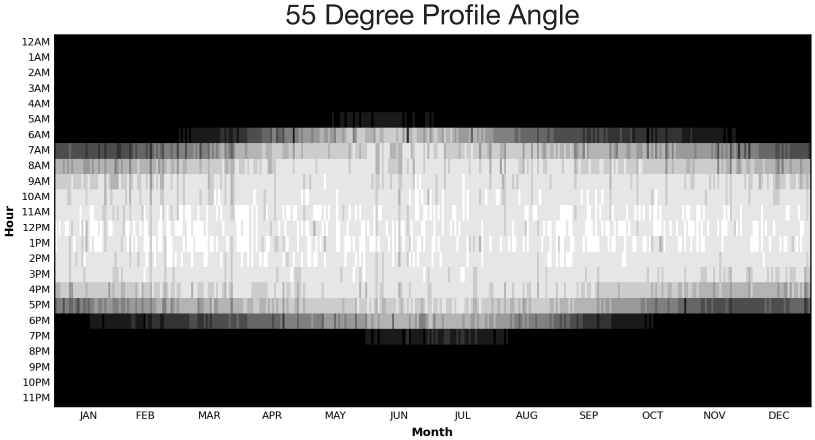
3.4. HOURLY USEFUL DAYLIGHT ILLUMINANCE

3.4.4 North Facade

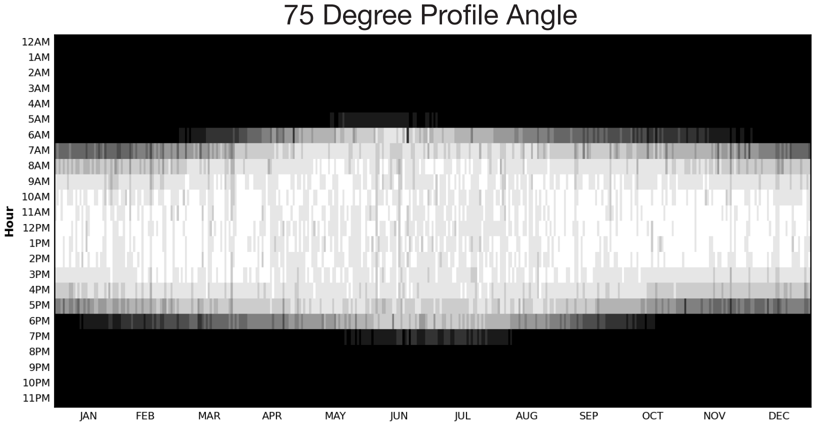
35 Degree Profile Angle

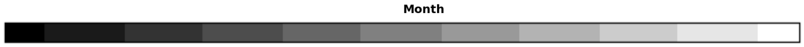


55 Degree Profile Angle



75 Degree Profile Angle

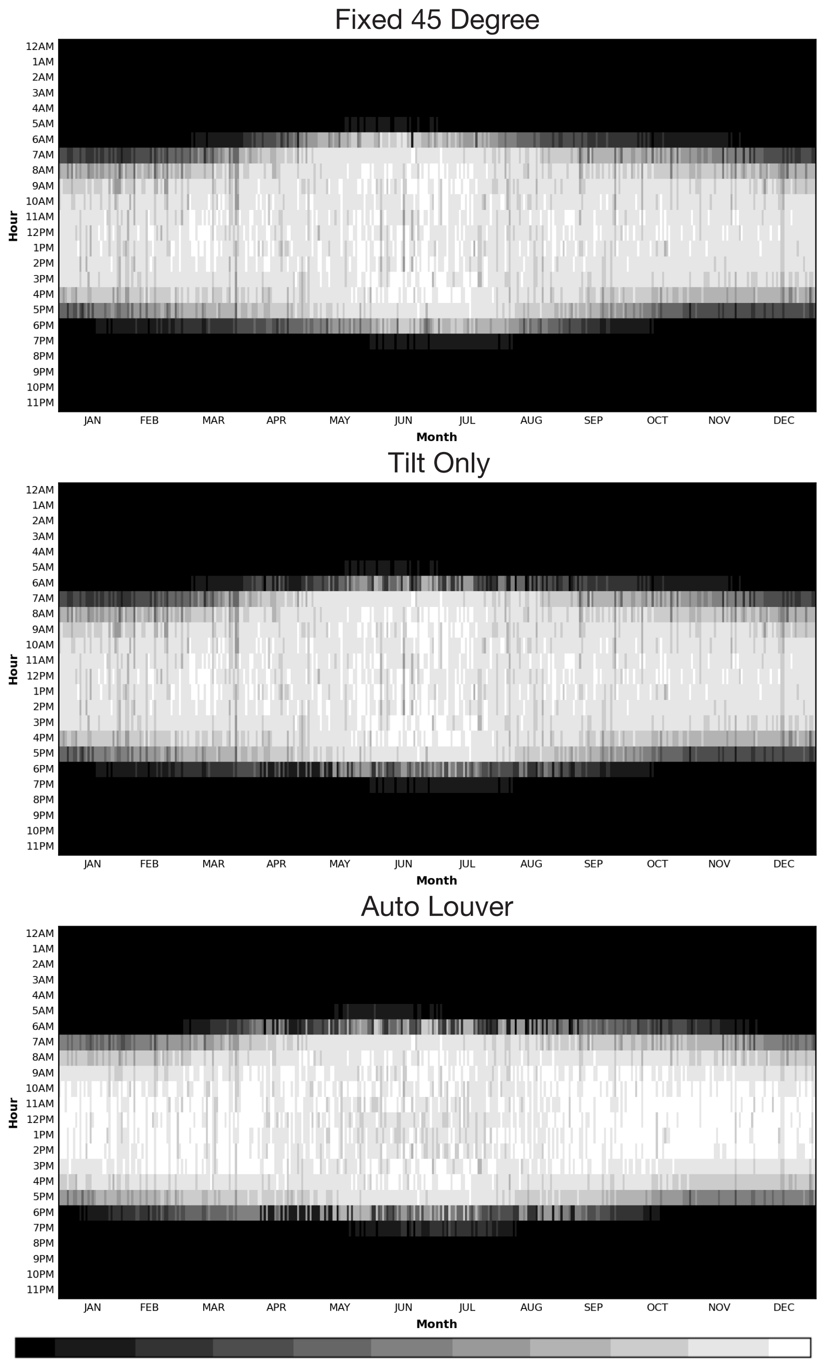




Percent Useful Illumination

Add/B. 3.4.4 Hourly Useful Daylight Illuminance:: North Facade (Continued)

These Hourly graphs below show the percentage of the space that Achieve between 30 and 300 FC with fractional credit for values below 30 FC.



Percent Useful Illumination

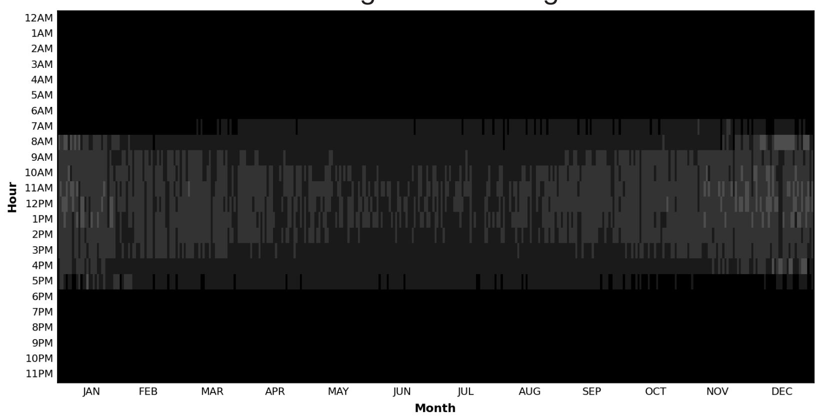
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

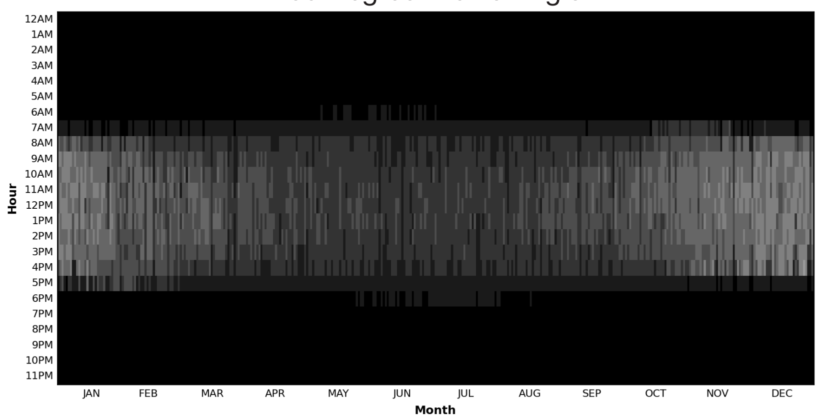
3.5. HOURLY EXCESSIVE ILLUMINANCE

3.5.1 South Facade

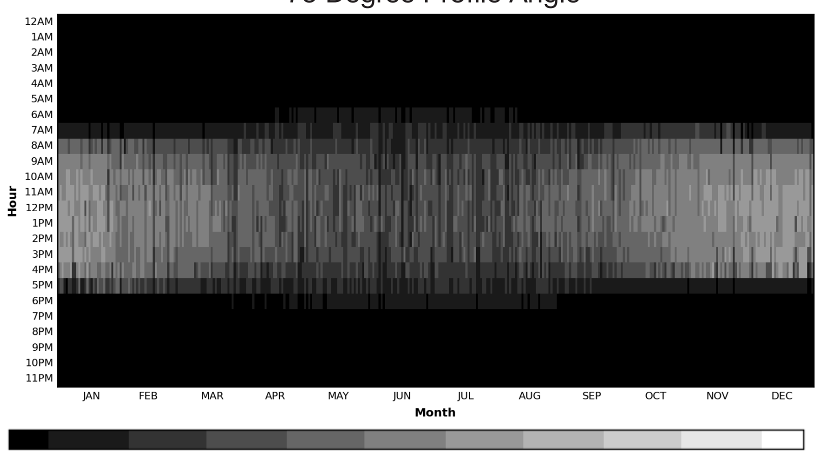
35 Degree Profile Angle



55 Degree Profile Angle



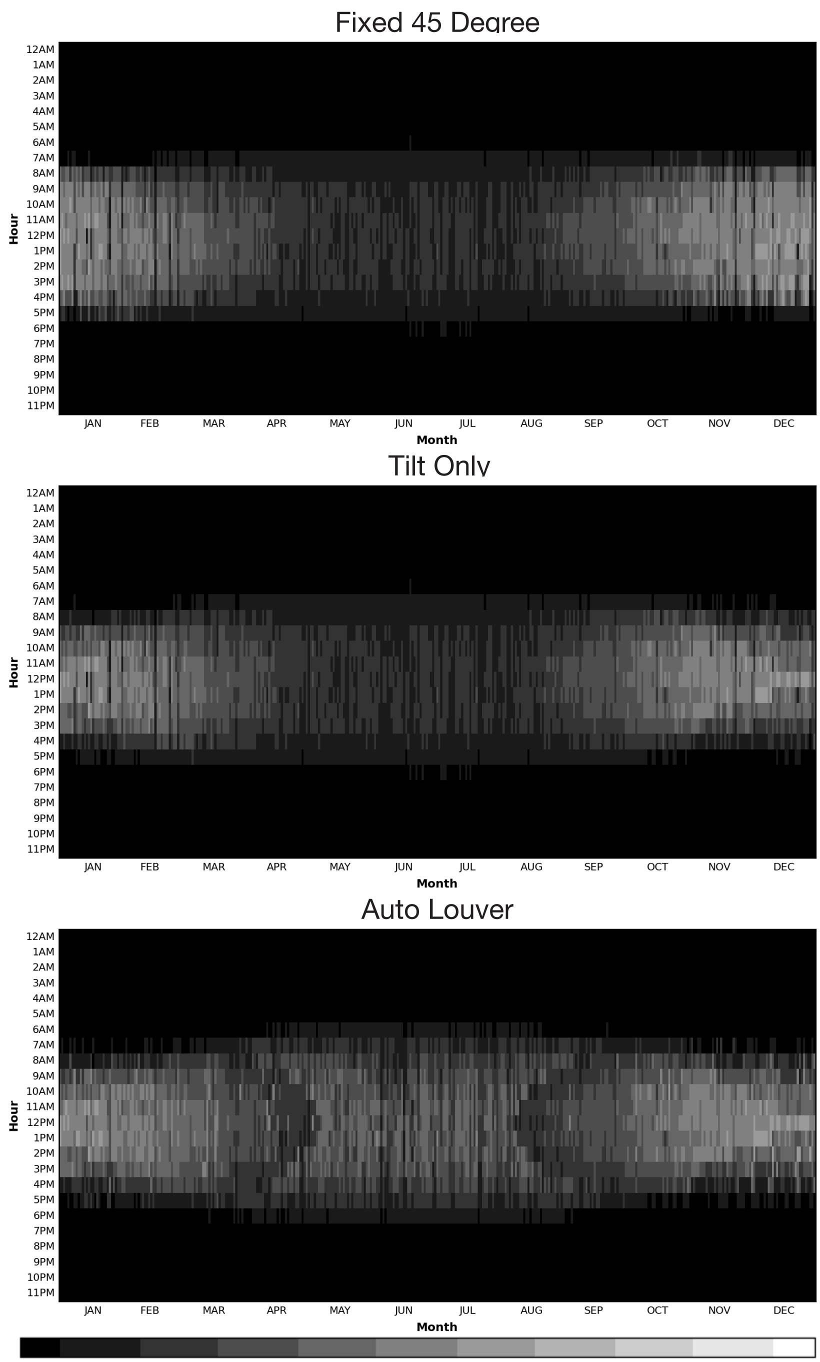
75 Degree Profile Angle



Percent Excessive Illumination

Add/B. 3.5.1 Hourly Excessive Illuminance:: South Facade (Continued)

These Hourly graphs below show the percentage of the space that exceeds 300 FC.



Percent Excessive Illumination

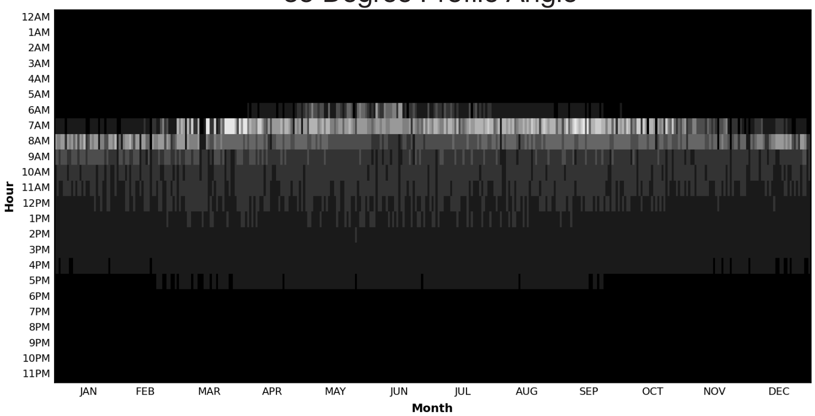
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

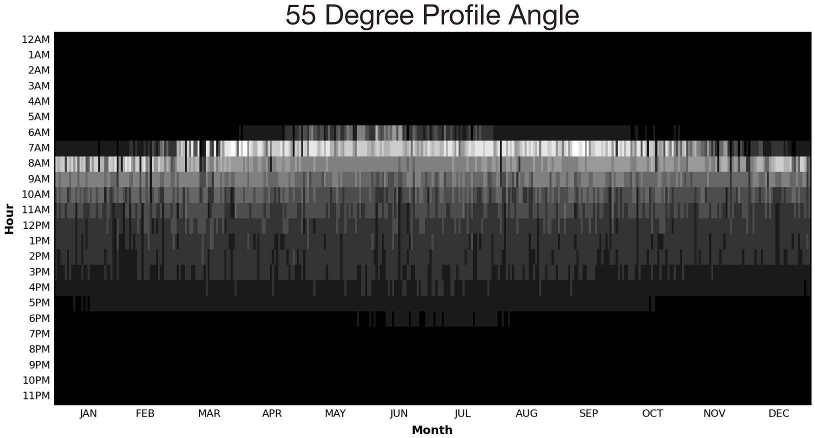
3.5. HOURLY EXCESSIVE ILLUMINANCE

3.5.2 East Facade

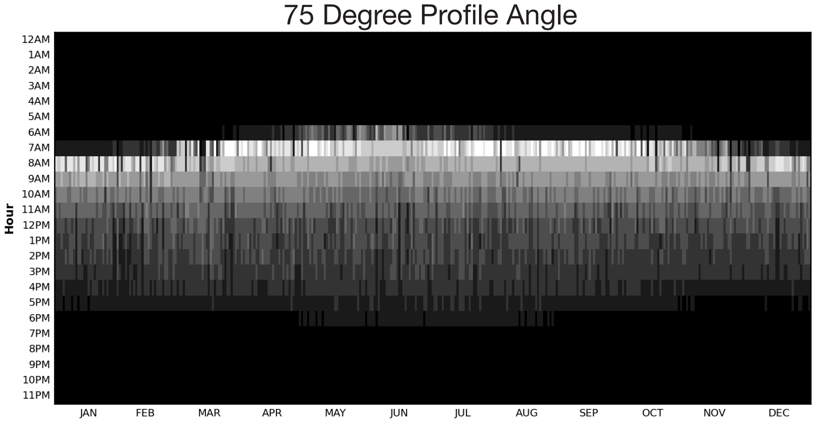
35 Degree Profile Angle

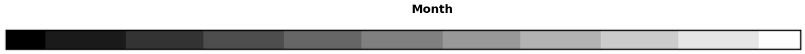


55 Degree Profile Angle



75 Degree Profile Angle



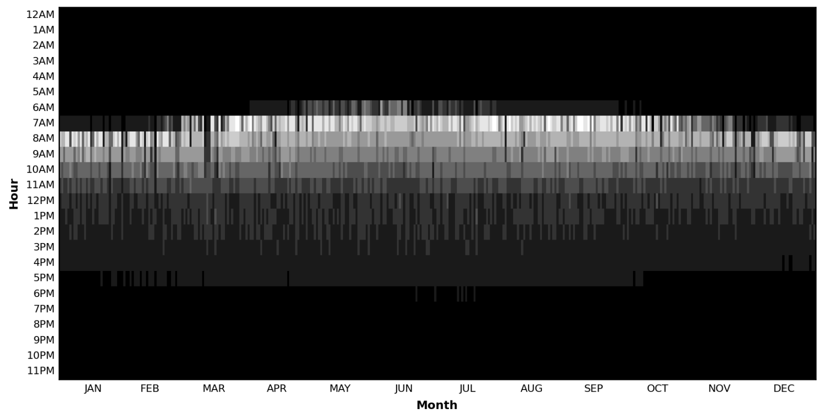


Percent Excessive Illumination

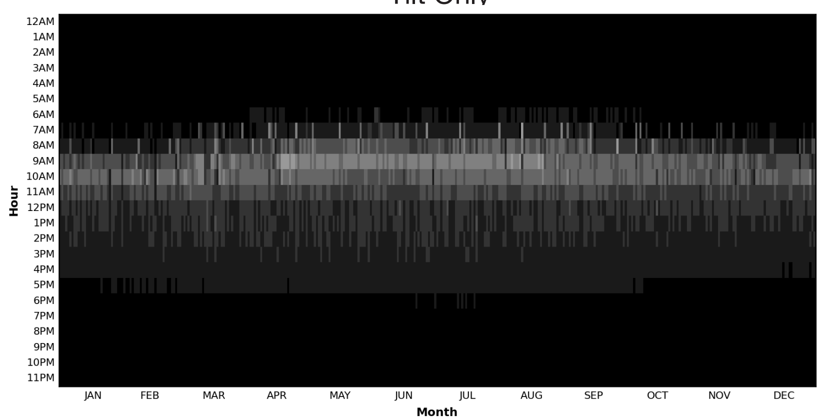
Add/B. 3. 5.2 Hourly Excessive Illuminance:: East Facade (Continued)

These Hourly graphs below show the percentage of the space that exceeds 300 FC.

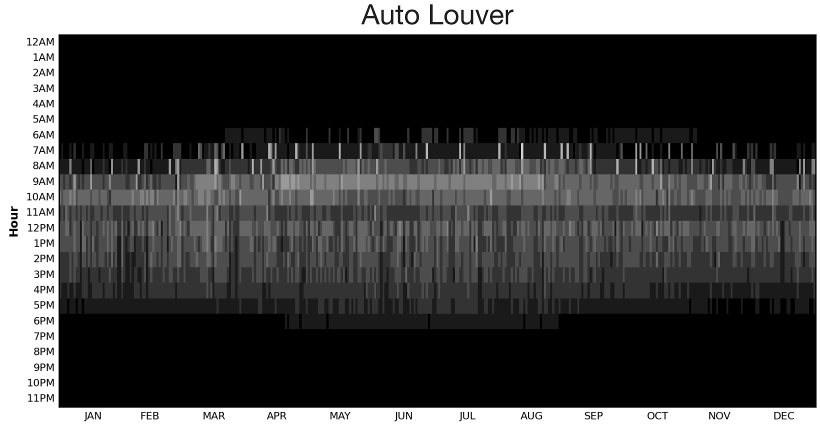
Fixed 45 Degree

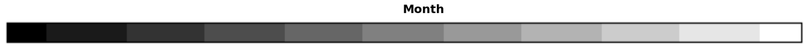


Tilt Only



Auto Louver





Percent Excessive Illumination

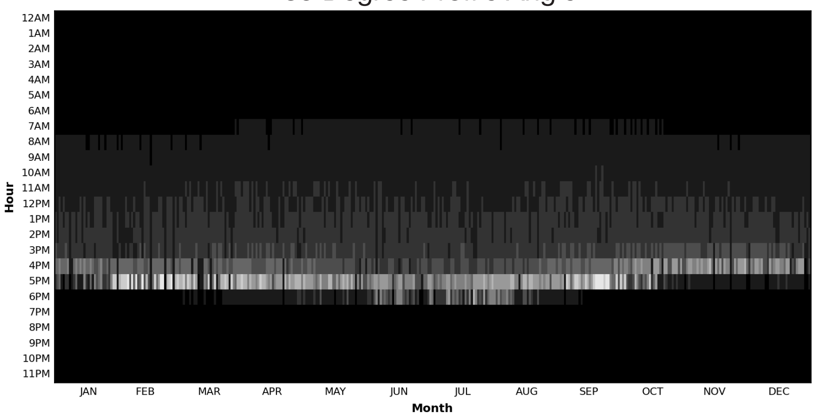
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

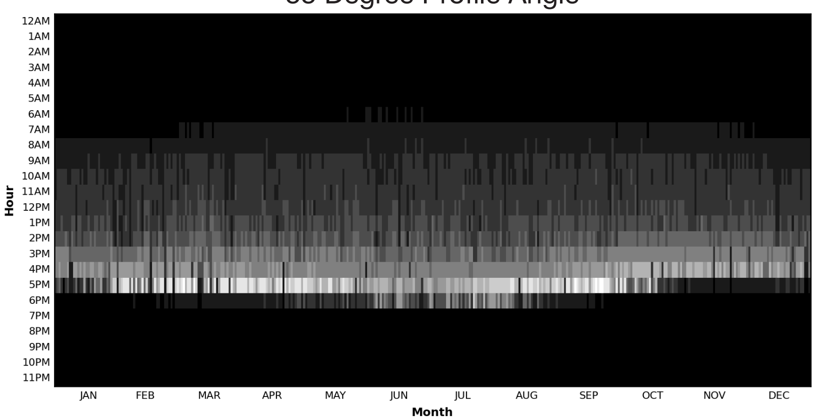
3.5. HOURLY EXCESSIVE ILLUMINANCE

3.5.3 West Facade

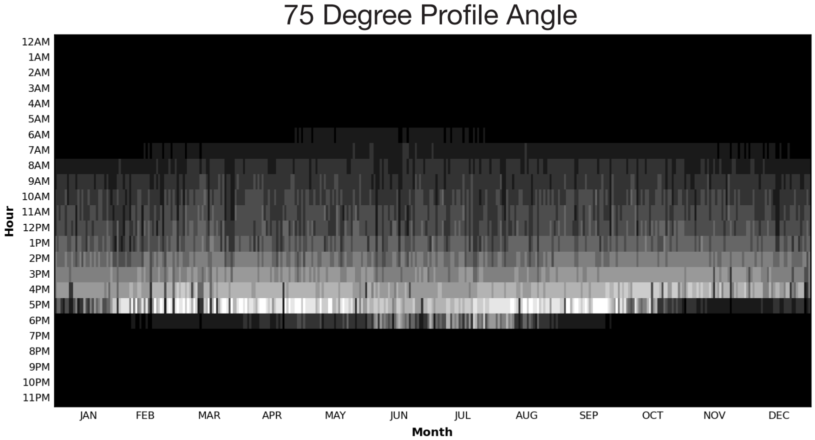
35 Degree Profile Angle

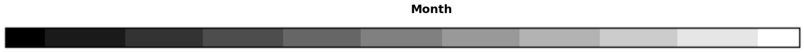


55 Degree Profile Angle



75 Degree Profile Angle

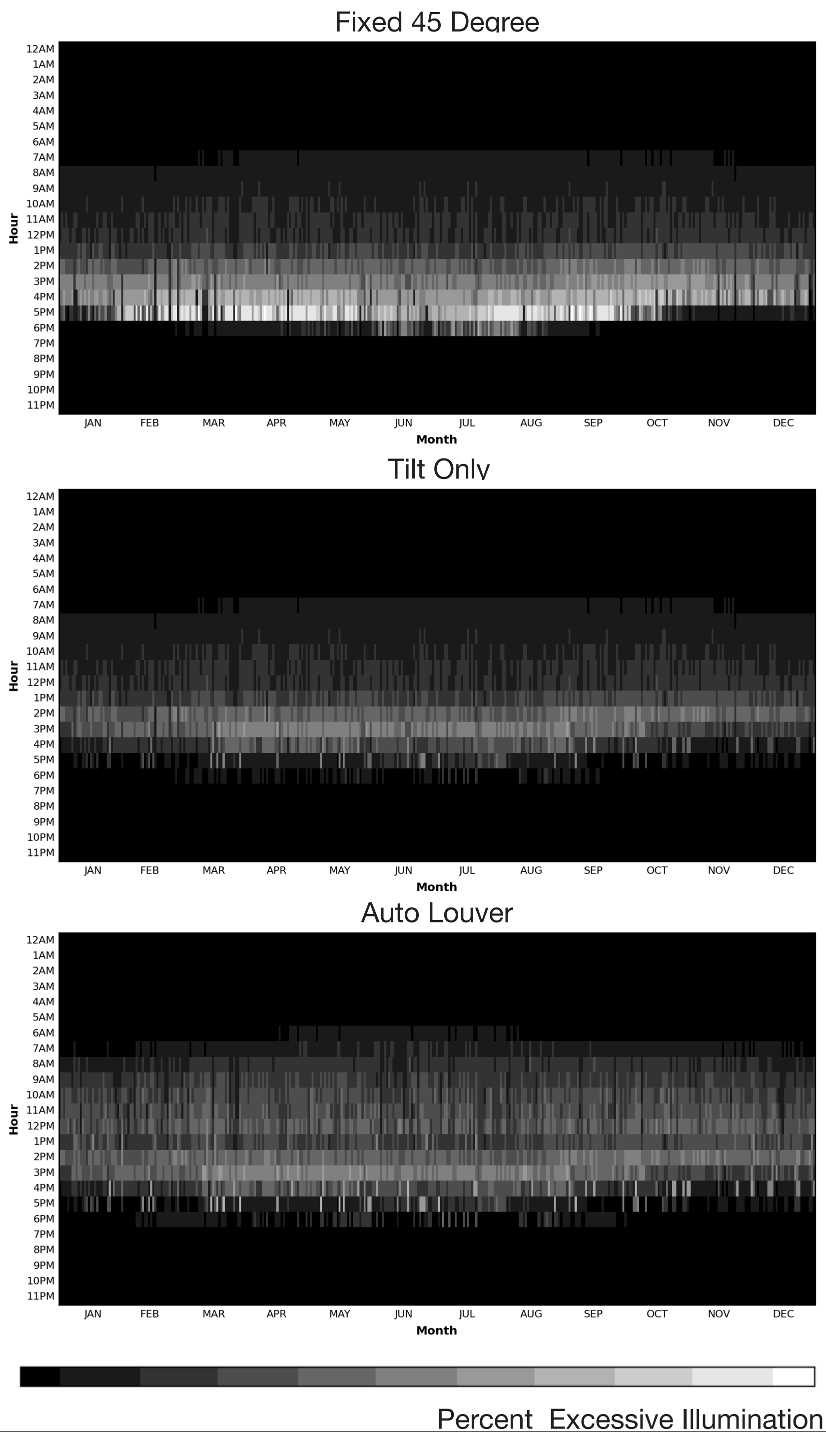




Percent Excessive Illumination

Add/B. 3.5.3 Hourly Excessive Illuminance:: West Facade (Continued)

These Hourly graphs below show the percentage of the space that exceeds 300 FC.



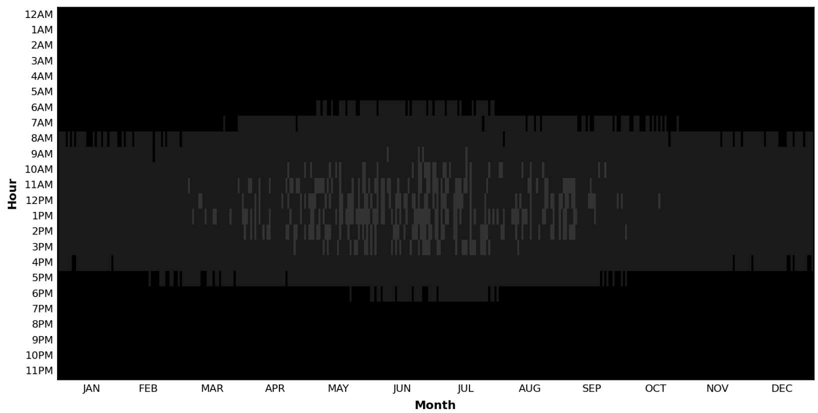
Add/B. DAYLIGHTING AND SHADING STUDIES

3. OPTIMIZING SOLAR CONTROL

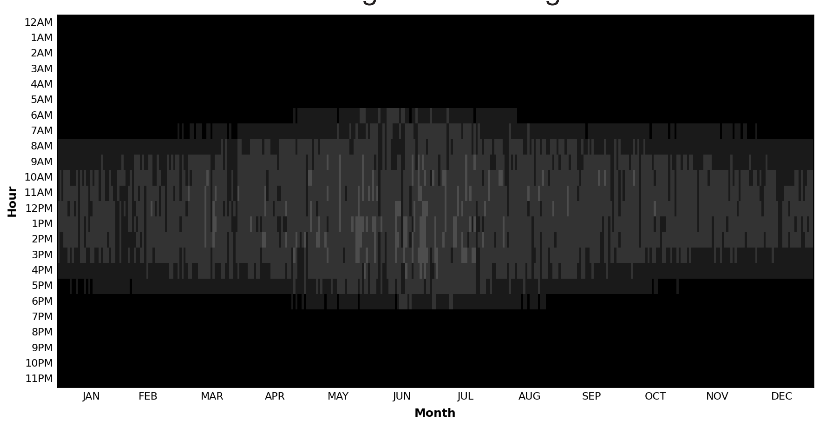
3.5. HOURLY EXCESSIVE ILLUMINANCE

3.5.4 Nortth Facade

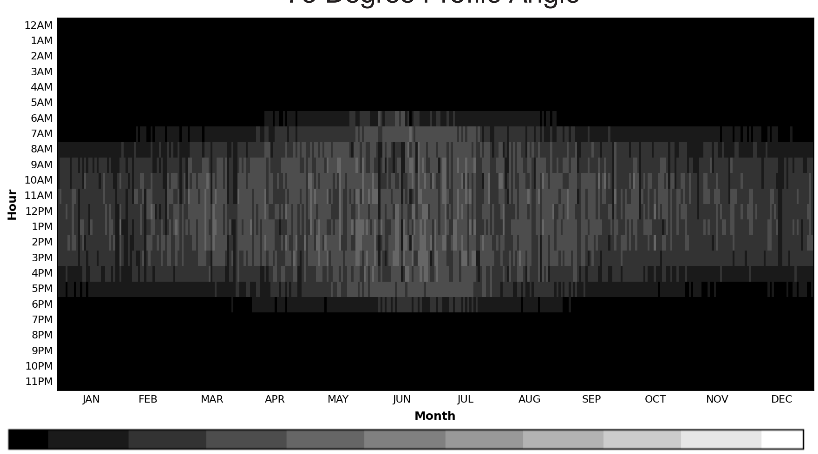
35 Degree Profile Angle



55 Degree Profile Angle



75 Degree Profile Angle

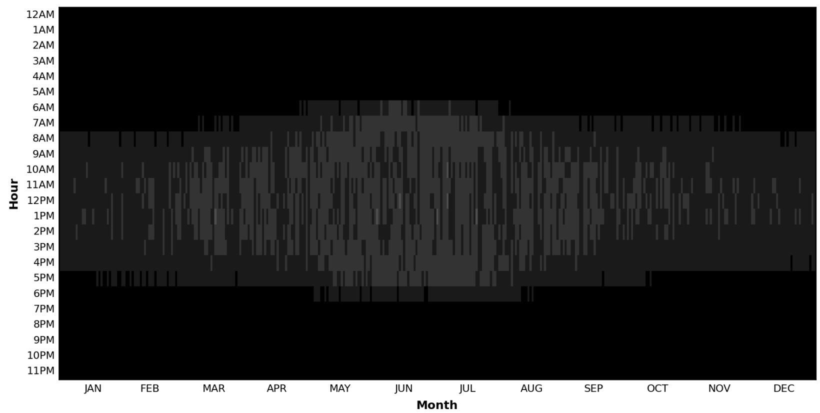


Percent Excessive Illumination

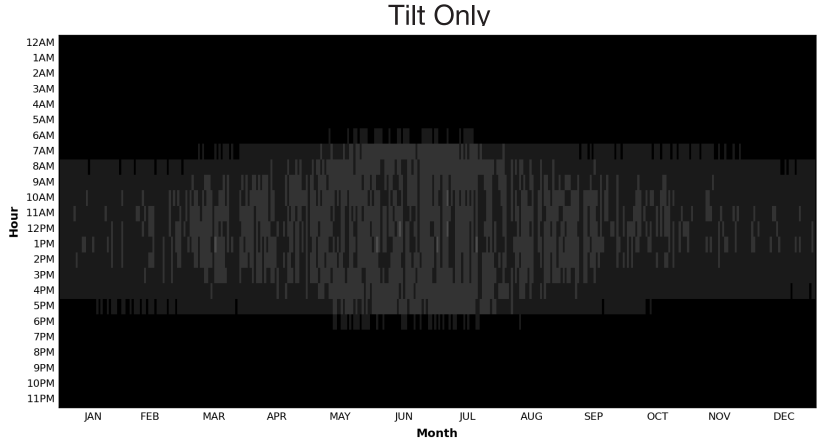
Add/B. 3.5.4 Hourly Excessive Illuminance:: North Facade (Continued)

These Hourly graphs below show the percentage of the space that exceeds 300 FC.

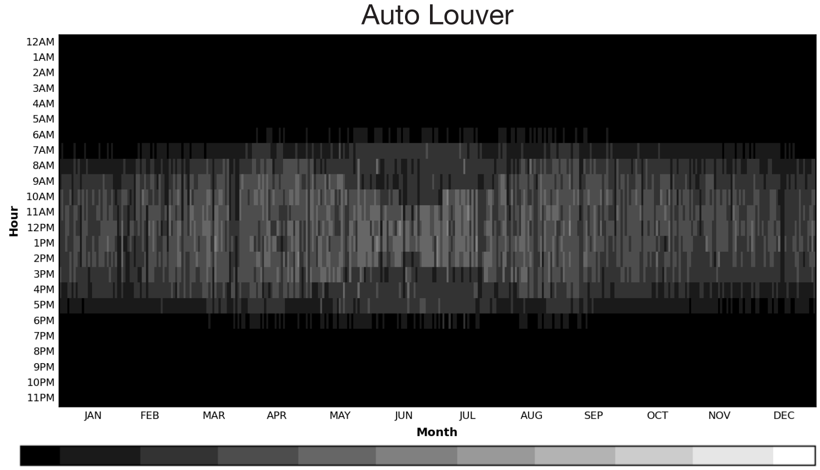
Fixed 45 Degree



Tilt Only



Auto Louver



Percent Excessive Illumination

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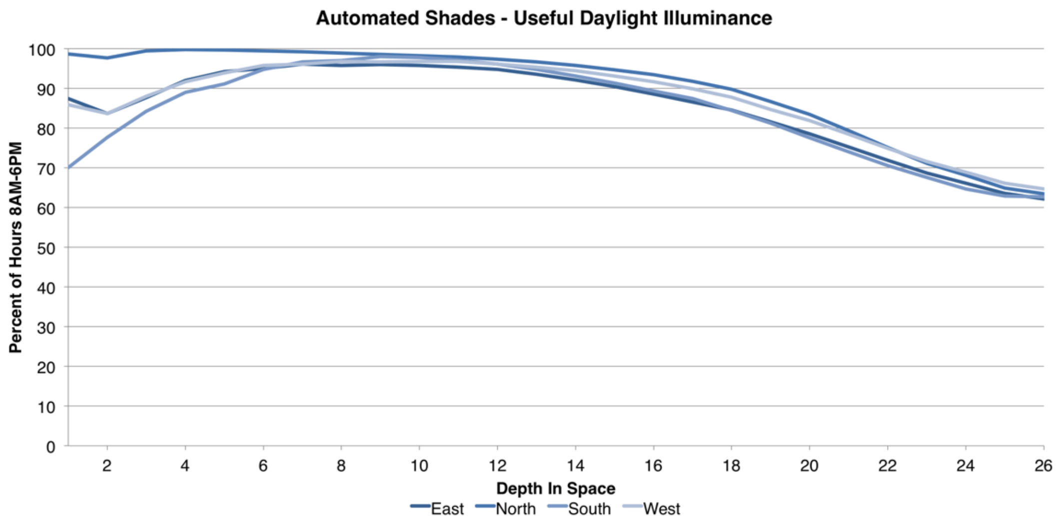
4. DAYLIGHTING AND VISUAL COMFORT ANALYSIS

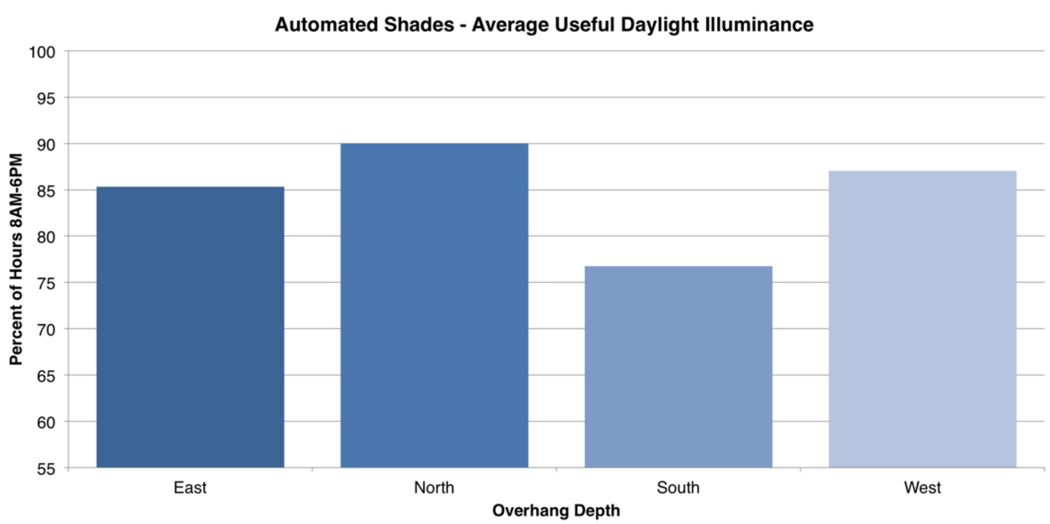
Add/B. DAYLIGHTING AND SHADING STUDIES

4. DAYLIGHTING AND VISUAL COMFORT ANALYSIS

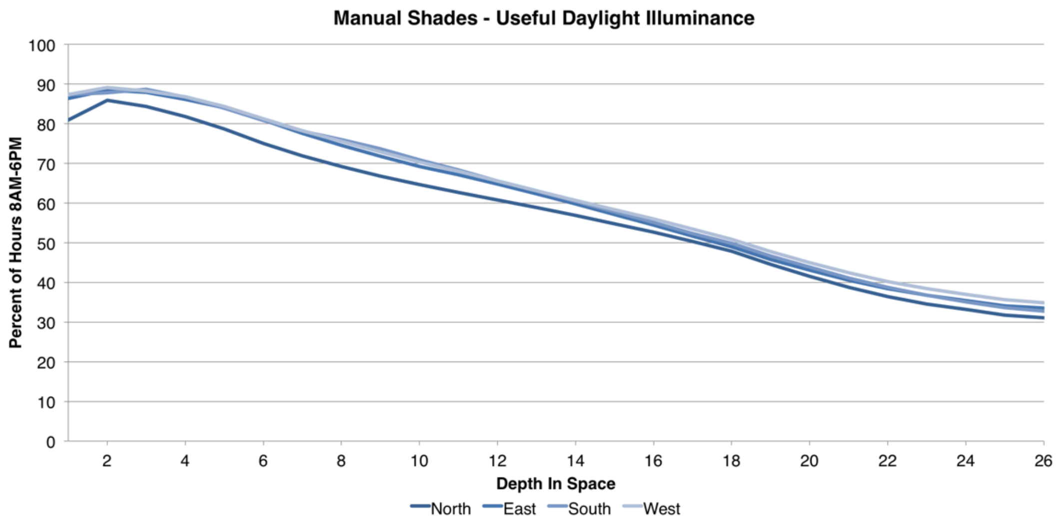
4.1. SUMMARY OF RESULTS

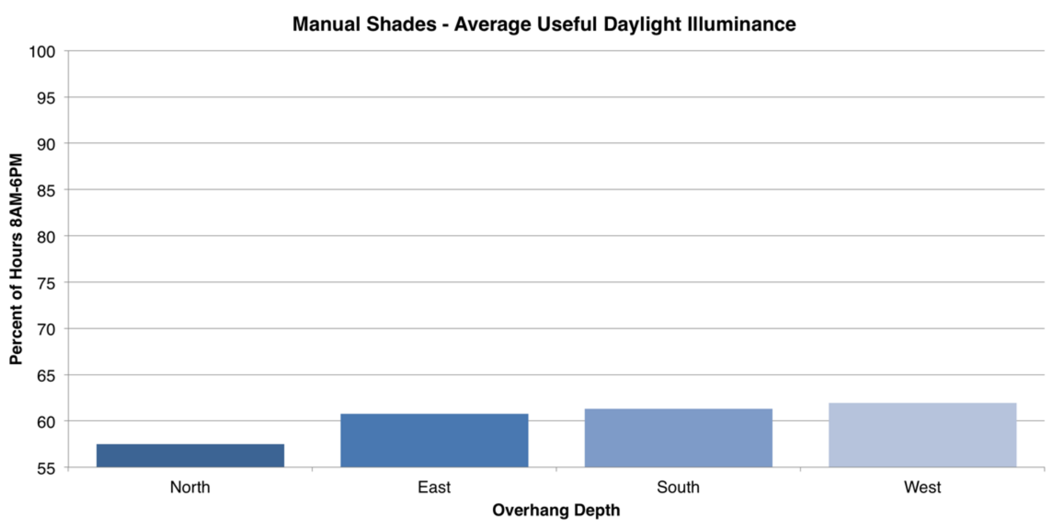
Roller Shades with 65 Degree Overhang:: Manual vs/ Automated





Add/B. 4.1. Summary of Results:: Roller Shades with 65 Degree Overhang:: Manual vs/ Automated (Continued)



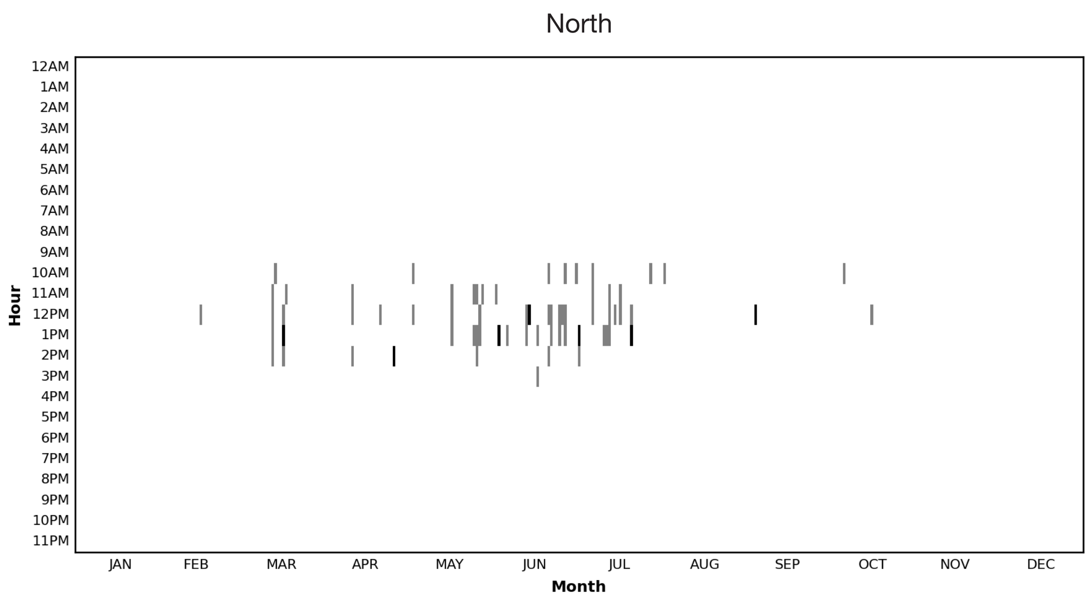


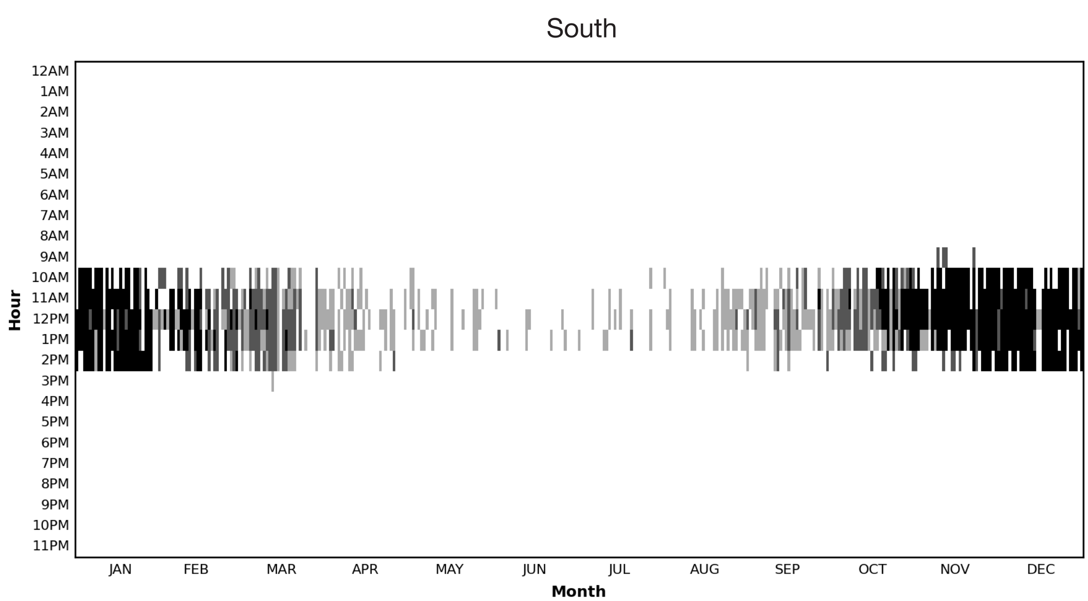
Add/B. DAYLIGHTING AND SHADING STUDIES

4. DAYLIGHTING AND VISUAL COMFORT ANALYSIS

4.2. AUTOMATED SHADE PROTOCOLS BY ORIENTATION

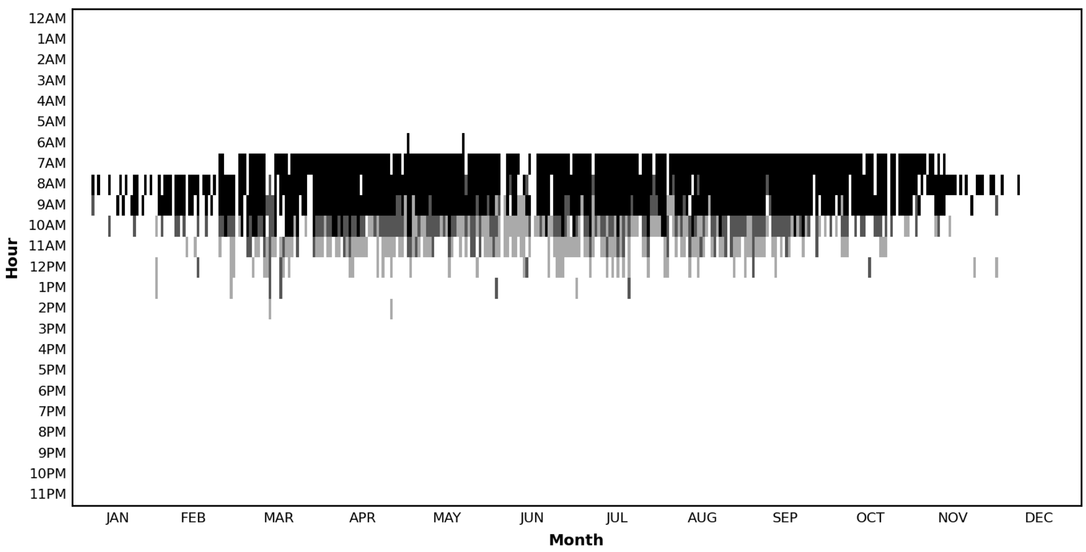
65 Degree Overhang



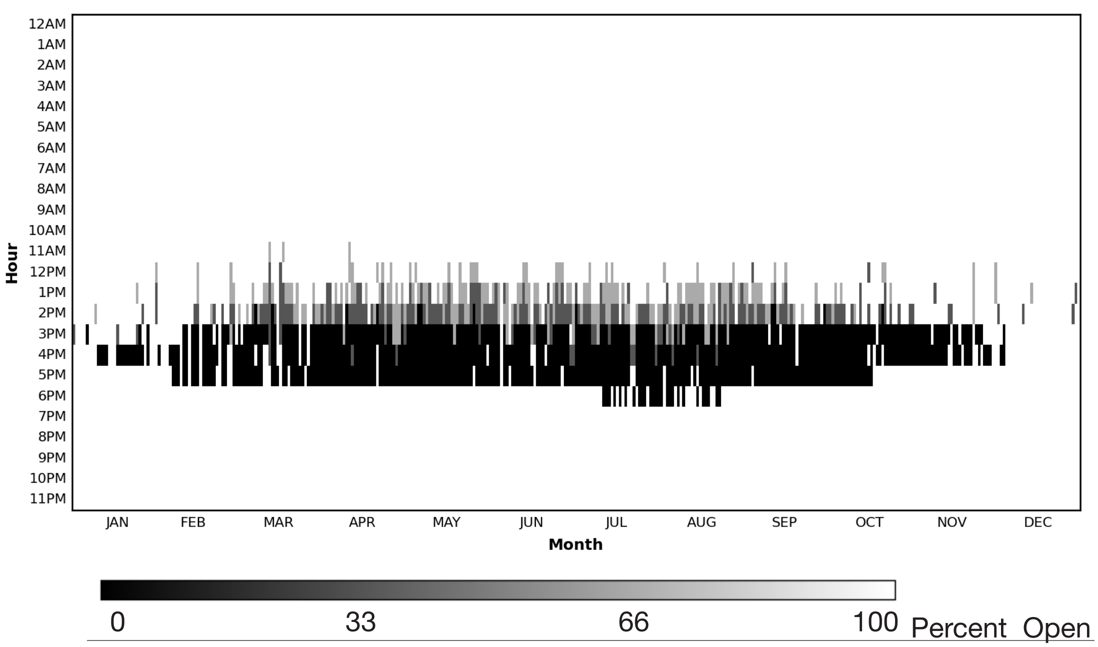


Add/B. 4.2 Automated Shade Protocols By Orientation:: 65 Degree Overhang (Continued)

East



West



Add/B. DAYLIGHTING AND SHADING STUDIES

4. DAYLIGHTING AND VISUAL COMFORT ANALYSIS

4.3. HUMAN RESPONSE RENDERINGS

65 Typical Classroom Facing West

With Shades Lowered for sky brightness

Typical Sunny Sky March 2 pm

Add/B. 4.3 Human Response Renderings:: Typical Classroom Facing West (Continued)

The perspective view is processed with an algorithm that mimics human visual acuity, and is tone mapped to simulate the saturation, exposure, and possible veiling glare a human eye would see.

Without shades

Typical Sunny Sky March 2 pm

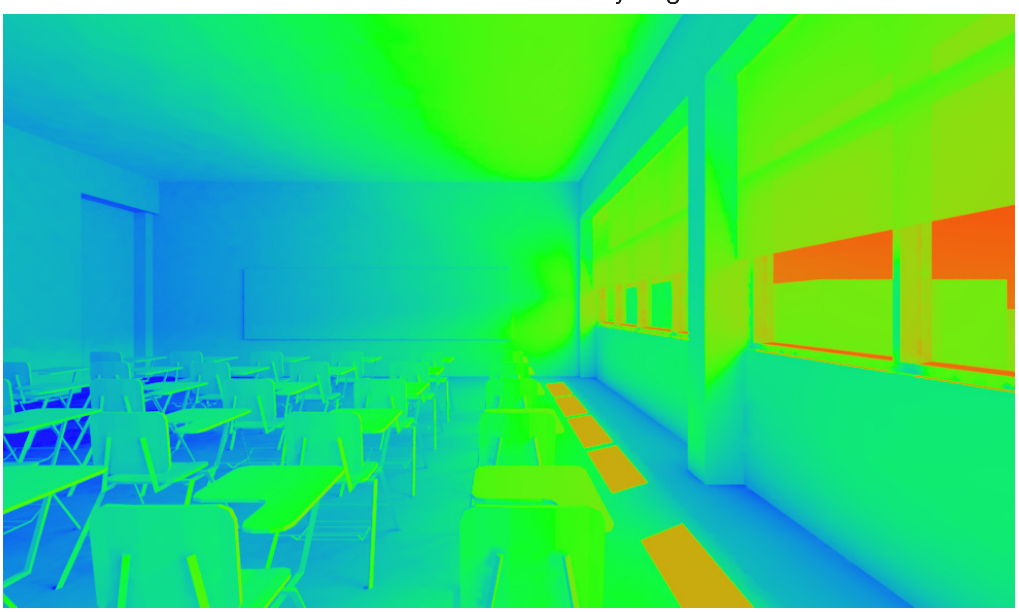
Add/B. DAYLIGHTING AND SHADING STUDIES

4. DAYLIGHTING AND VISUAL COMFORT ANALYSIS

4.4. FALSECOLOR LUMINANCE

Typical Classroom Facing West

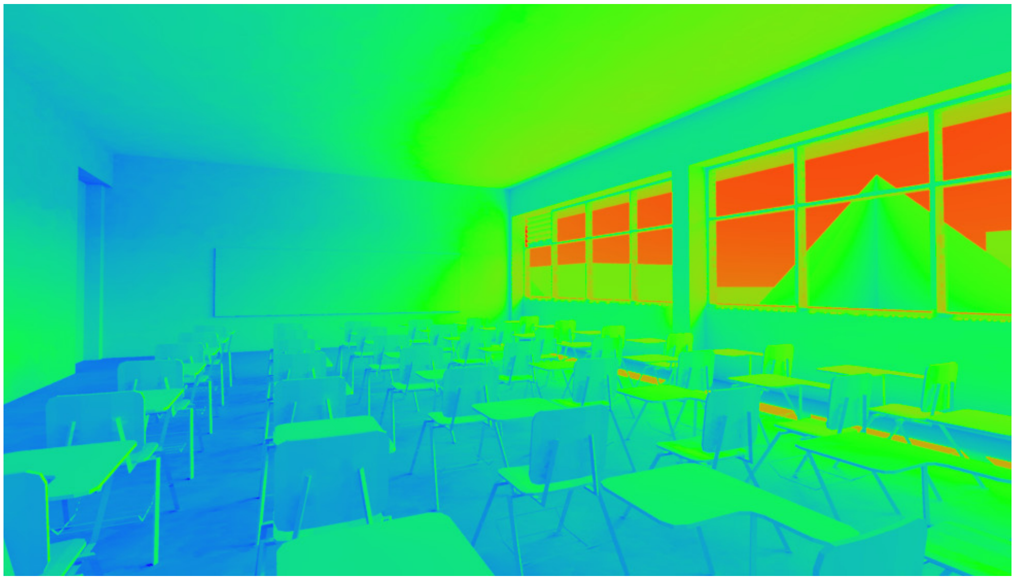
With Shades Lowered for sky brightness



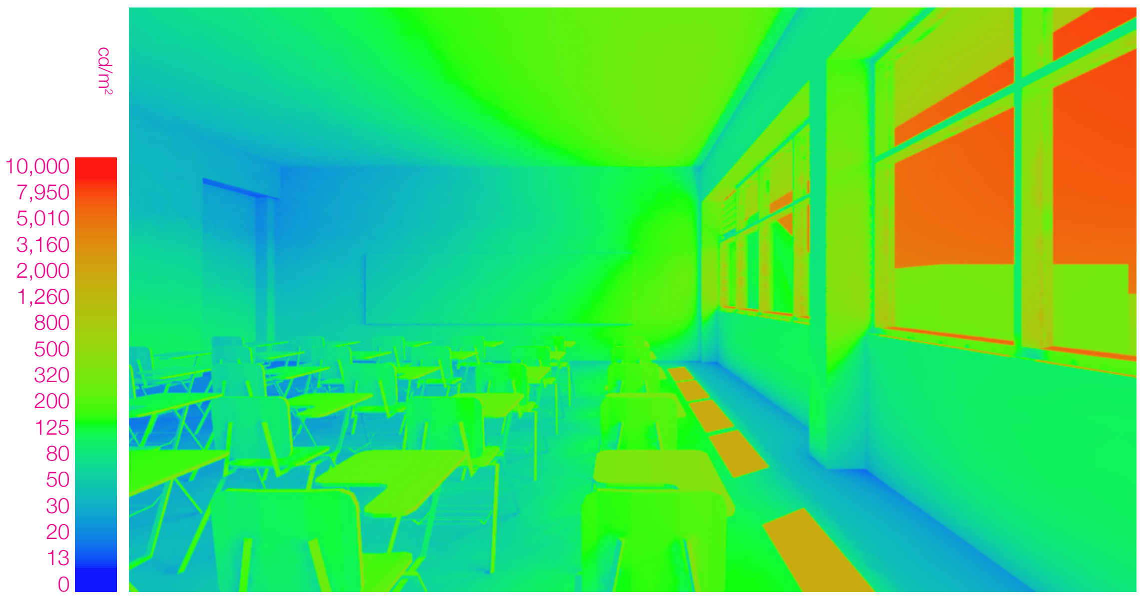
Typical Sunny Sky March 2 pm

Add/B. 4.4 Falsecolor Luminance:: Typical Classroom Facing West (Continued)

The falsecolor luminance map shows the rendered view on a color scale to communicate surface brightness. The scale is set to approximate the range of values an occupant can comfortably handle while in a daylighted space. As a point-in-time metric (rather and annualized data), this is a useful tool to identify potential glare sources and the experiential quality of the luminous environment. These luminance maps are shown in candelas per square meter (cd/m2), also known as nits. As reference, a new LCD computer monitor has a peak brightness of approximately 300 cd/m2.



Without shades



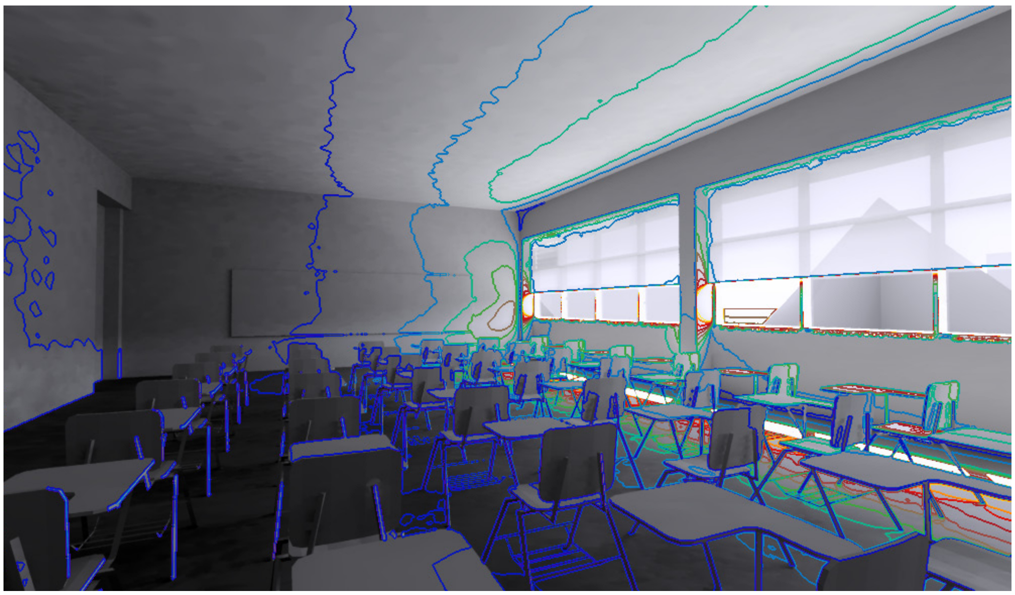
Typical Sunny Sky March 2 pm

Add/B. DAYLIGHTING AND SHADING STUDIES

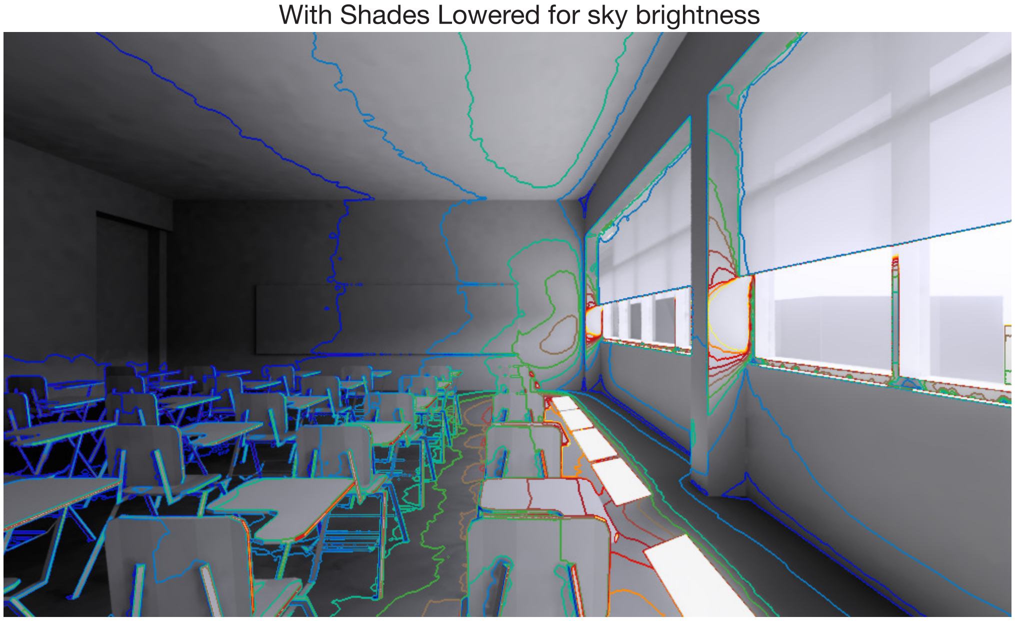
4. DAYLIGHTING AND VISUAL COMFORT ANALYSIS

4.4. FALSECOLOR LUMINANCE

Typical Classroom Facing West



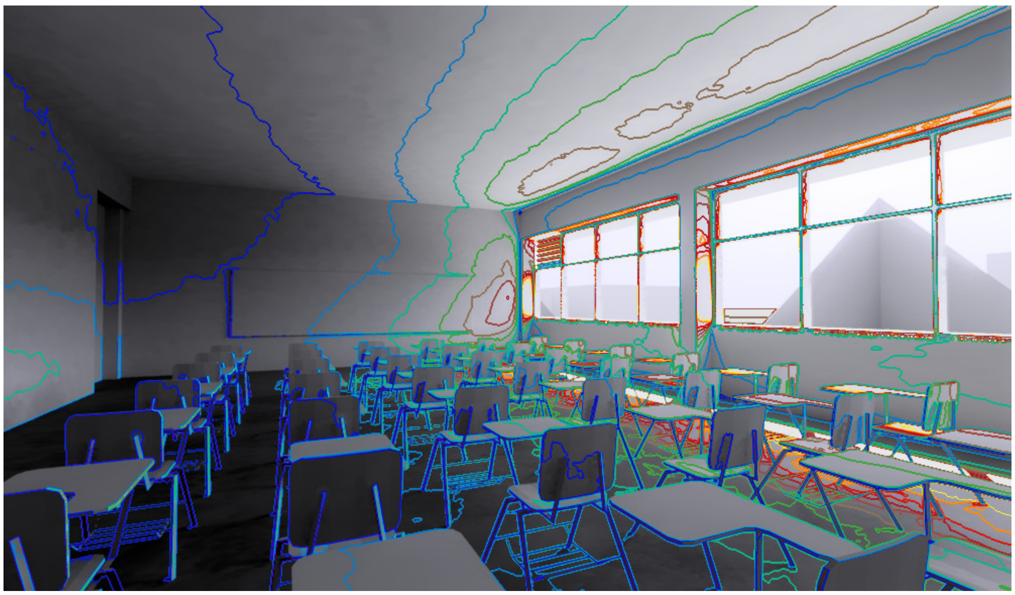
With Shades Lowered for sky brightness



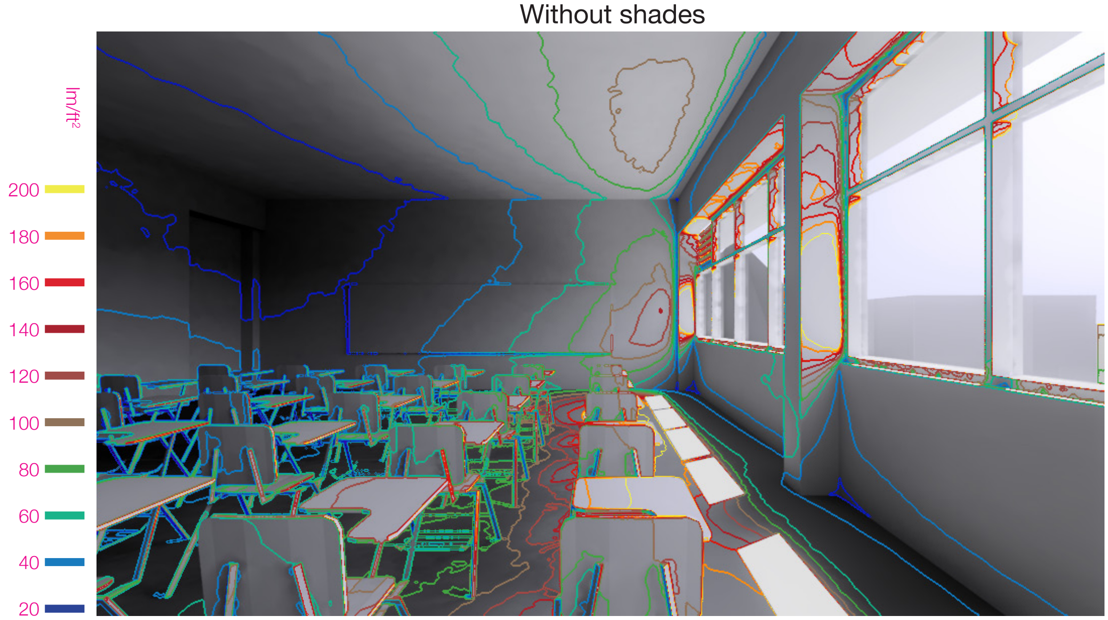
Typical Sunny Sky March 2 pm

Add/B. 4.4 Falsecolor Luminance:: Typical Classroom Facing West (Continued)

The illuminance levels are shown as contour lines in perspective views. These contour lines show illuminance levels in footcandles, and as a contour map shows changes in elevation, these show changes in illuminance levels throughout the space. As opposed to luminance which measures surface brightness, illuminance measures how much light is falling on a surface.



Without shades



Typical Sunny Sky March 2 pm

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Add/C. HVAC AND THERMAL COMFORT STUDIES

1. EXECUTIVE SUMMARY

To understand occupant comfort, we initially assume there are no HVAC systems and study only the passive ability of the building to provide comfort. These models predict the number of occupied hours that occupants will feel comfortable without mechanical conditioning (HVAC autonomy).

Human comfort depends on a host of conditions. In this study, occupant comfort is calculated as defined by the ASHRAE 55 Adaptive Thermal Comfort Standard. Indoor operative temperatures range between 65.8°F - 86.1°F (18.78°C - 30.1°C). This assumes that occupants will wear clothing appropriate to the weather. Furthermore, air movement is assumed to be less than 40 fpm, as this is the threshold for comfort cooling due to air movement.

We use two typical south facing classrooms as the base case, and assume the most basic usual envelope for existing buildings on campus. Observing the comfort load factors for each space, we determined the priorities to improve thermal comfort which include increasing natural ventilation, reducing internal heat from lighting, reducing the heat gain or loss through glazing areas, and increasing the thermal mass effect. From these, we could identify how much comfort can be improved relying only on passive strategies and building design decisions. By parametrically modeling envelope improvements in an Additive fashion we could quantify the relative effect of each measure.

In summary, the factors associated with decreased comfort in this analysis are the solar radiation through the windows and internal loads (heat released to the space by the occupants as well as from lighting and equipment).

The analysis also indicates that ventilation and thermal mass (interior floor and wall conduction) improve building thermal performance and thus improving comfort and reducing future HVAC loads. Ventilation introducing outside air when heat is building up in the space due to high internal loads or solar radiation, can prevent overheating. Thermal mass in the floor, such as a concrete slab contributes to comfortable

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

conditions by absorbing heat during the day and releasing it at night.
We identified a series of customized suite of improvements that directly Address the potential for overheating and correspond to typical UHM retrofit project scopes, including future deferred maintenance projects on the UHM campus. These suite models were then run for each orientation and then for offices and laboratories. The studies present the following cumulative scenarios:

- Typical Existing: Base case with assumptions for envelope features and internal loads usually found in existing campus buildings.

- Typical with Improved Windows: If a retrofit project is approved, window improvement opportunities should be considered by the design team in an effort to pursue holistic interventions that Achieve the largest performance benefits. These improvements include good glazing, exterior shading and window operability.

- Minimum Suite: reducing the internal loads by using efficient lighting and daylight controls is the most critical retrofit need in existing UHM buildings.

- Improved Suite: roofs are upgraded to fulfill the prescriptive IECC 2015 requirements.

- Code Suite: prescriptive IECC 2015 requirements for walls are also included. This suite represents the most ambitious and realistic retrofit interventions in existing buildings, affecting all exterior envelope surfaces and lighting loads.

- Ideal: these models represent ideal assumptions for new buildings, and include exposing thermal mass to all interior surfaces.

- Ideal with Smart Ventilation: these models assume that two Additional air changes per hour (ACH) are introduced as needed (either by natural ventilation or fan

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

assistance) to the Ideal Suite described above.

In this executive summary, the results have been averaged for all four orientations, and summarized by building type. Tables describing the hours of overheating for both the whole year and occupied hours only, with and without ceiling fans are included. In Addition, hourly graphs representing degrees from comfort for the top floor spaces for all hours of the year are presented, summarizing graphically the effect of the improvement strategies. These results have been used to validate and inform the metrics included as requirements in the UHM Building Design and Performance Standards.

Observing the thermal comfort results, the main recommendations for classroom and offices are::

- Ceiling fans (to provide air motion) and operable windows are critical (as they allow the adaptive comfort model and bring in 1ACH of outside air beyond breathing requirements).
- For all orientations, good glazing and shading, in Addition to efficient lighting with controls (both occupancy and daylight) should be part of every retrofit project, if possible.
- New buildings should be designed to include as much thermal mass and ventilation as possible (ideally, to achieve 2 or 3 ACH minimum).
- Design teams that do not have the capacity to replicate the studies presented in this section are encouraged to include the model assumptions that Achieve the highest building performance results as part of the specifications for their projects (prescriptive recommendations in the UHM BDP Standards).

Even if laboratory buildings do not have the same potential to be passively conditioned as the other building types, introducing the envelope improvements and reductions in internal loads would still have a significant impact on building performance.

This Addendum also includes the detailed results from every simulation, with graphs for operative temperatures and degrees from comfort for each hour of the year, cumulative bin summaries for comfort results and comfort load factors for both top and bottom floors, for each building type and orientation. Design teams are encouraged to selectively look at the results that are relevant to their project and provide their own

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

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Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

a. Thermal Comfort and HVAC Autonomy:: Classroom Results

On average, for all orientations, classrooms in existing UHM buildings (Typical Existing) need HVAC conditioning during all occupied hours. By improving the windows, bringing in a minimum amount of outside air (1ACH) and installing ceiling fans (Typical with Window Improvements), occupants in these spaces would feel too warm during 49% of the time in floors with no roof exposure and 68% in the top floors.

Controlling the time the lights are on and effectively reducing the lighting loads during daytime hours, in Addition to the strategies mentioned above (Minimum Suite), improves comfort conditions so that these spaces would only need HVAC conditioning during 26% of the occupied times on average for both floors.

Adding IECC 2015 prescriptive requirements for the roof (Improved Suite), improves comfort conditions in the top floor so that and HVAC system would be needed during 20% of the occupied hours. Similarly, upgrading the walls to IECC 2015 prescriptive requirements (Code Suite), would make the lower classrooms and the classrooms on the top floors need HVAC conditioning during 21% and 15% of the occupied time respectively.

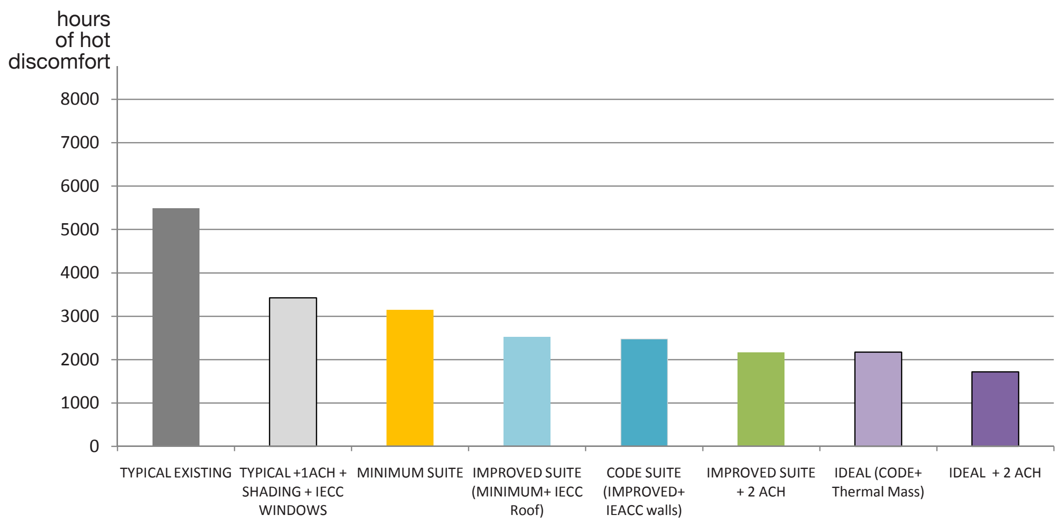
Exposed thermal mass in all interior surfaces (Ideal Suite) would reduce the need for HVAC conditioning to 7% of the occupied hours in both spaces, or 5% if Additional outside air is introduced to the classrooms. This essentially means that, in this climate, the HVAC system only needs to be available during extreme heat wave periods in buildings with the features considered in these studies.

It is important to note that if ceiling fans are not installed, only the well insulated spaces with thermal mass and increased ventilation (Ideal Suite) would reduce hot discomfort and the need for HVAC conditioning beyond 77% of the occupied hours.

Also, as described in the weather data analysis section of this Addendum, these models were run using TMY3 data, which deliberately avoids extreme conditions. In order to evaluate the validity of this study under more severe weather conditions, such as the periods of high humidity, high temperature and very low wind speeds (August 2015) that are expected to increase in frequency due to climate change,

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

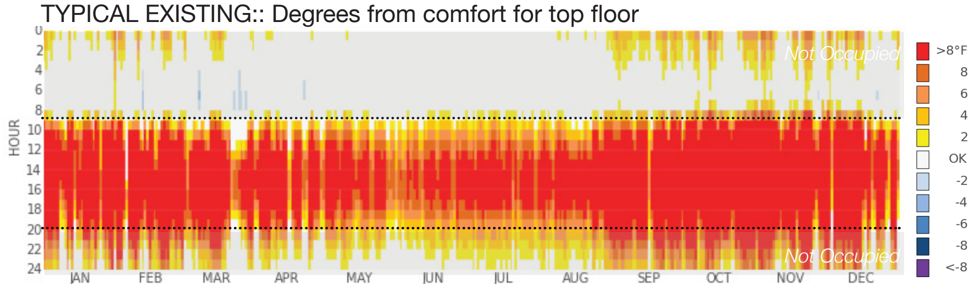
CLASSROOM RESULTS:: SUMMARY



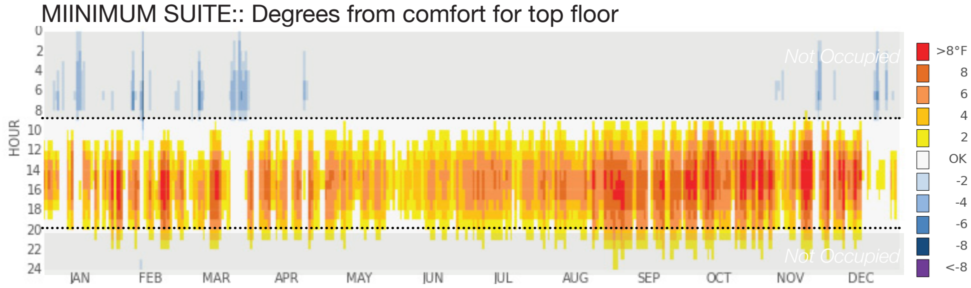
			Bottom Floor			Top Floor		
			hours	% of the whole year	% of occupied time	hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	5943	**68%**	**100%**	5490	**63%**	**100%**
		w/ celing fans	4353.3	50%	100%	4070	46%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3059.5	**35%**	**100%**	3422	**39%**	**100%**
		w/ celing fans	1323.3	15%	49%	1847	21%	68%
B-3	MINIMUM SUITE	too warm	2615.3	**30%**	**97%**	3144	**36%**	**100%**
		w/ celing fans	673	8%	25%	726	8%	27%
C-1	IMPROVED SUITE (MINIMUM+ IECC Roof)	too warm	2561.8	**29%**	**95%**	2523	**29%**	**93%**
		w/ celing fans	690	8%	26%	534	6%	20%
C-2	CODE SUITE (IMPROVED+ IEACC walls)	too warm	2504.5	**29%**	**93%**	2473	**28%**	**92%**
		w/ celing fans	569	6%	21%	407	5%	15%
D-2	IMPROVED SUITE + 2 ACH	too warm	2207.3	**25%**	**82%**	2165	**25%**	**80%**
		w/ celing fans	464	5%	17%	327	4%	12%
E-1	IDEAL (CODE+ Thermal Mass)	too warm	2077.3	**24%**	**77%**	2171	**25%**	**80%**
		w/ celing fans	176	2%	7%	183	2%	7%
E-1	IDEAL + 2 ACH	too warm	1605.5	**18%**	**59%**	1717	**20%**	**64%**
		w/ celing fans	127	1%	5%	126	1%	5%

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

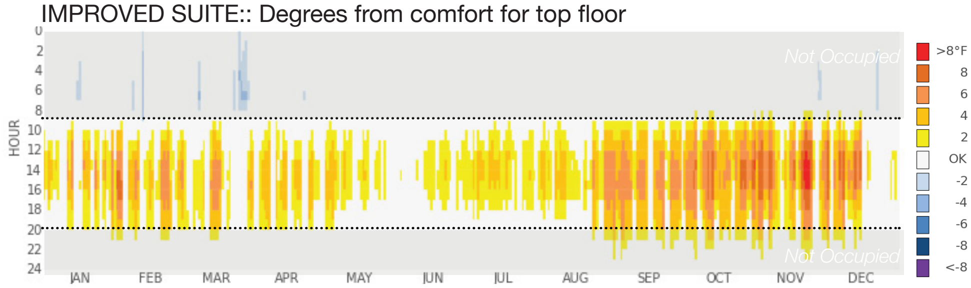
TYPICAL EXISTING:: Degrees from comfort for top floor



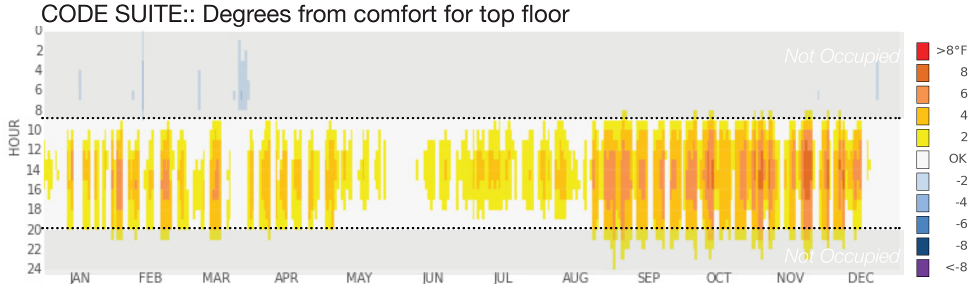
MIINIMUM SUITE:: Degrees from comfort for top floor



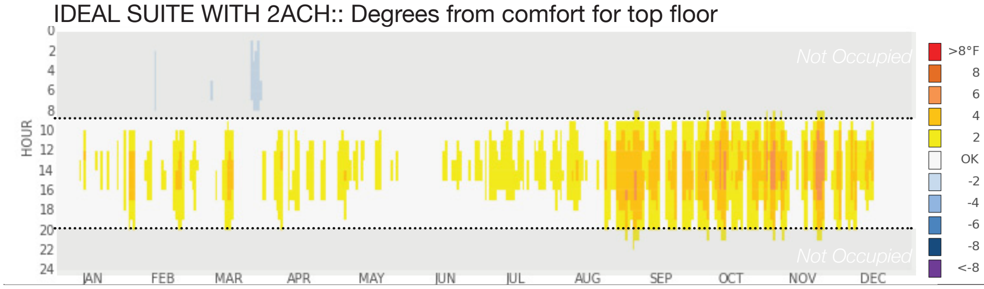
IMPROVED SUITE:: Degrees from comfort for top floor



CODE SUITE:: Degrees from comfort for top floor



IDEAL SUITE WITH 2ACH:: Degrees from comfort for top floor



Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

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Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

b. Thermal Comfort and HVAC Autonomy:: Office Results

The main difference between classroom and office models is the internal load assumptions and ventilation rates. On the one hand, classroom spaces assume a much higher occupancy than the ASHRAE 90.1 assumptions for office spaces. However, ASHRAE 62.1 defines the requirements for minimum fresh air ventilation rates as the sum of a “per floor area” and a “per person” airflow rate. Thus, the more people in a space, the more fresh air is introduced in the model. As a consequence, office models show more discomfort hours (twice as many overall).

On average, for all orientations, offices in existing UHM buildings (Typical Existing) would need HVAC conditioning during all the occupied hours. By improving the windows, bringing in a minimum amount of outside air (1ACH) and installing ceiling fans (Typical with Window Improvements), occupants in these spaces would feel uncomfortable during 86% of the time in floors with no roof exposure and but still feel too warm during all occupied hours in the top floors.

Controlling the time the lights are on and effectively reducing the lighting loads during daytime hours, in Addition to the strategies mentioned above (Minimum Suite), improves comfort conditions so that these spaces would only need HVAC conditioning during 43% of the occupied times on lower floors and 83% in upper floors.

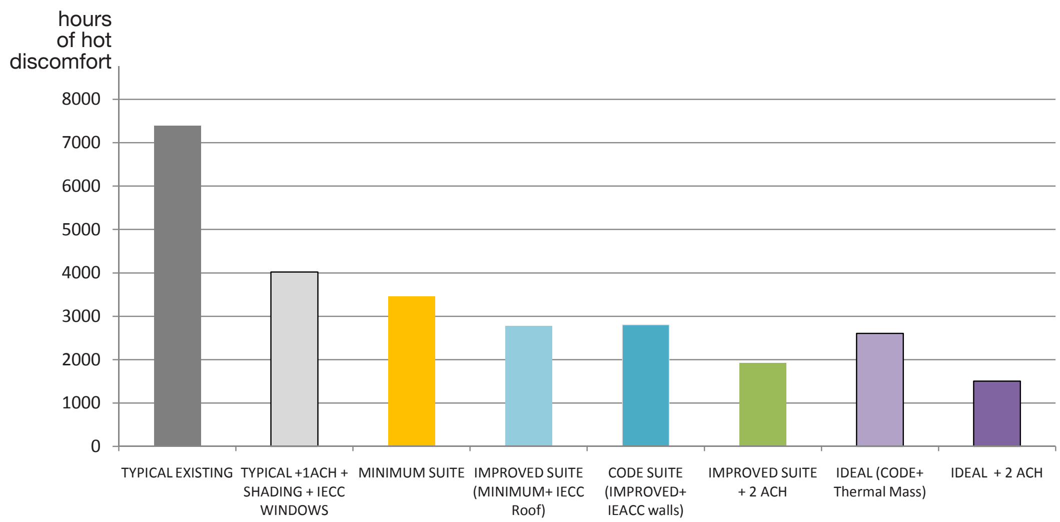
Adding IECC 2015 prescriptive requirements for the roof (Improved Suite), improves comfort conditions in the top floor so that and HVAC system would be needed during 37% of the occupied hours (making the interior conditions much more similar to ones in the lower floors). Similarly, upgrading the walls to IECC 2015 prescriptive requirements (Code Suite), would make the lower classrooms and the classrooms on the top floors need HVAC conditioning during 34% and 29% of the occupied time respectively.

Exposed thermal mass in all interior surfaces (Ideal Suite) would reduce the need for HVAC conditioning to 18% of the occupied hours in both spaces. However, Adding more ventilation makes the office models perform more similarly to the classroom models, Achievingreducing the overheating hours to 4% of the occupied hours. This essentially means that, same as for the classroom spaces

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

in this climate, the HVAC system only needs to be available during extreme heat wave periods in buildings with the features considered in these studies.

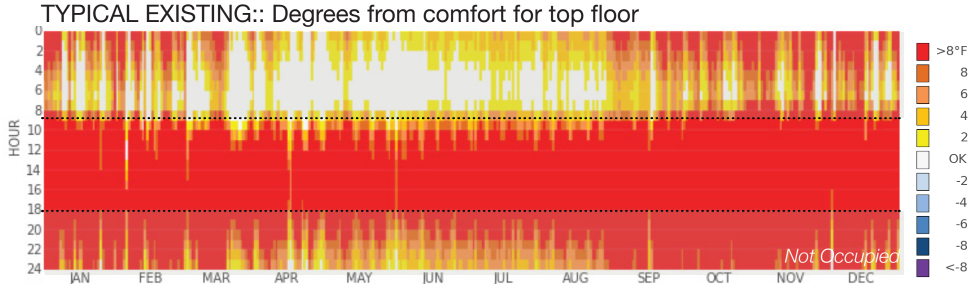
It is important to note that if ceiling fans are not installed, only the well insulated spaces with thermal mass and increased ventilation (Ideal Suite) would reduce hot discomfort and the need for HVAC conditioning during the occupied hours.



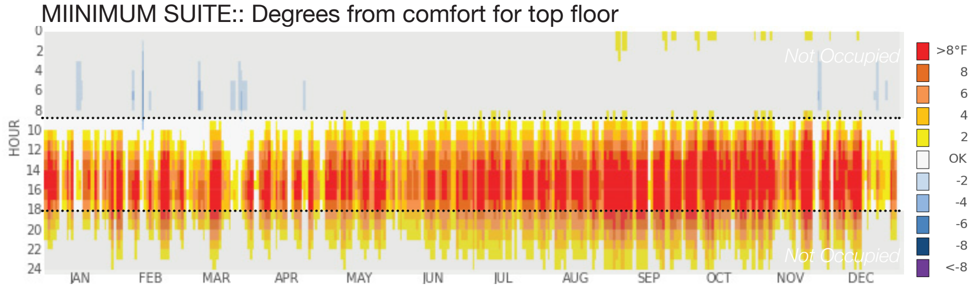
			Bottom Floor			Top Floor		
			hours	% of the whole year	% of occupied time	hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	7986.5	**91%**	**100%**	7393	**84%**	**100%**
		w/ celing fans	6865.3	78%	100%	6038	69%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3862.5	**44%**	**100%**	4020	**46%**	**100%**
		w/ celing fans	1750.3	20%	86%	2295	26%	100%
B-3	MINIMUM SUITE	too warm	2921	**33%**	**100%**	3460	**39%**	**100%**
		w/ celing fans	864	10%	43%	1681	19%	83%
C-1	IMPROVED SUITE (MINIMUM+ IECC Roof)	too warm	2759.3	**31%**	**100%**	2780	**32%**	**100%**
		w/ celing fans	832.5	10%	41%	757	9%	37%
C-2	CODE SUITE (IMPROVED+ IEACC walls)	too warm	2759.5	**32%**	**100%**	2799	**32%**	**100%**
		w/ celing fans	697	8%	34%	594	7%	29%
D-2	IMPROVED SUITE + 2 ACH	too warm	1911.5	**22%**	**94%**	1922	**22%**	**95%**
		w/ celing fans	360	4%	18%	291	3%	14%
E-1	IDEAL (CODE+ Thermal Mass)	too warm	2475.8	**28%**	**100%**	2607	**30%**	**100%**
		w/ celing fans	362	4%	18%	372	4%	18%
E-1	IDEAL + 2 ACH	too warm	1364.8	**16%**	**67%**	1504	**17%**	**74%**
		w/ celing fans	73	1%	4%	77.8	1%	4%

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

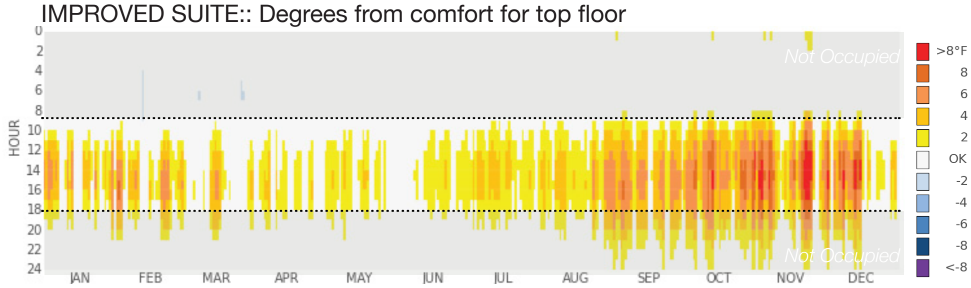
TYPICAL EXISTING:: Degrees from comfort for top floor



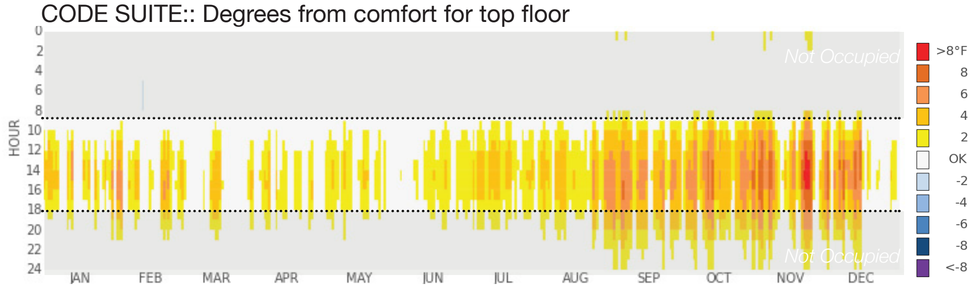
MIINIMUM SUITE:: Degrees from comfort for top floor



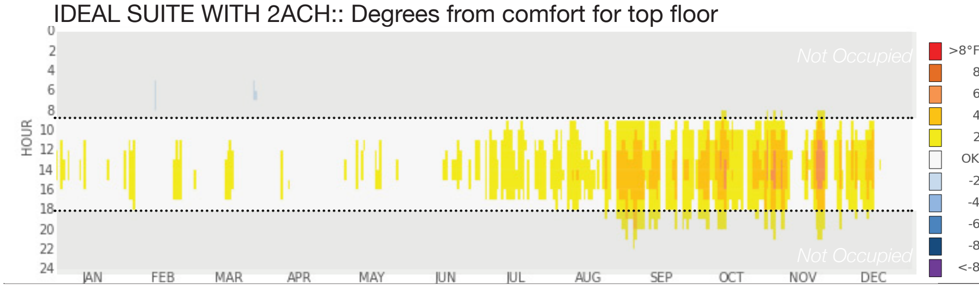
IMPROVED SUITE:: Degrees from comfort for top floor



CODE SUITE:: Degrees from comfort for top floor



IDEAL SUITE WITH 2ACH:: Degrees from comfort for top floor



Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

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Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

c. Thermal Comfort and HVAC Autonomy:: Laboratory Results

Laboratories operate in a tighter range of acceptable interior conditions, which requires controlling and potentially conditioning the air that comes into the building whenever the outdoor conditions do not fall within that acceptable range. In Addition, the internal loads in laboratory spaces are significantly higher than in other building types, especially for equipment but also for lighting. As described in the Labs 21 Best Practices guidelines, zoning the equipment efficiently is a good way to reduce the impact of the heat released from laboratory equipment on the interior conditions and thus the HVAC energy use. Also, a careful design of the ventilation rates, adapting them to differences in interior conditions and occupancy, provides the most benefits in terms of overall laboratory building performance.

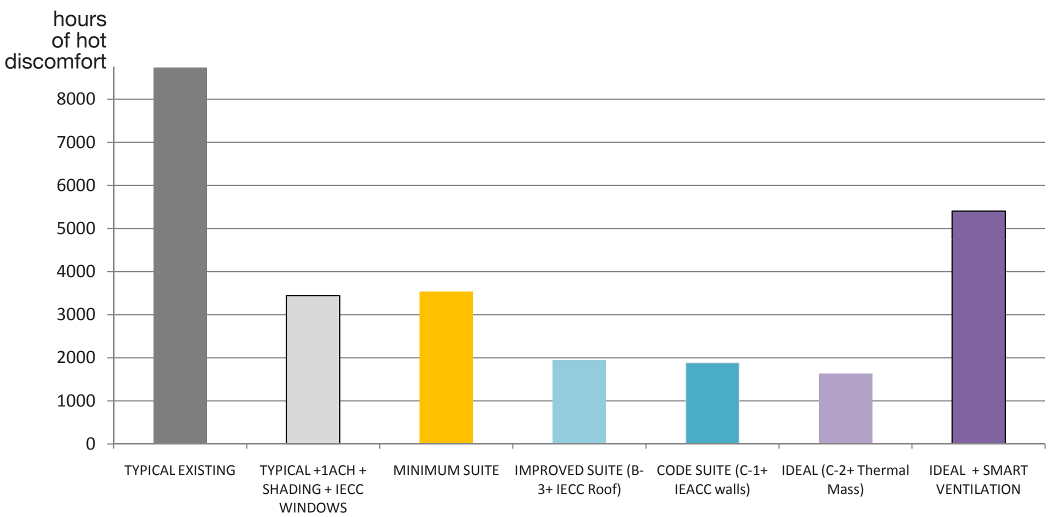
Our results confirm that laboratories need HVAC conditioning during all occupied hours, independently of the envelope improvements introduced in the building. Not only that, ceiling fans do not provide the advantages noticed in other building types, and the adaptive comfort model is not applicable in these spaces.

However, even if thermal comfort and HVAC autonomy are not as critical as for other building types, these parametric studies were repeated with an HVAC conditioning system to predict total building energy use. These results show that envelope improvements have a measurable impact on optimizing building energy performance.

In the hourly graphs showing the degrees from comfort over the year for each suite model, we observe that with controlling the internal loads, improving the windows (shading+glazing) and bringing in more air than just the breathing requirements (Minimum Suite), interior conditions during the unoccupied times are widely improved. Furthermore the results from the model with IECC 2015 prescriptive envelope, thermal mass and smart ventilation (which means half as low ventilation rates during occupied hours and four times lower rates during unoccupied hours) show that even if the amount of overheating **hours** increases compared to the other models with higher constant ventilation rates, the **conditions** are not as extreme. This means that the space would be able to be conditioned with a significantly smaller HVAC system.

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

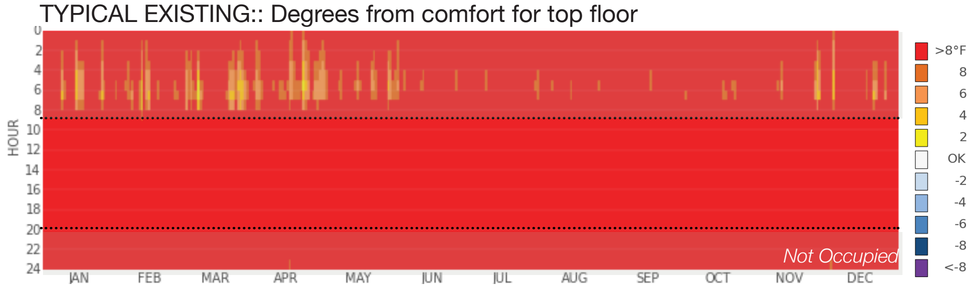
LABORATORY RESULTS:: SUMMARY



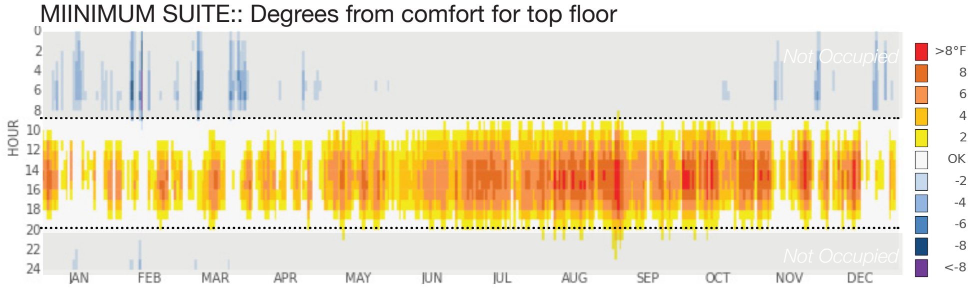
			Bottom Floor				Top Floor		
			hours	% of the whole year	% of occupied time		hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	8758	**100%**	**100%**	too warm	8739	**100%**	**100%**
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3262.5	**37%**	**100%**	too warm	3443	**39%**	**100%**
B-3	MINIMUM SUITE	too warm	1996.5	**23%**	**100%**	too warm	3538	**40%**	**100%**
C-1	IMPROVED SUITE (MINIMUM+ IECC Roof)	too warm	1972.5	**23%**	**100%**	too warm	1950	**22%**	**100%**
C-2	CODE SUITE (IMPROVED+ IEACC walls)	too warm	1891.5	**22%**	**100%**	too warm	1885	**22%**	**100%**
E-1	IDEAL (CODE+ Thermal Mass)	too warm	1556	**18%**	**100%**	too warm	1639	**19%**	**100%**
E-2	IDEAL + SMART VENTILATION	too warm	5380	**61%**	**100%**	too warm	5406	**62%**	**100%**

Add/C.1 HVAC and Thermal Comfort Studies:: Executive Summary (Continued)

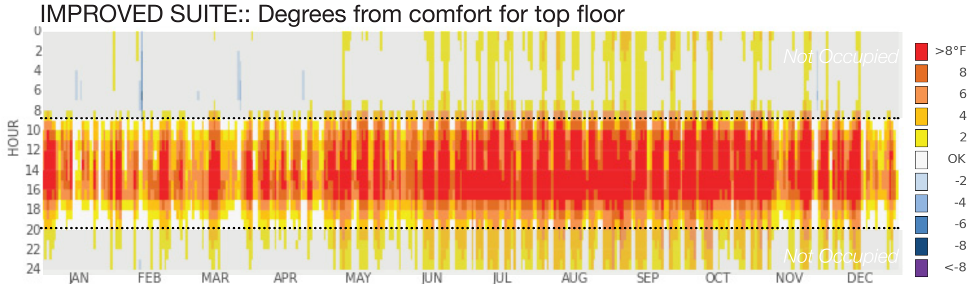
TYPICAL EXISTING:: Degrees from comfort for top floor



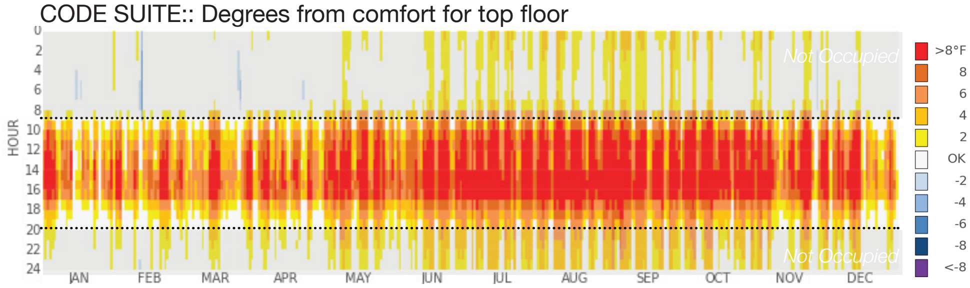
MIINIMUM SUITE:: Degrees from comfort for top floor



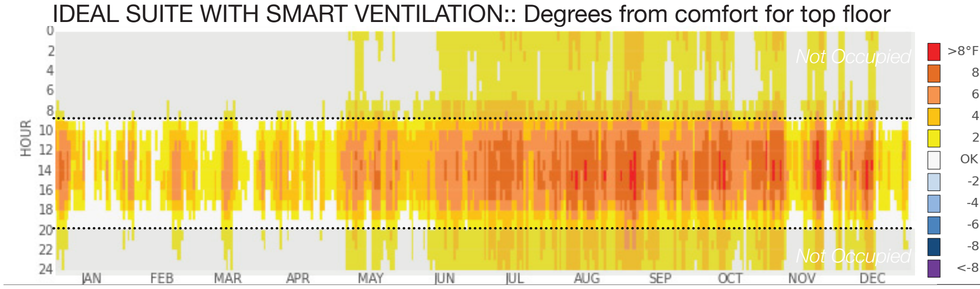
IMPROVED SUITE:: Degrees from comfort for top floor



CODE SUITE:: Degrees from comfort for top floor



IDEAL SUITE WITH SMART VENTILATION:: Degrees from comfort for top floor

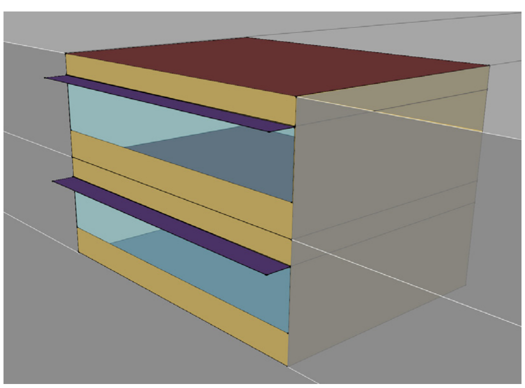


Add/C. HVAC AND THERMAL COMFORT STUDIES

2. MODEL ASSUMPTIONS

We modeled the building using EnergyPlus, a research-grade simulation platform that accounts for sub-hourly building envelope heat flows through conduction, convection, and radiation. The model contains envelope geometry, shading devices (overhangs), and orientation, as well as assumptions about ventilation strategy, construction assemblies, and internal gains. Typical meteorological year (TMY) weather data for Honolulu International Airport (the closest representative data set), were used for the analysis.

The analysis consisted of annual hour-by-hour simulations using the EnergyPlus software to identify the potential strategies to improve the energy performance of a typical existing classroom. The geometry and classroom layout was based on rooms 302 and 402 currently located in Kuykendall Hall. They represent classroom units within a larger building, located on the third floor and the fourth floor, to understand the impact of roof exposure, and with adiabatic interior walls. Window sizes were modified according to the findings and recommendations from the daylighting models to maximize interior lighting levels. Internal loads based on a medium sized classroom according to the UHM Space Planning guidelines were considered. In terms of schedules, an 8am to 8pm occupancy was modeled, with light power density and receptacle use per ASHRAE 90.1 Appendix G. We also modeled that the building provides fresh air for breathing as required per code.



Weather file::
Honolulu International Airport (USA_HI_Honolulu.Intl.AP.911820_TMY3.epw), IECC climate zone 1A

All models: 50% Window to wall Ratio, as per daylighting model recommendations to maximize interior lighting levels.

Typical Models: No insulation in opaque envelope: walls (assembly U=0.410 Btu/h-ft2-F), roof (assembly U=0.393 Btu/h-ft2-F). Single pane windows (U= 1.017, SHGC= 0.819, VT=0.881). No shading (exterior or interior). Interior walls: (1) 5/8” gypsum board.

Add/C.2 Model Assumptions (Continued)

Alternative Construction assemblies::
IECC Roof:: Coolroof: Three-year aged solar reflectance 0.55, thermal emittance 0.75, SRI 64,
U= 0.048 Btu/h-ft2-F (insulation entirely above roof deck)
IECC Exterior Walls:: (wood framed) U= 0.064 Btu/h-ft2-F

Thermal Mass Interior Walls:: Two 5/8" Gypsum boards on each side, Exposed Concrete Floor (Heavyweight concrete)

Shading:: According to daylight model results for each orientation:: 65 degree profile angle (3') for South, East, West Orientations, 75 (2') for North
IECC Windows:: U-Factor: 0.65 (operable), SHGC: 0.27, Tvis: 0.64 (LSG -Light to solar gain: 2.37)
Maximum air leakage rate 0.20 cfm/ft2

Internal Loads::
Occupancy:: Classrooms : 42 people, M-F 8am to 8pm
Office 275 sqft/person (ASHRAE 90.1, Appendix G), M-F 8am to 6pm
Labs, 275 sqft/person (ASHRAE 90.1, Appendix G), schedule per Labs 21 Modeling guidelines.
Equipment:: ASHRAE 90.1 Receptacle Loads: Classrooms : 0.5 W/sqft ,
Office 0.75 W/sqft,
Labs: 10W/sqft
Lighting:: IECC max LPD: Classrooms 1.24 W/sqft ,
Offices: 0.98 W/sqft (open office),
Laboratory 1.43 W/sqft (laboratory-classroom),
Ventilation:: per ASHRAE 62.1::
Lecture classroom: 7.5 cfm/person + 0.06 cfm/sqft
Office: 5 cfm/person + 0.06 cfm/sqft
University laborato¬ries: 10 cfm/person + 0.18 cfm/sqft

Infiltration:: 0.004 cfm/ft2 exterior wall (maximum allowed per IECC)

Add/C.2 Model Assumptions (Continued)

Alternative Internal Load Assumptions:
Additional 1ACH corresponds to assuming that windows are operable and bring in outdoor air if needed (when it gets too warm inside (from 74°F) and the Outdoor Temperature is cooler than the interior temperature)

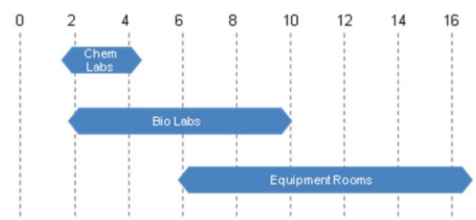
University laboratories: 10 cfm/person + 2 cfm/sqft (equivalent to 13ACH) as described as usual ventilation rates in Labs 21 Modeling guidelines.
Smart Lab Ventilation:: 4ACH when unoccupied, 6ACH when occupied (as per LBNL self-benchmarking tool)

Lower LPD (see Add/E Efficient Lighting Examples)::

Classrooms 0.6 W/sqft,
Offices 0.6 W/sqft,
Labs 1 W/sqft.

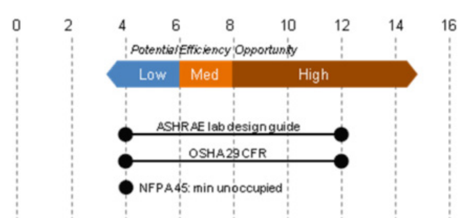
Daylight sensors to continuously dim lights down to 15% when 30Fc on workplane.

Efficient Laboratory Equipment: 6W/sqft (average biolabs plug load intensity as per LBNL self-benchmarking tool)



Laboratory Plug Load Density Ranges (W/nsf)

Laboratory Lighting Installed Power Density ranges (W/nsf)



Minimum Air Change Rate (ACH) Ranges in source: LBNL self-benchmarking tool

Add/C. HVAC AND THERMAL COMFORT STUDIES

3. CLASSROOM ANALYSIS

The following is a list of the models that were part of this analysis:

a. SOUTH FACING CLASSROOM

0. ***TYPICAL EXISTING***:: No Insulation in Opaque Surfaces, Single Pane Glass Windows

A- Window Parametrics

A-1. TYPICAL + 1ACH (Operable Windows)

A-2. TYPICAL + 1ACH + Shading

A-3. TYPICAL + 1ACH + Shading + IECC Glazing

B. Internal Load Parametrics (Lighting)

B.1. TYPICAL + 1ACH + IECC Glazing + Shading + lower LPD

B.2. TYPICAL + 1ACH + IECC Glazing + Shading + Daylight controls

B.3. ***MINIMUM SUITE*** :: TYPICAL + 1ACH + IECC Glazing + Shading + lower LPD + daylight controls

C. Exterior Surface Parametrics

C.1. ***IMPROVED SUITE***:: Minimum Suite + IECC Roof

C.2 ***CODE SUITE***:: Improved Suite + IECC Walls

D. Ventilation Parametrics::

D.1 MINIMUM SUITE + 2ACH

D.2 IMPROVED SUITE + 2ACH

D.3 CODE SUITE + 2ACH

D.4 MINIMUM SUITE + 3ACH

D.5 IMPROVED SUITE + 3ACH

D.6 CODE SUITE + 3ACH

E. Thermal Mass

E.1. ***IDEAL SUITE***:: Code Suite + Thermal Mass

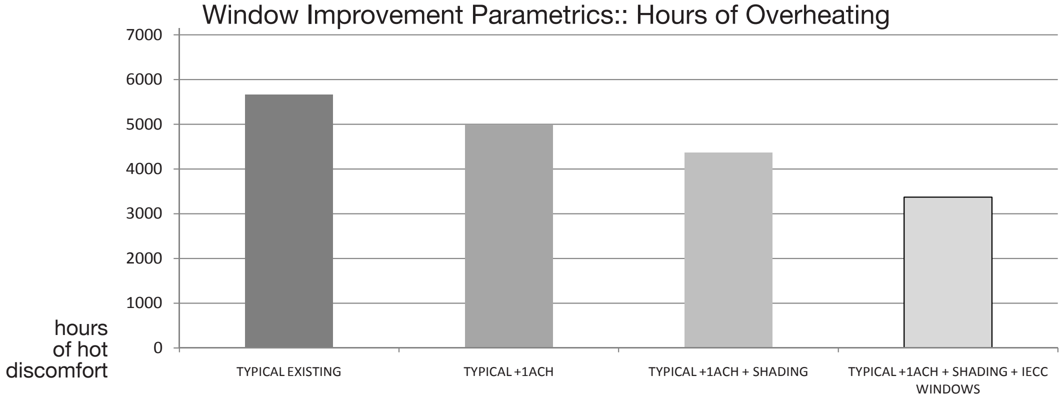
E.2 IDEAL SUITE + 2ACH

OTHER ORIENTATIONS (b. NORTH, c.EAST AND d. WEST)

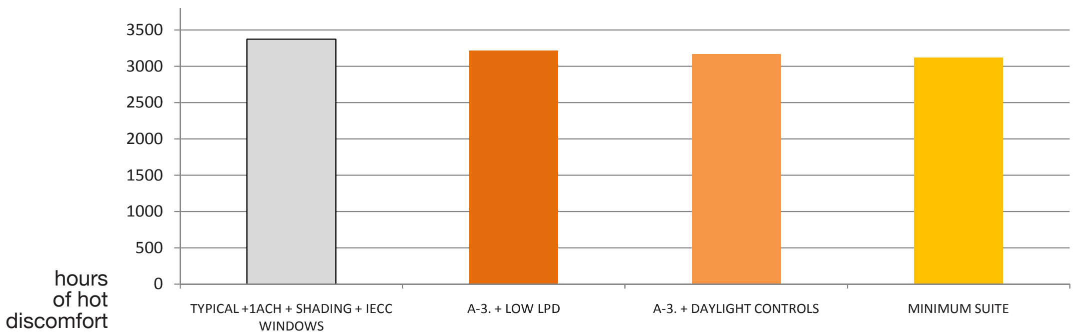
0. ***TYPICAL EXISTING***:: No Insulation in Opaque Surfaces, Single Pane Glass Windows
1. TYPICAL + 1ACH + Shading + IECC Glazing
2. ***MINIMUM SUITE***
3. ***IMPROVED SUITE***
4. ***CODE SUITE***
5. IMPROVED SUITE + 2ACH
6. ***IDEAL SUITE***
7. IDEAL SUITE + 2ACH

Add/C.3 Classroom Analysis (Continued)

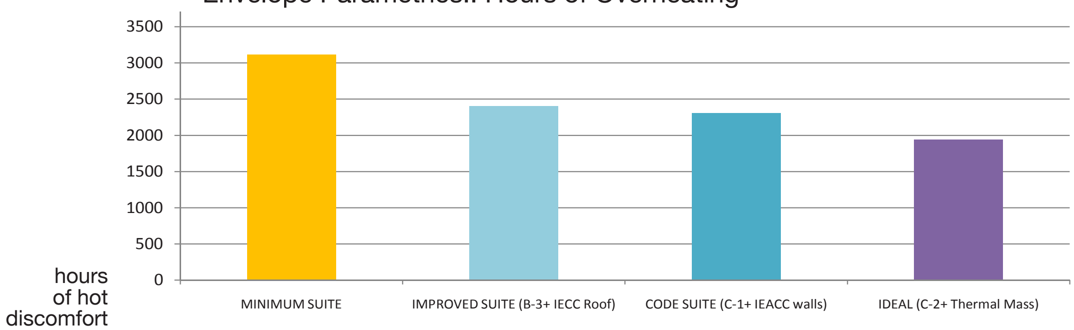
Window Improvement Parametrics:: Hours of Overheating



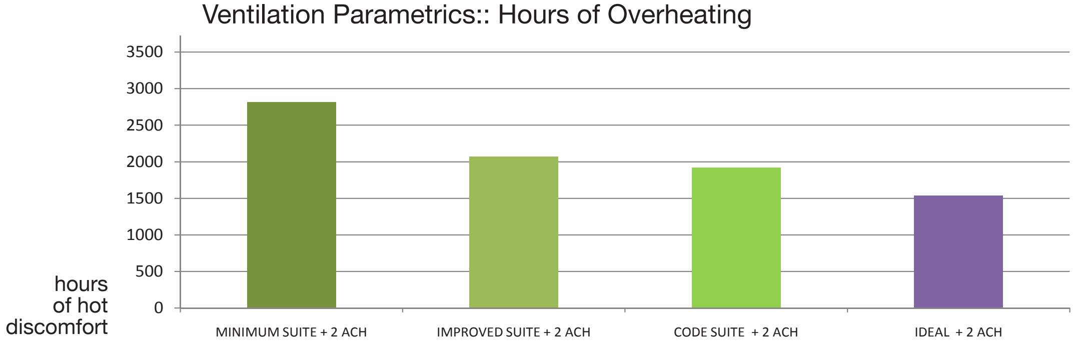
Internal Load (lighting) Parametrics:: Hours of Overheating



Envelope Parametrics:: Hours of Overheating



Ventilation Parametrics:: Hours of Overheating



Add/C.3 Classroom Analysis (Continued)

Window Improvement Parametrics:: Summary of Results

Case	Description		Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time		Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
	TYPICAL EXISTING	too warm	6118	**70%**	**100%**	too warm	5662	**65%**	**100%**
		w/ celing fans	4461	51%	100%	w/ celing fans	4203	48%	100%
A-1	TYPICAL +1ACH	too warm	5247	**60%**	**100%**	too warm	4981	**57%**	**100%**
		w/ celing fans	3629	41%	100%	w/ celing fans	3600	41%	100%
A-2	TYPICAL +1ACH + SHADING	too warm	4446	**51%**	**100%**	too warm	4368	**50%**	**100%**
		w/ celing fans	2692	31%	100%	w/ celing fans	2905	33%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	2918	**33%**	**100%**	too warm	3373	**39%**	**100%**
		w/ celing fans	1249	14%	46%	w/ celing fans	1790	20%	66%

Internal Load (lighting) Parametrics:: Summary of Result

Case	Description		Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time		Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
B-1	A-3. + LOW LPD	too warm	2651	**30%**	**98%**	too warm	3218	**37%**	**100%**
		w/ celing fans	912	10%	34%	w/ celing fans	1515	17%	56%
B-2	A-3. + DAYLIGHT CONTROLS	too warm	2569	**29%**	**95%**	too warm	3168	**36%**	**100%**
		w/ celing fans	797	9%	30%	w/ celing fans	1446	17%	54%
B-3	MINIMUM SUITE	too warm	2461	**28%**	**91%**	too warm	3116	**36%**	**100%**
		w/ celing fans	675	8%	25%	w/ celing fans	1345	15%	50%

Envelope Parametrics:: Summary of Results

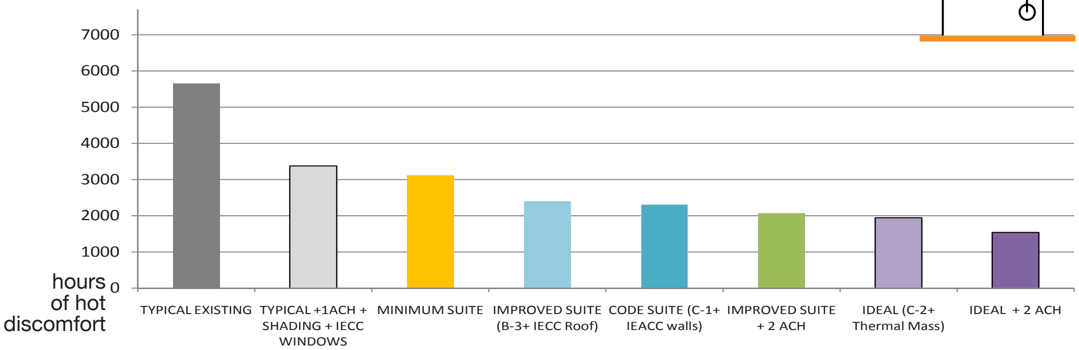
Case	Description		Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time		Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2406	**27%**	**89%**	too warm	2402	**27%**	**89%**
		w/ celing fans	678	8%	25%	w/ celing fans	525	6%	19%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2317	**26%**	**86%**	too warm	2306	**26%**	**85%**
		w/ celing fans	528	6%	20%	w/ celing fans	357	4%	13%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1850	**21%**	**69%**	too warm	1944	**22%**	**72%**
		w/ celing fans	149	2%	6%	w/ celing fans	146	2%	5%

Ventilation Parametrics:: Summary of Results

Case	Description		Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time		Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
D-1	MINIMUM SUITE + 2 ACH	too warm	2136	**24%**	**79%**	too warm	2817	**32%**	**100%**
		w/ celing fans	436	5%	16%	w/ celing fans	1083	12%	40%
D-2	IMPROVED SUITE + 2 ACH	too warm	2087	**24%**	**77%**	too warm	2068	**24%**	**77%**
		w/ celing fans	427	5%	16%	w/ celing fans	327	4%	12%
D-3	CODE SUITE + 2 ACH	too warm	1954	**22%**	**72%**	too warm	1918	**22%**	**71%**
		w/ celing fans	305	3%	11%	w/ celing fans	193	2%	7%
D-4	MINIMUM SUITE + 3 ACH	too warm	1905	**22%**	**71%**	too warm	2620	**30%**	**97%**
		w/ celing fans	309	4%	11%	w/ celing fans	902	10%	33%
D-5	IIMPROVED SUITE + 3 ACH	too warm	1869	**21%**	**69%**	too warm	1821	**21%**	**67%**
		w/ celing fans	308	4%	11%	w/ celing fans	218	2%	8%
D-6	CODE SUITE + 3 ACH	too warm	1715	**20%**	**64%**	too warm	1665	**19%**	**62%**
		w/ celing fans	190	2%	7%	w/ celing fans	128	1%	5%
E-2	IDEAL + 2 ACH	too warm	1425	**16%**	**53%**	too warm	1536	**18%**	**57%**
		w/ celing fans	55	1%	2%	w/ celing fans	52	1%	2%

Add/C.3 Classroom Analysis (Continued)

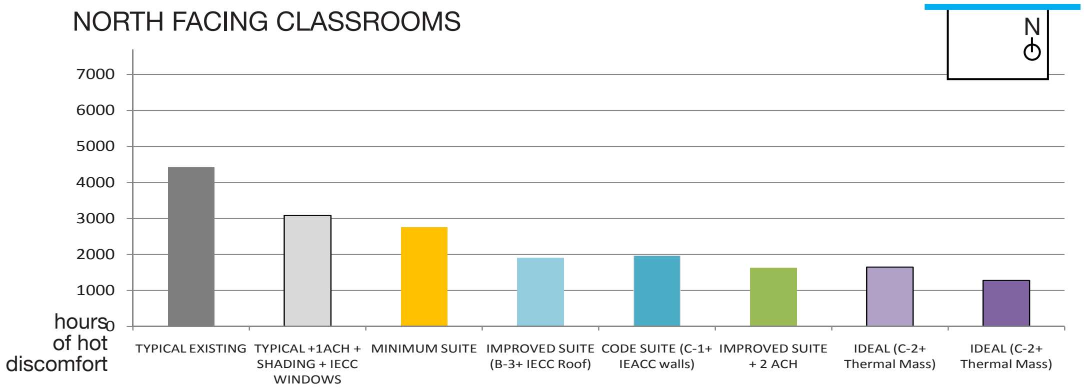
SOUTH FACING CLASSROOMS



			Bottom Floor			Top Floor		
			hours	% of the whole year	% of occupied time	hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	6118	**70%**	**100%**	5662	**65%**	**100%**
		w/ celing fans	4461	51%	100%	4203	48%	100%
A-1	TYPICAL +1ACH	too warm	5247	**60%**	**100%**	4981	**57%**	**100%**
		w/ celing fans	3629	41%	100%	3600	41%	100%
A-2	TYPICAL +1ACH + SHADING	too warm	4446	**51%**	**100%**	4368	**50%**	**100%**
		w/ celing fans	2692	31%	100%	2905	33%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	2918	**33%**	**100%**	3373	**39%**	**100%**
		w/ celing fans	1249	14%	46%	1790	20%	66%
B-1	A-3. + LOW LPD	too warm	2651	**30%**	**98%**	3218	**37%**	**100%**
		w/ celing fans	912	10%	34%	1515	17%	56%
B-2	A-3. + DAYLIGHT CONTROLS	too warm	2569	**29%**	**95%**	3168	**36%**	**100%**
		w/ celing fans	797	9%	30%	1446	17%	54%
B-3	MINIMUM SUITE	too warm	2461	**28%**	**91%**	3116	**36%**	**100%**
		w/ celing fans	675	8%	25%	1345	15%	50%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2406	**27%**	**89%**	2402	**27%**	**89%**
		w/ celing fans	678	8%	25%	525	6%	19%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2317	**26%**	**86%**	2306	**26%**	**85%**
		w/ celing fans	528	6%	20%	357	4%	13%
D-1	MINIMUM SUITE + 2 ACH	too warm	2136	**24%**	**79%**	2817	**32%**	**100%**
		w/ celing fans	436	5%	16%	1083	12%	40%
D-2	IMPROVED SUITE + 2 ACH	too warm	2087	**24%**	**77%**	2068	**24%**	**77%**
		w/ celing fans	427	5%	16%	327	4%	12%
D-3	CODE SUITE + 2 ACH	too warm	1954	**22%**	**72%**	1918	**22%**	**71%**
		w/ celing fans	305	3%	11%	193	2%	7%
D-4	MINIMUM SUITE + 3 ACH	too warm	1905	**22%**	**71%**	2620	**30%**	**97%**
		w/ celing fans	309	4%	11%	902	10%	33%
D-5	IIMPROVED SUITE + 3 ACH	too warm	1869	**21%**	**69%**	1821	**21%**	**67%**
		w/ celing fans	308	4%	11%	218	2%	8%
D-6	CODE SUITE + 3 ACH	too warm	1715	**20%**	**64%**	1665	**19%**	**62%**
		w/ celing fans	190	2%	7%	128	1%	5%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1850	**21%**	**69%**	1944	**22%**	**72%**
		w/ celing fans	149	2%	6%	146	2%	5%
E-2	IDEAL + 2 ACH	too warm	1425	**16%**	**53%**	1536	**18%**	**57%**
		w/ celing fans	55	1%	2%	52	1%	2%

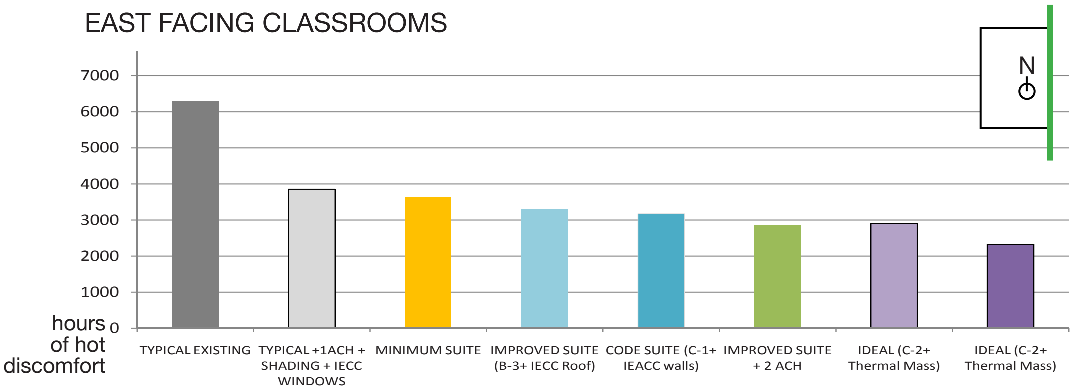
Add/C.3 Classroom Analysis (Continued)

NORTH FACING CLASSROOMS



			Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time		Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
	TYPICAL EXISTING	too warm	4566	**52%**	**100%**	too warm	4426	**51%**	**100%**
		w/ celing fans	2941	34%	100%	w/ celing fans	2997	34%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	2599	**30%**	**96%**	too warm	3087	**35%**	**100%**
		w/ celing fans	888	10%	33%	w/ celing fans	1498	17%	55%
B-3	MINIMUM SUITE	too warm	2057	**23%**	**76%**	too warm	2754	**31%**	**100%**
		w/ celing fans	242	3%	9%	w/ celing fans	1029	12%	38%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	1995	**23%**	**74%**	too warm	1909	**22%**	**71%**
		w/ celing fans	210	2%	8%	w/ celing fans	111	1%	4%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2001	**23%**	**74%**	too warm	1966	**22%**	**73%**
		w/ celing fans	225	3%	8%	w/ celing fans	129	1%	5%
D-2	IMPROVED SUITE + 2 ACH	too warm	1671	**19%**	**62%**	too warm	1626	**19%**	**60%**
		w/ celing fans	95	1%	4%	w/ celing fans	58	1%	2%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1536	**18%**	**57%**	too warm	1650	**19%**	**61%**
		w/ celing fans	27	0%	1%	w/ celing fans	36	0%	1%
E-1	IDEAL + 2 ACH	too warm	1141	**13%**	**42%**	too warm	1282	**15%**	**47%**
		w/ celing fans	3	0%	0%	w/ celing fans	4	0%	0%

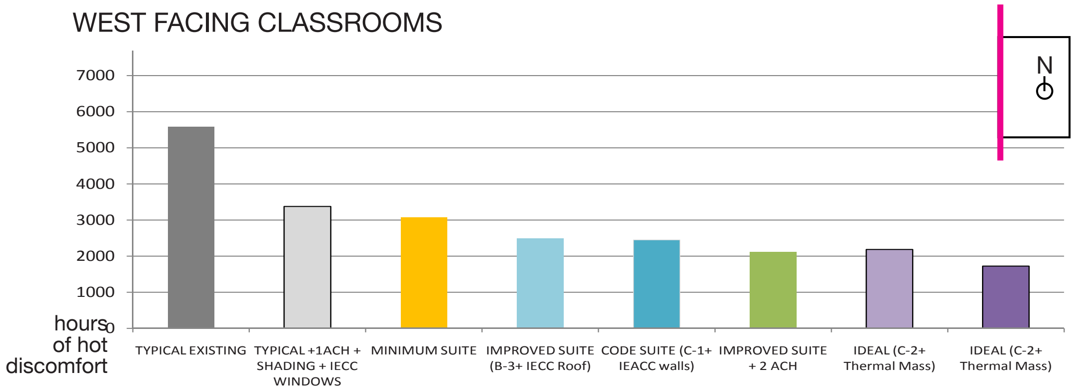
Add/C.3 Classroom Analysis (Continued)



			Bottom Floor				Top Floor		
			hours	% of the whole year	% of occupied time		hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	6858	**78%**	**100%**	too warm	6291	**72%**	**100%**
		w/ celing fans	5490	63%	100%	w/ celing fans	5017	57%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3673	**42%**	**100%**	A-3 TYPICAL +1ACH + too warm	3855	**44%**	**100%**
		w/ celing fans	1883	21%	70%	w/ celing fans	2270	26%	84%
B-3	MINIMUM SUITE	too warm	3374	**39%**	**100%**	too warm	3632	**41%**	**100%**
		w/ celing fans	1226	14%	45%	w/ celing fans	1799	21%	67%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	3334	**38%**	**100%**	too warm	3293	**38%**	**100%**
		w/ celing fans	1226	14%	45%	w/ celing fans	991	11%	37%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	3239	**37%**	**100%**	too warm	3173	**36%**	**100%**
		w/ celing fans	962	11%	36%	w/ celing fans	718	8%	27%
D-2	IMPROVED SUITE + 2 ACH	too warm	2923	**33%**	**100%**	too warm	2845	**32%**	**100%**
		w/ celing fans	888	10%	33%	w/ celing fans	584	7%	22%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2872	**33%**	**100%**	too warm	2904	**33%**	**100%**
		w/ celing fans	333	4%	12%	w/ celing fans	338	4%	13%
E-1	IDEAL + 2 ACH	too warm	2267	**26%**	**84%**	too warm	2325	**27%**	**86%**
		w/ celing fans	350	4%	13%	w/ celing fans	346	4%	13%

Add/C.3 Classroom Analysis (Continued)

WEST FACING CLASSROOMS

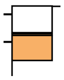


			Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time		Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
	TYPICAL EXISTING	too warm	6230	**71%**	**100%**	too warm	5580	**64%**	**100%**
		w/ celing fans	4521	52%	100%	w/ celing fans	4063	46%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3048	**35%**	**100%**	too warm	3373	**39%**	**100%**
		w/ celing fans	1273	15%	47%	w/ celing fans	1829	21%	68%
B-3	MINIMUM SUITE	too warm	2569	**29%**	**95%**	too warm	3074	**35%**	**100%**
		w/ celing fans	673	8%	25%	w/ celing fans	1398	16%	52%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2512	**29%**	**93%**	too warm	2487	**28%**	**92%**
		w/ celing fans	644	7%	24%	w/ celing fans	507	6%	19%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2461	**28%**	**91%**	too warm	2446	**28%**	**91%**
		w/ celing fans	559	6%	21%	w/ celing fans	423	5%	16%
D-2	IMPROVED SUITE + 2 ACH	too warm	2148	**25%**	**80%**	too warm	2120	**24%**	**79%**
		w/ celing fans	444	5%	16%	w/ celing fans	339	4%	13%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2051	**23%**	**76%**	too warm	2187	**25%**	**81%**
		w/ celing fans	196	2%	7%	w/ celing fans	211	2%	8%
E-1	IDEAL + 2 ACH	too warm	1589	**18%**	**59%**	too warm	1726	**20%**	**64%**
		w/ celing fans	99	1%	4%	w/ celing fans	102	1%	4%

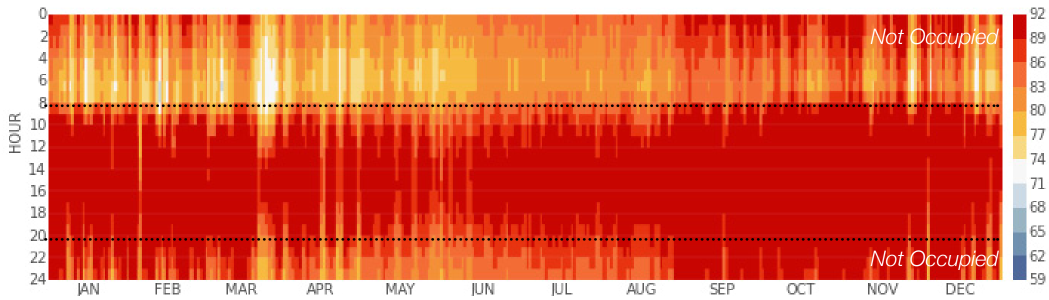
Add/C.3 CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.0. TYPICAL EXISTING

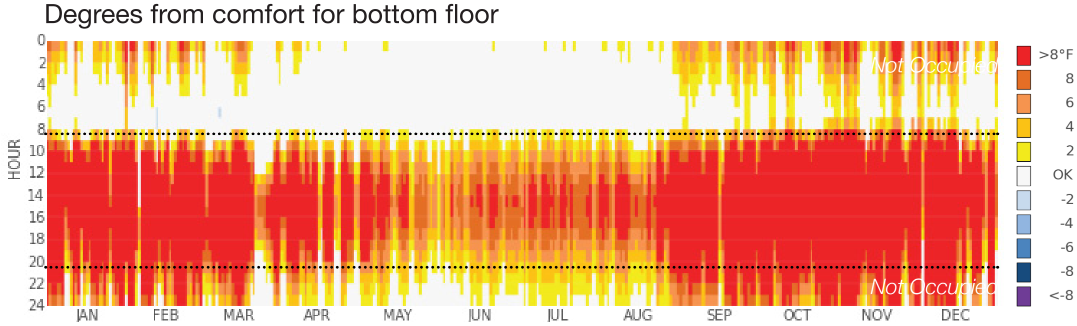
No Insulation in Opaque Surfaces and Single Pane Glass

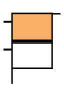


Operative Temperature for bottom floor

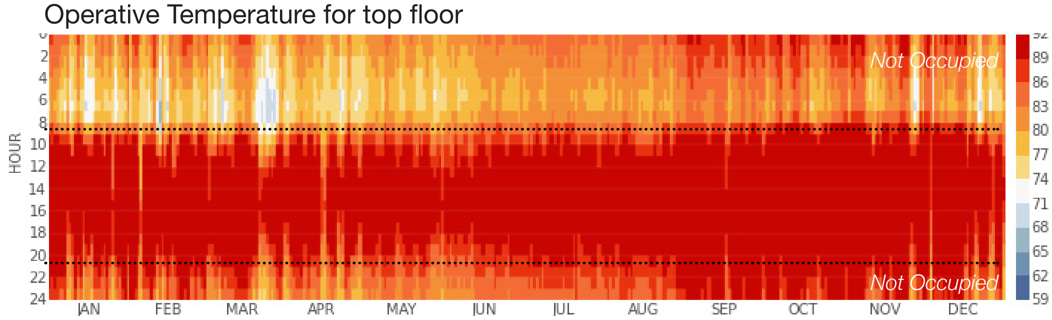


Degrees from comfort for bottom floor

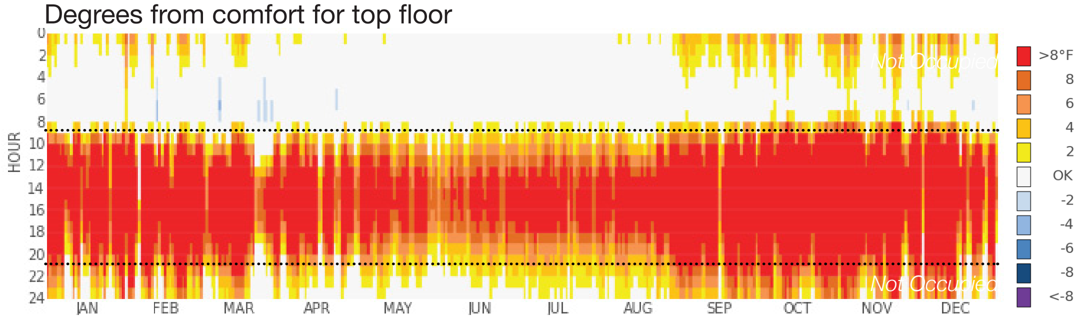




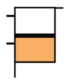
Operative Temperature for top floor



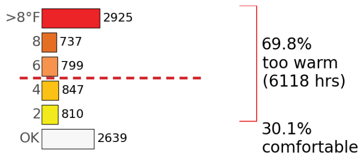
Degrees from comfort for top floor



Add/C.3.a.0 Classroom Analysis:: South Facing (Continued)



TYPICAL EXISTING		Bottom Floor		
		hours	% of the whole year	% of occupied time
	too warm	6118	**70%**	**100%**
	w/ celing fans	4461	51%	100%

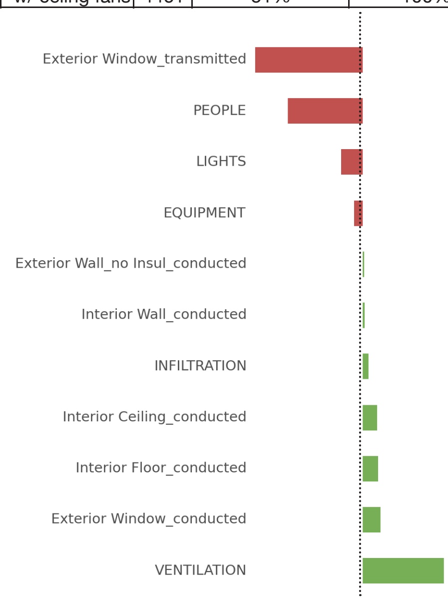


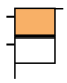
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

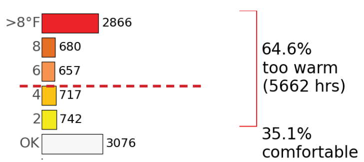
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*





TYPICAL EXISTING		Top Floor		
		hours	% of the whole year	% of occupied time
	too warm	5662	**65%**	**100%**
	w/ celing fans	4203	48%	100%

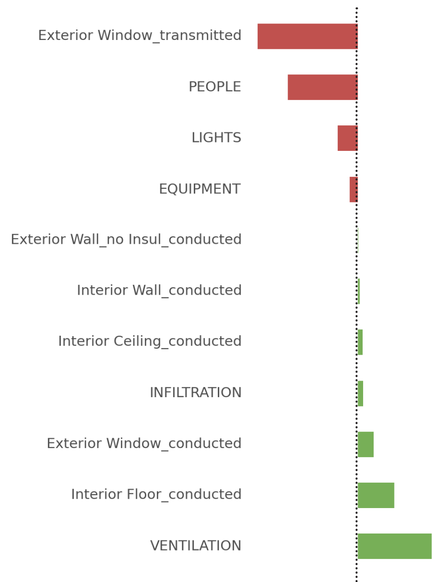


** Including all 8760 hrs of the year, not only occupied hours*

---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

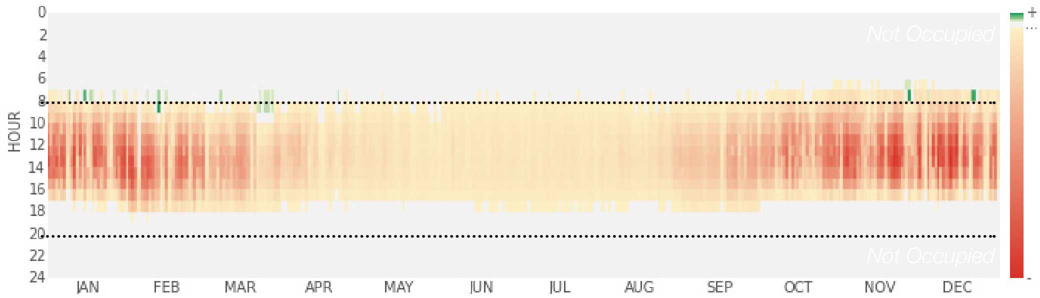


Add/C.3.a CLASSROOM ANALYSIS:: SOUTH FACING

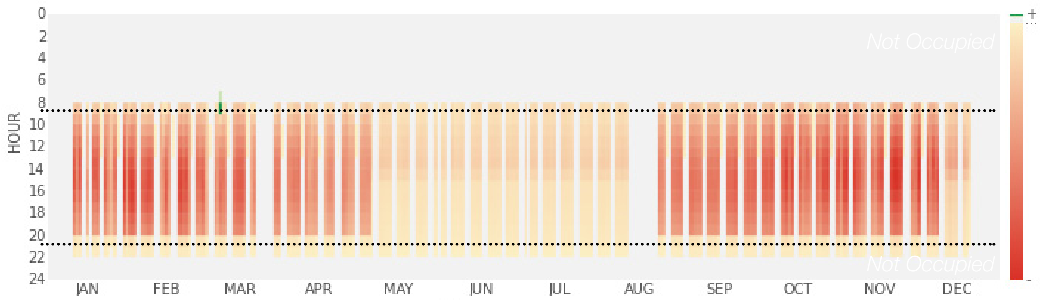
C.3.a.0 TYPICAL EXISTING:: Comfort Load Factors

No Insulation in Opaque Surfaces and Single Pane Glass

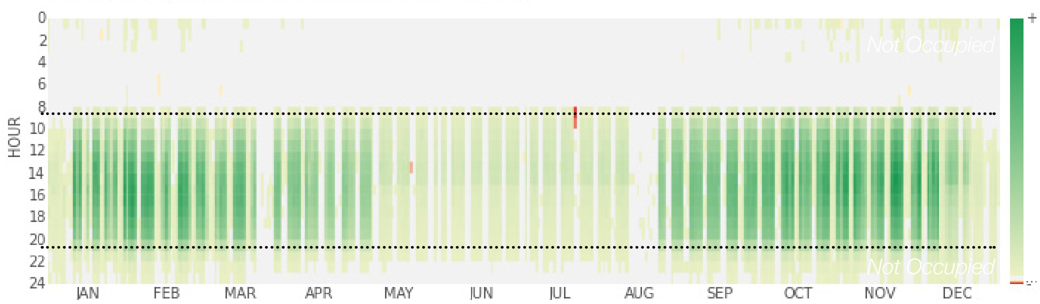
SUMMARY:Exterior Window_transmitted COMFORT Load Factors



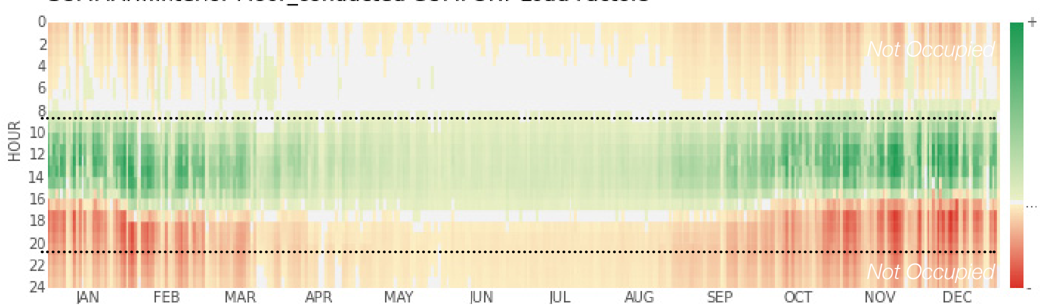
Class_402: LIGHTS COMFORT Load Factors



SUMMARY:VENTILATION COMFORT Load Factors



SUMMARY:Interior Floor_conducted COMFORT Load Factors



Add/C.3.a.0 Classroom Analysis:: South Facing (Continued)

In order to provide a more fine grained analysis of comfort factors, we analyzed the heat flows into and out of the spaces, as well as the difference between the space temperatures and the ideal space temperature (adaptive comfort range). We compared these space loads to the ideal temperature difference to determine which loads are improving comfort and which loads are decreasing comfort. The comfort load factors indicate the degree to which a particular load is pushing the temperature of a space towards the middle of the comfort zone or away from it.

In summary, the factors associated with decreased comfort in this analysis are the solar radiation through the windows and the internal loads (heat released to the space by the occupants but also lighting and equipment).

This analysis also indicates that ventilation and thermal mass (interior floor and wall conduction) are improving building thermal performance and thus improving comfort and reducing future HVAC loads. Ventilation introducing outside air when heat is building up in the space due to high internal loads or solar radiation can prevent overheating. Thermal mass in the floor contributes to achievingcomfort conditions by absorbing heat during the day and releasing it at night.

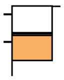
The graphs on the left show the times of the year when each load factor either decreases or increases comfort. For example, the solar transmitted radiation never increases comfort and decreases comfort the most during the fall and winter seasons, which is likely when the lower sun angles hit the windows for longer periods of time.

The internal heat coming from the lights always decreases comfort while ventilation always increases comfort. The interior floor increases comfort during most of the occupied times, even if it decreases comfort during the late afternoons. This is likely due to the floors not being able to absorb any more internal heat and starting to release it into the space even if that further increases the interior temperature.

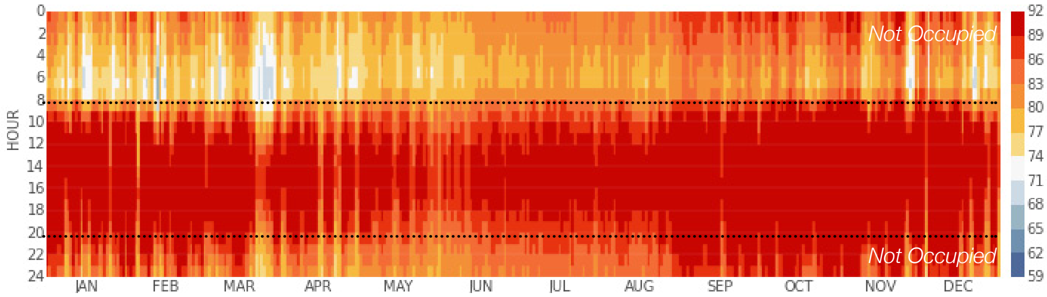
Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.A. WINDOW PARAMETRICS

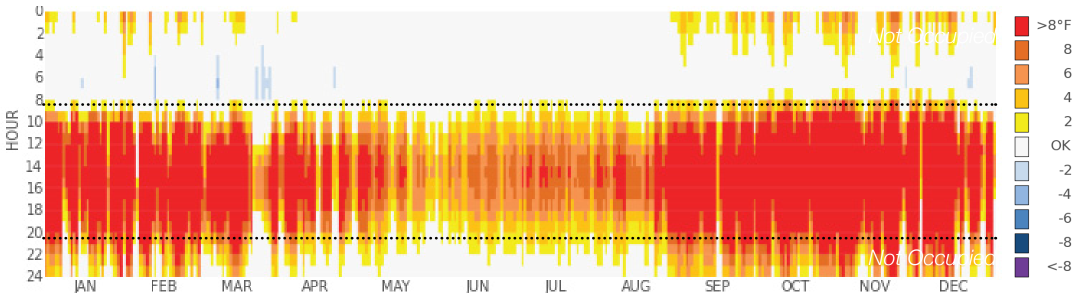
C.3.a. A.1 TYPICAL +1ACH (OPERABLE WINDOWS)

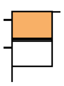


Operative temperature for bottom floor

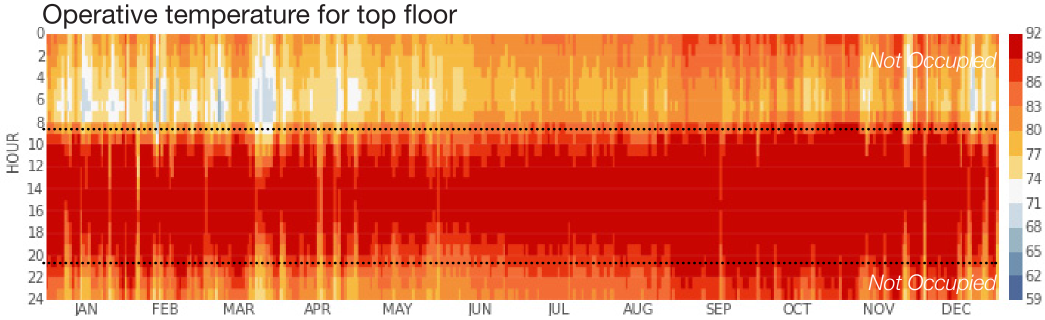


Degrees from comfort for bottom floor

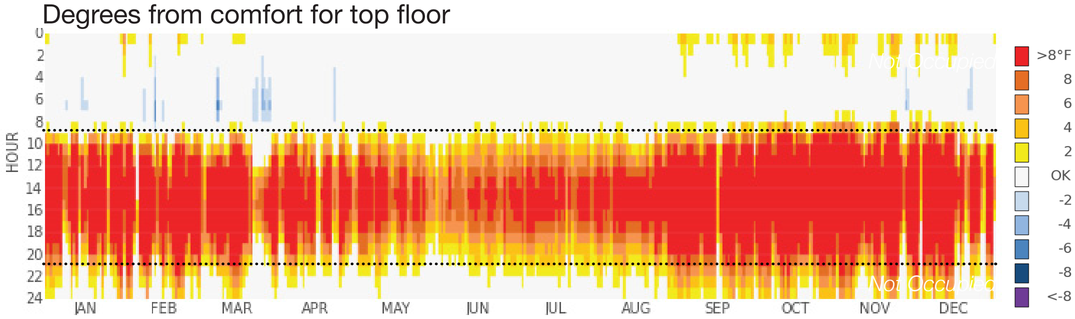




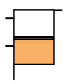
Operative temperature for top floor



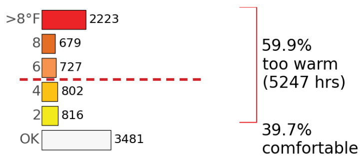
Degrees from comfort for top floor



Add/C.3.a.A.1 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-1	TYPICAL +1ACH	too warm	5247	**60%**	**100%**
		w/ celing fans	3629	41%	100%

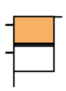


** Including all 8760 hrs of the year, not only occupied hours*

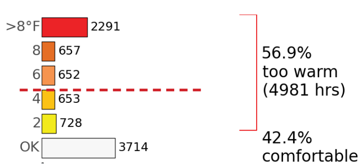
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

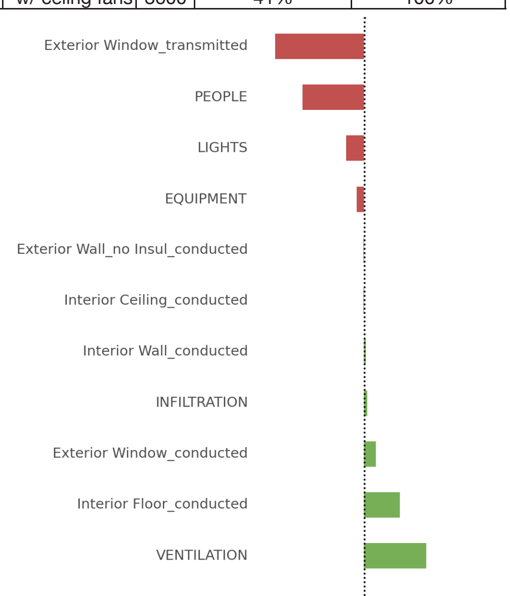


			Top Floor		
			hours	% of the whole year	% of occupied time
A-1	TYPICAL +1ACH	too warm	4981	**57%**	**100%**
		w/ celing fans	3600	41%	100%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



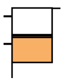
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

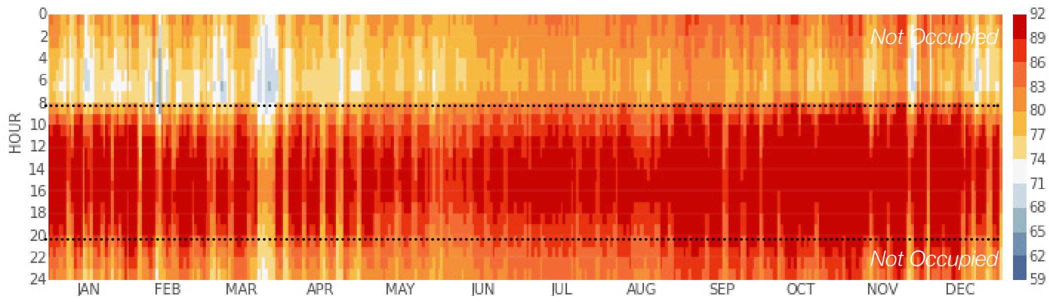
Add/C.3.a_ CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.A. WINDOW PARAMETRICS

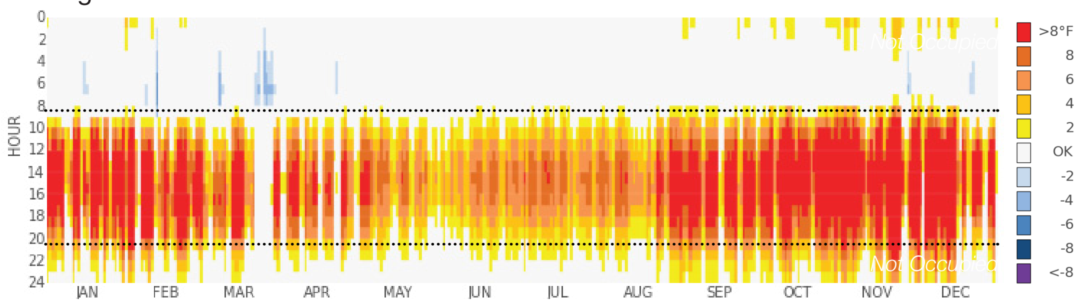
C.3.a.A.2 TYPICAL + 1ACH + Shading

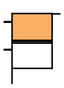


Operative temperature for bottom floor

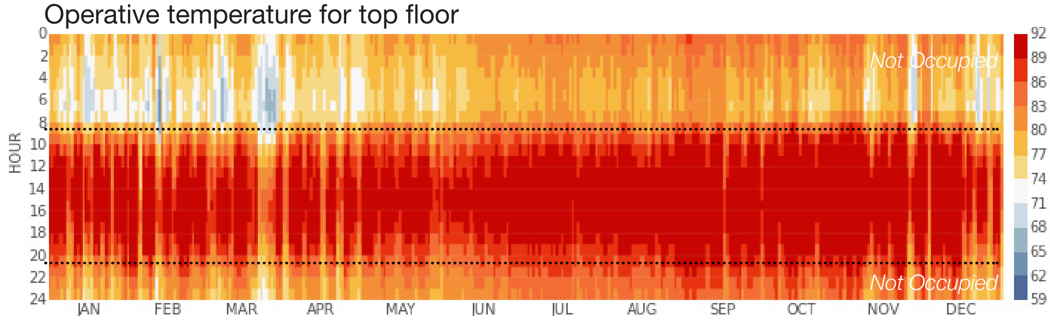


Degrees from comfort for bottom floor

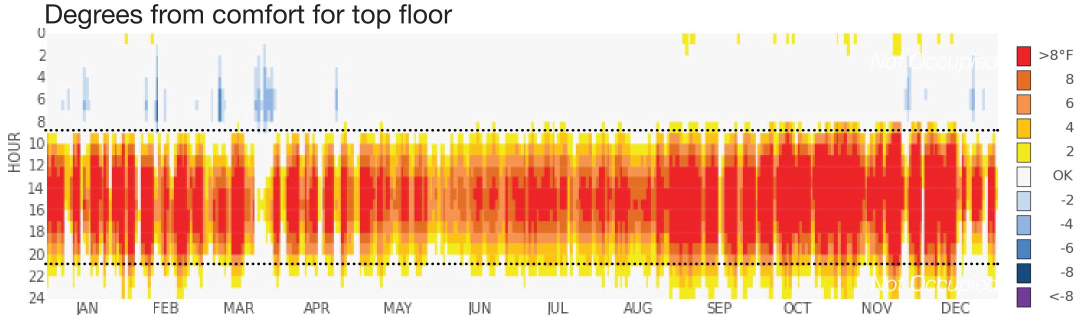




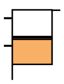
Operative temperature for top floor



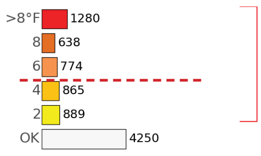
Degrees from comfort for top floor



Add/C.3.a.A.2 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-2	TYPICAL +1ACH + SHADING	too warm	4446	**51%**	**100%**
		w/ celing fans	2692	31%	100%

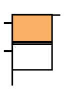


** Including all 8760 hrs of the year, not only occupied hours*

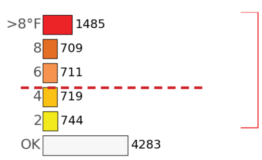
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
A-2	TYPICAL +1ACH + SHADING	too warm	4368	**50%**	**100%**
		w/ celing fans	2905	33%	100%

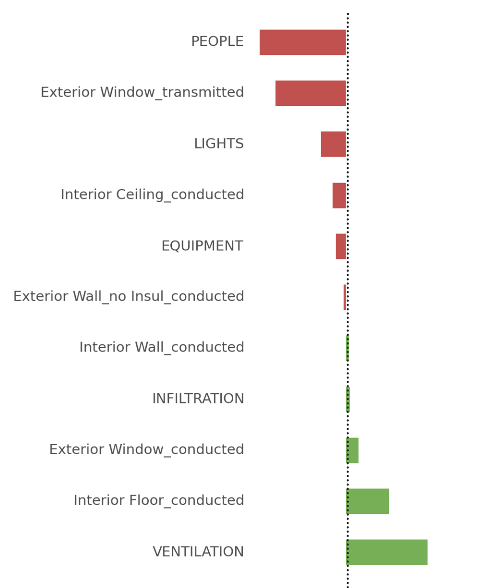


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

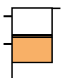
**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*



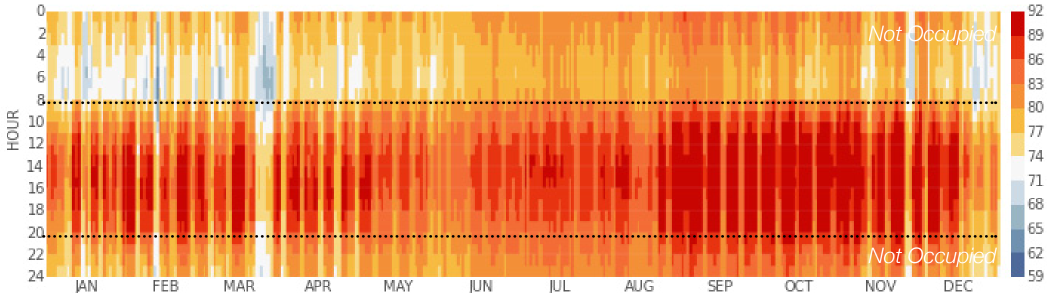
Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.A. WINDOW PARAMETRICS

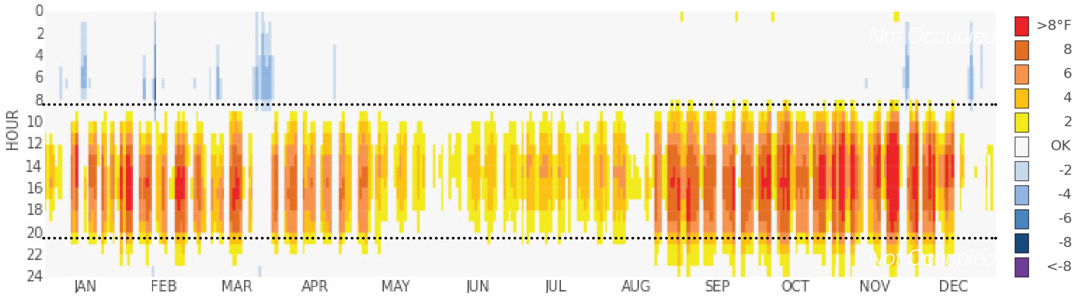
C.3.a.A,3 TYPICAL + 1ACH + Shading + IECC 2015 Windows

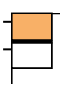


Operative temperature for bottom floor

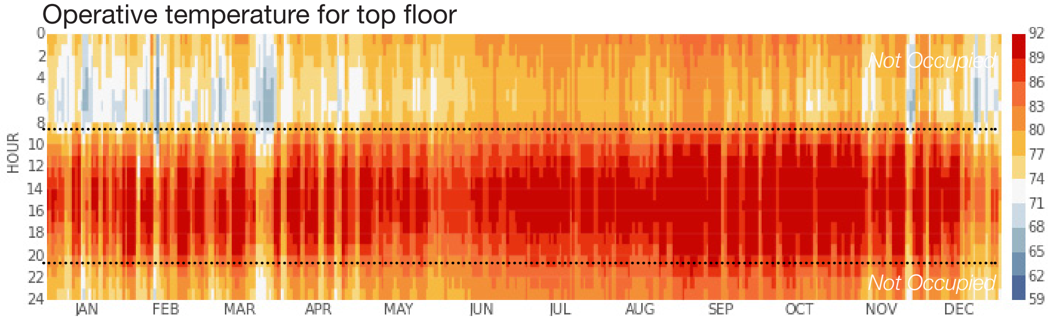


Degrees from comfort for bottom floor

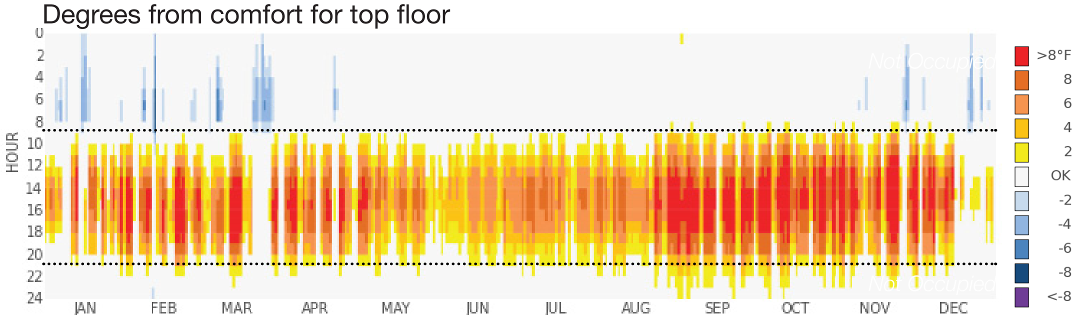




Operative temperature for top floor



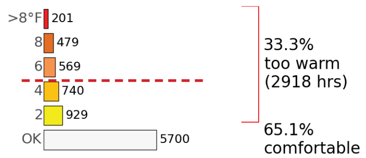
Degrees from comfort for top floor



LOISOS + UBBELOHDE

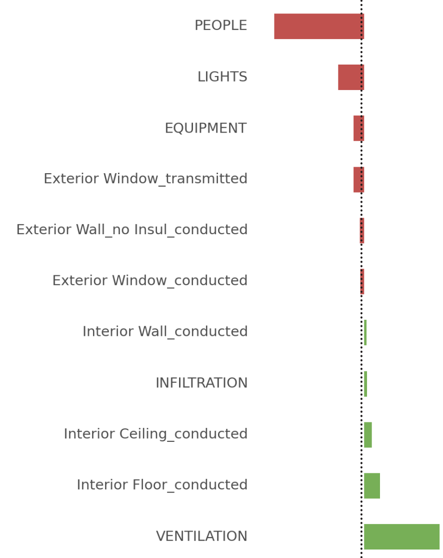
Add/C.3.a.A.3 Classroom Analysis:: South Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	2918	**33%**	**100%**
		w/ celing fans	1249	14%	46%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



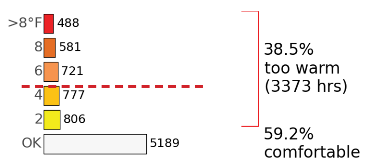
*** If considering only occupied hours*

(M-F 8am-8pm):: 100% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

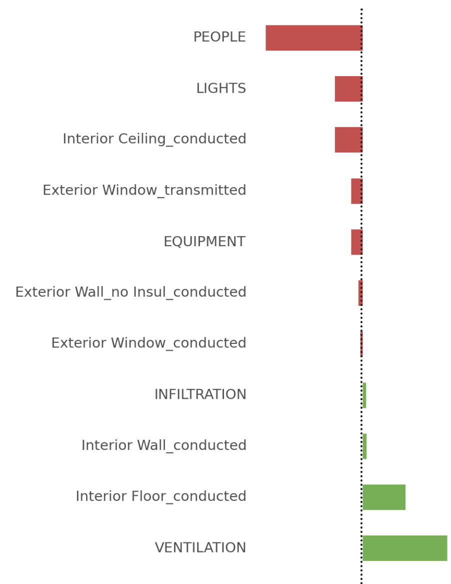
46% too warm.

			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3373	**39%**	**100%**
		w/ celing fans	1790	20%	66%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



*** If considering only occupied hours*

(M-F 8am-8pm):: 100% too warm.

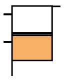
**** With ceiling fans (M-F 8am-8pm)::*

66% too warm.

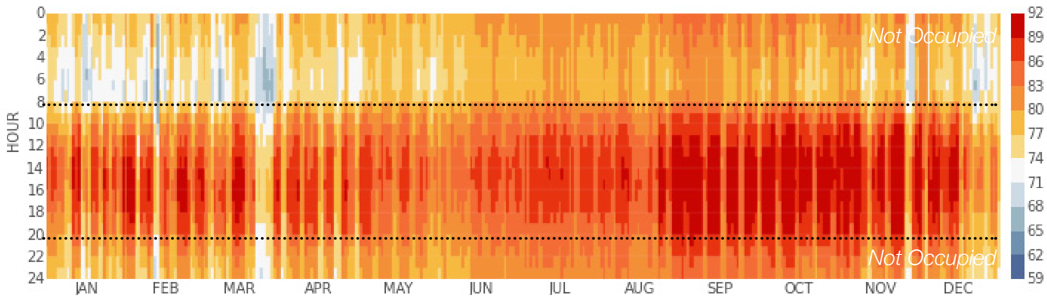
Add/C.3.a CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.B. INTERNAL LOAD PARAMETRICS

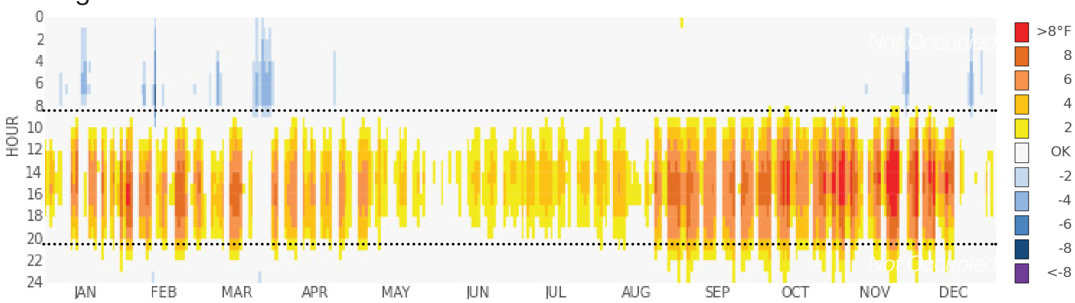
C.3.a.B.1 TYPICAL + IECC Windows + Shading + lower LPD +1ACH

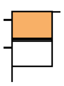


Operative temperature for bottom floor

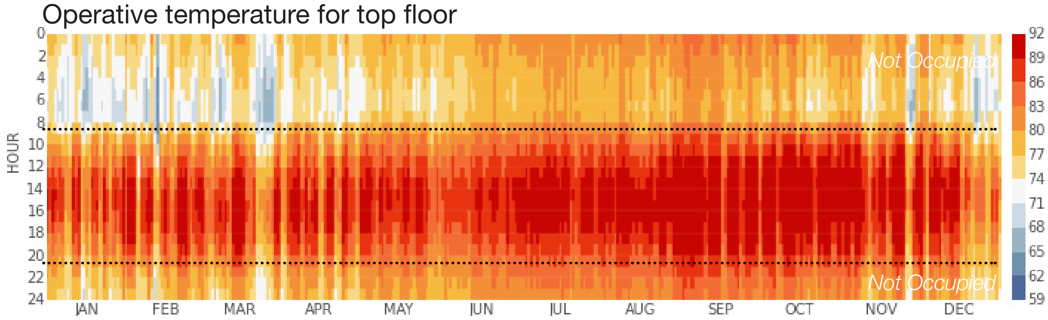


Degrees from comfort for bottom floor

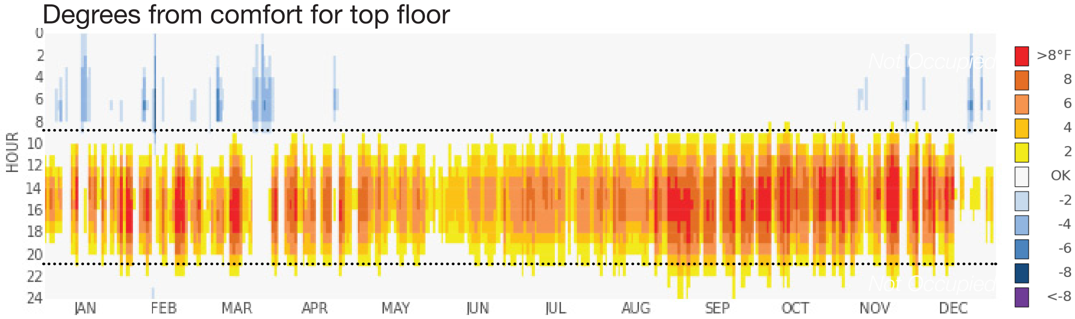




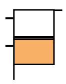
Operative temperature for top floor



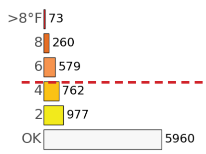
Degrees from comfort for top floor



Add/C.3.a.B.1 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-1	A-3. + LOW LPD	too warm	2651	**30%**	**98%**
		w/ celing fans	912	10%	34%

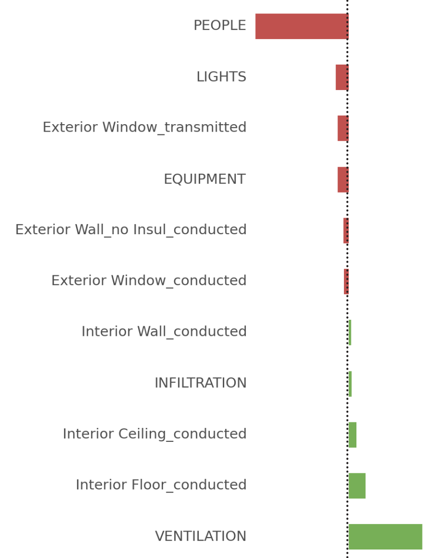


30.3%
too warm
(2651 hrs)

68.0%
comfortable

** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

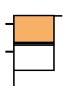


*** If considering only occupied hours*

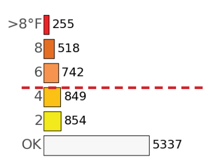
(M-F 8am-8pm):: 98% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

34% too warm.



			Top Floor		
			hours	% of the whole year	% of occupied time
B-1	A-3. + LOW LPD	too warm	3218	**37%**	**100%**
		w/ celing fans	1515	17%	56%

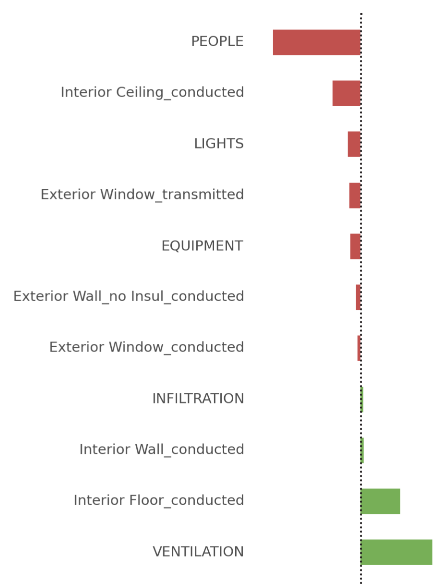


36.7%
too warm
(3218 hrs)

60.9%
comfortable

** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



*** If considering only occupied hours*

(M-F 8am-8pm):: 100% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

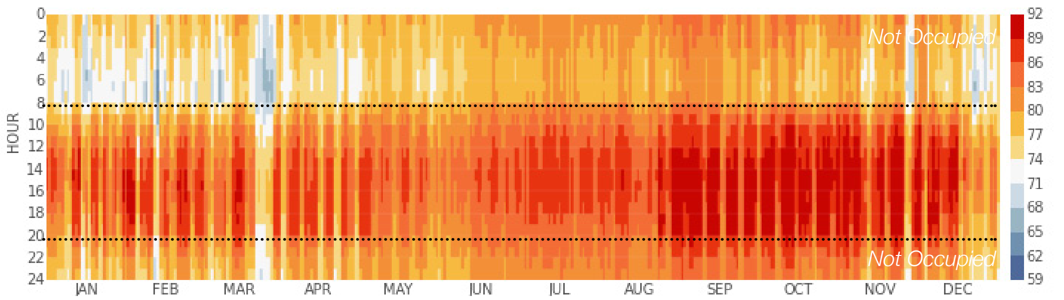
56% too warm.

Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

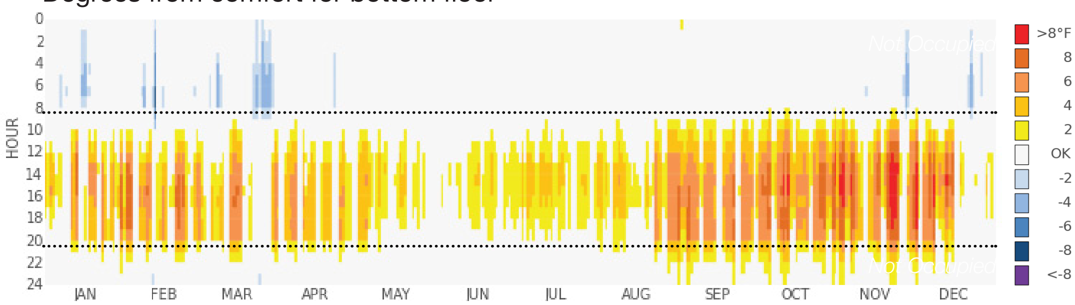
C.3.a.B. INTERNAL LOAD PARAMETRICS

C.3.a.B.2 TYPICAL + IECC Windows + Shading + Daylight Controls +1ACH

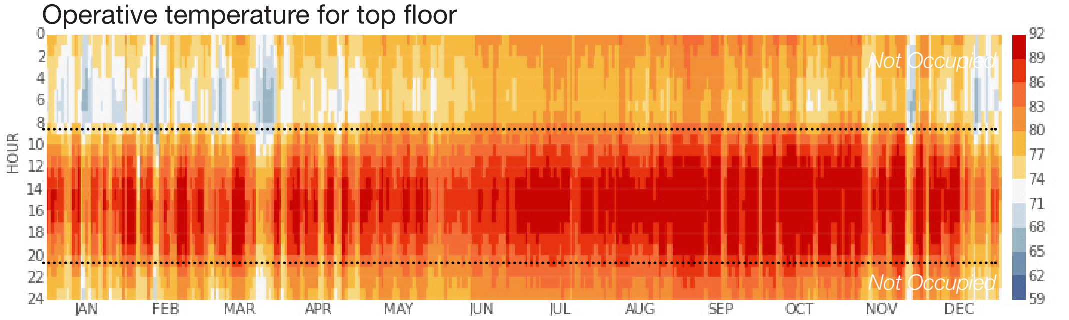
Operative temperature for bottom floor



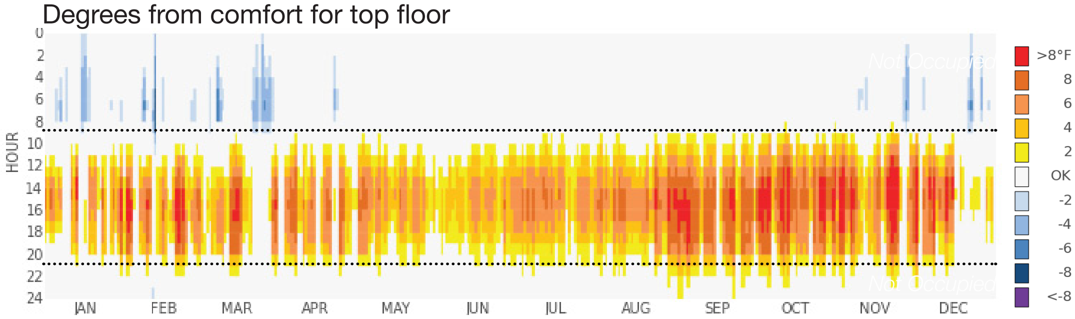
Degrees from comfort for bottom floor



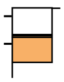
Operative temperature for top floor



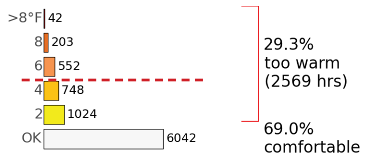
Degrees from comfort for top floor



Add/C.3.a.B.2 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-2	A-3. + DAYLIGHT CONTROLS	too warm	2569	**29%**	**95%**
		w/ celing fans	797	9%	30%

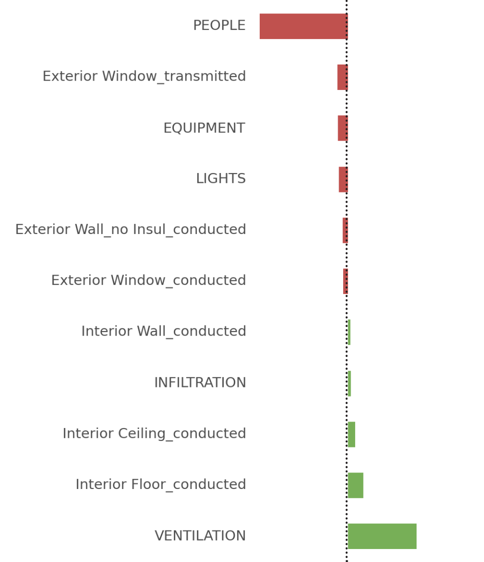


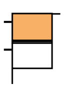
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

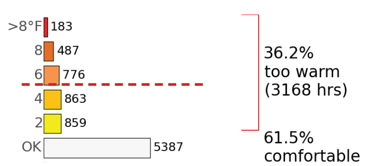
*** If considering only occupied hours (M-F 8am-8pm):: 95% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 30% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
B-2	A-3. + DAYLIGHT CONTROLS	too warm	3168	**36%**	**100%**
		w/ celing fans	1446	17%	54%

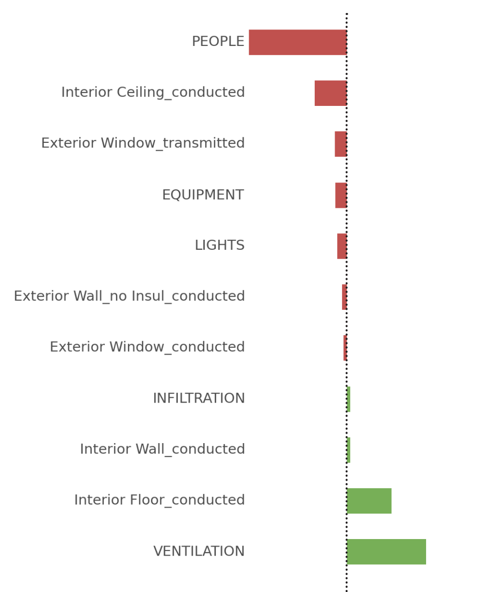


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 54% too warm.*

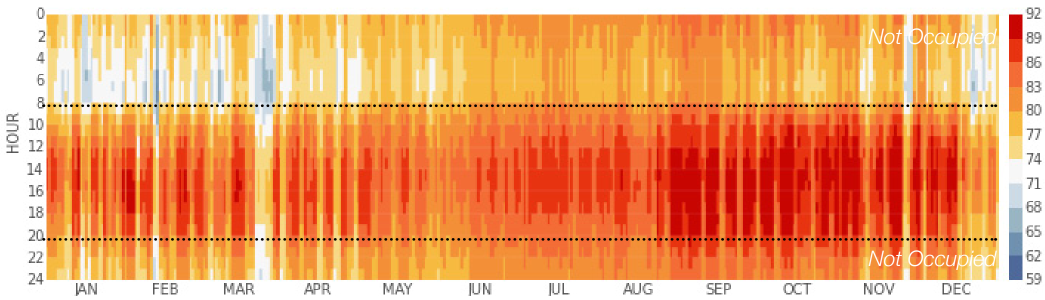


Add/C.3.a CLASSROOM ANALYSIS:: SOUTH FACING

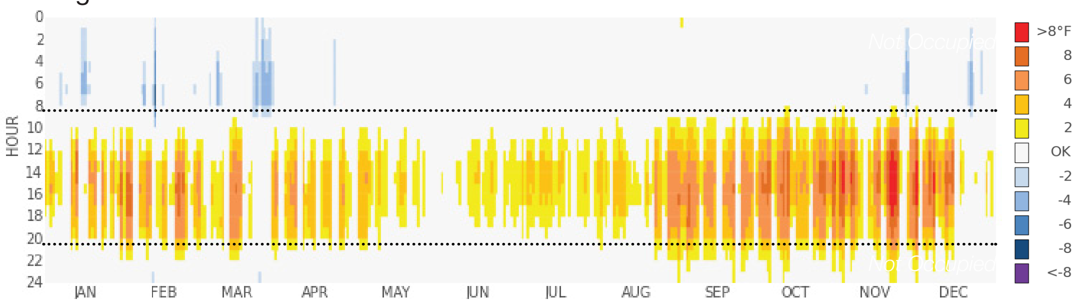
C.3.a.B. INTERNAL LOAD PARAMETRICS:: MINIMUM SUITE

C.3.a.B.3 TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

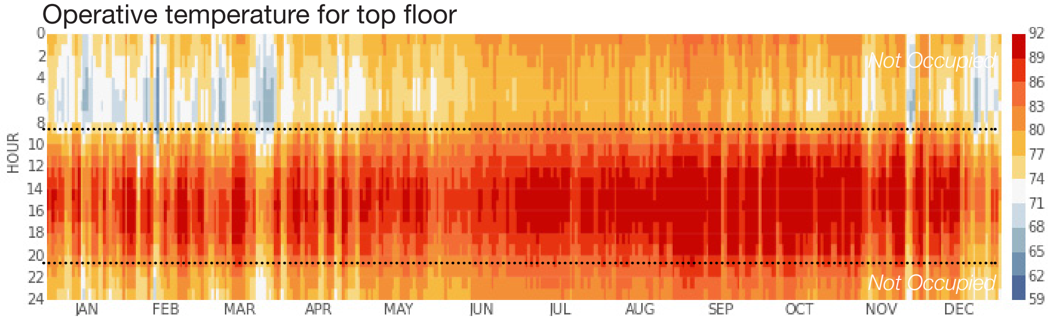
Operative temperature for bottom floor



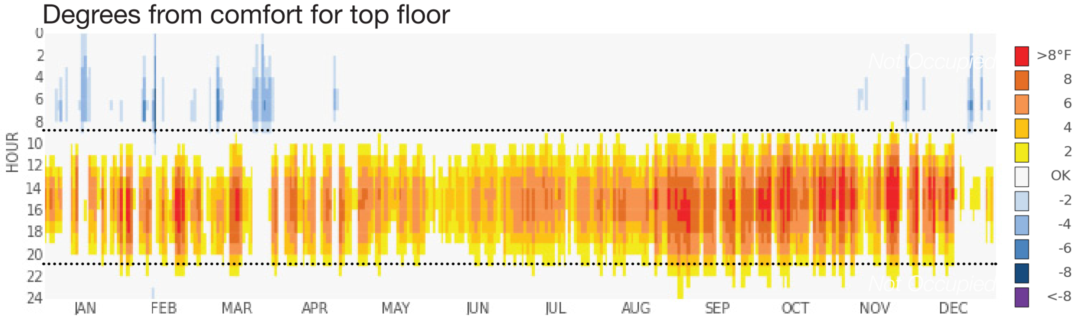
Degrees from comfort for bottom floor



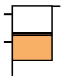
Operative temperature for top floor



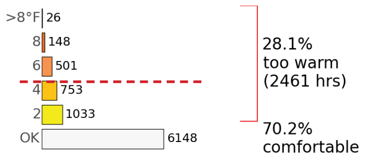
Degrees from comfort for top floor



Add/C.3.a.B.3 Classroom Analysis:: South Facing (Continued)

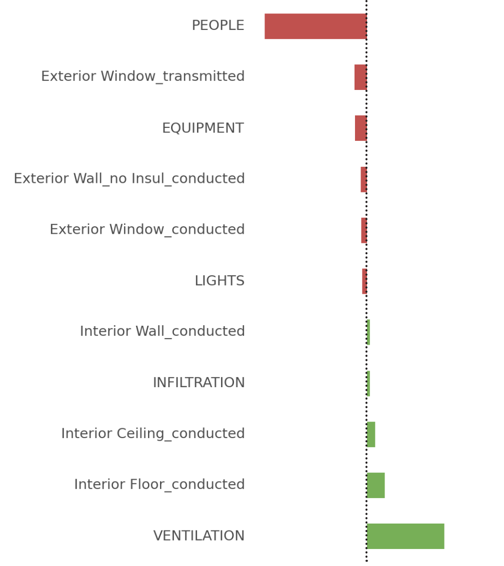


B-3	MINIMUM SUITE		Bottom Floor		
			hours	% of the whole year	% of occupied time
		too warm	2461	**28%**	**91%**
		w/ celing fans	675	8%	25%



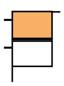
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

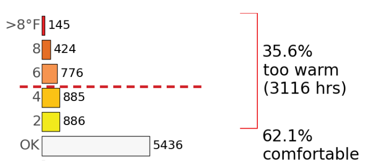


*** If considering only occupied hours (M-F 8am-8pm)::91% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 25% too warm.*

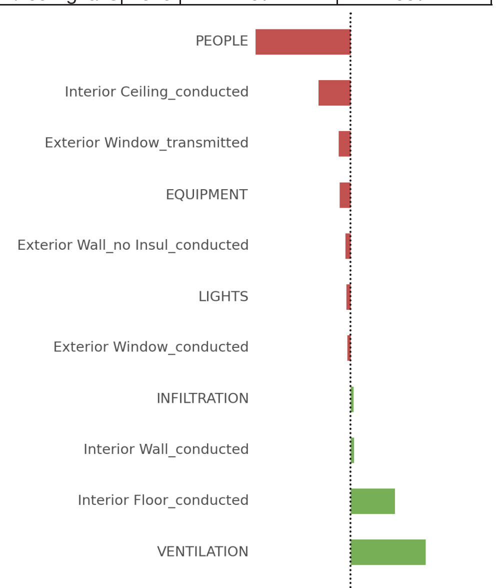


B-3	MINIMUM SUITE		Top Floor		
			hours	% of the whole year	% of occupied time
		too warm	3116	**36%**	**100%**
		w/ celing fans	1345	15%	50%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

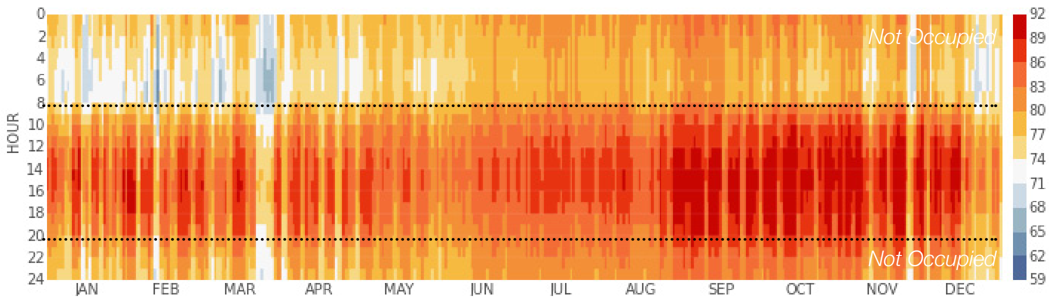
**** With ceiling fans (M-F 8am-8pm):: 50% too warm.*

Add/C.3.a CLASSROOM ANALYSIS:: SOUTH FACING

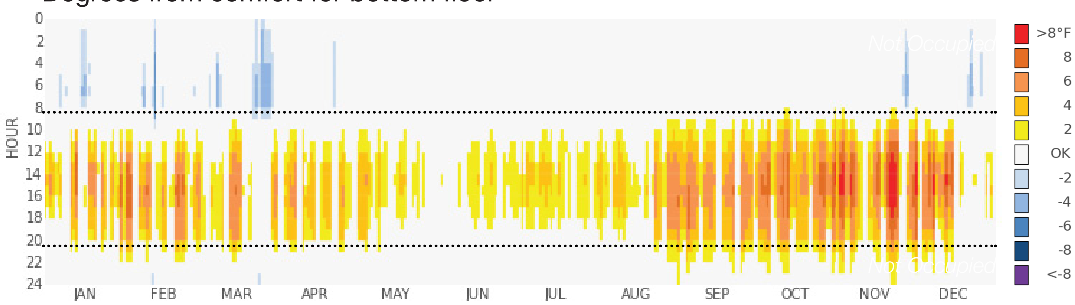
C.3.a.C. EXTERIOR OPAQUE SURFACE PARAMETRICS:: IMPROVED SUITE

C.3.a.C.1 MINIMUM SUITE + IECC Roof

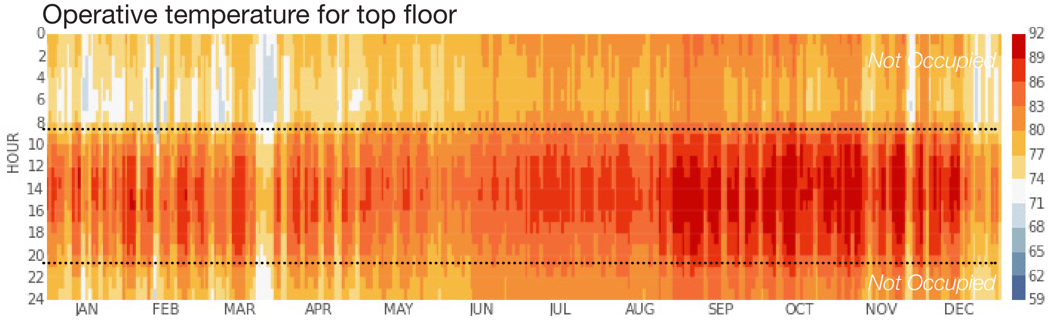
Operative temperature for bottom floor



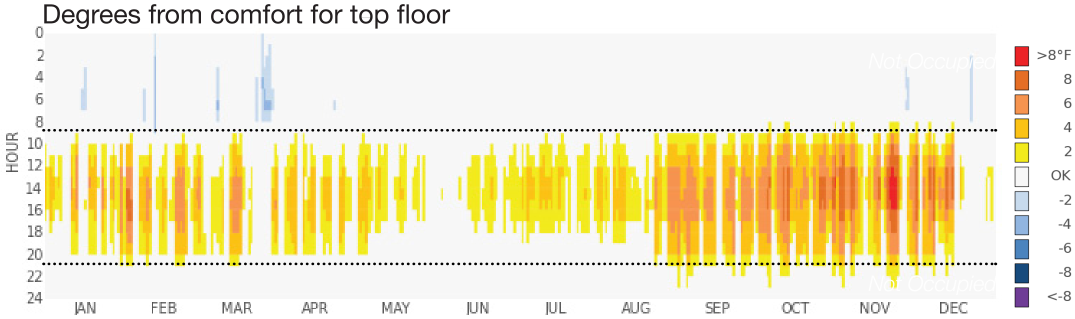
Degrees from comfort for bottom floor



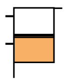
Operative temperature for top floor



Degrees from comfort for top floor



Add/C.3.a.C.1 Classroom Analysis:: South Facing (Continued)



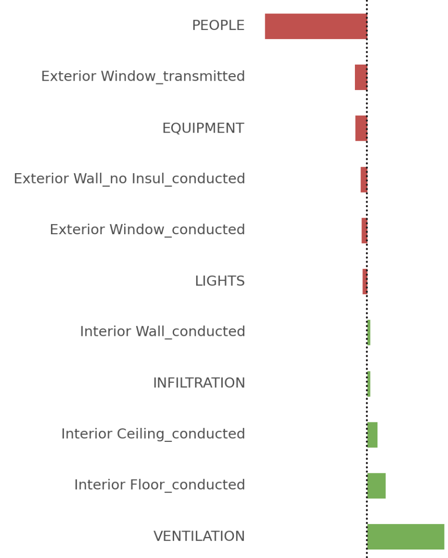
			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2406	**27%**	**89%**
		w/ celing fans	678	8%	25%

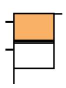
** Including all 8760 hrs of the year, not only occupied hours*

----- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 89% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 25% too warm.*





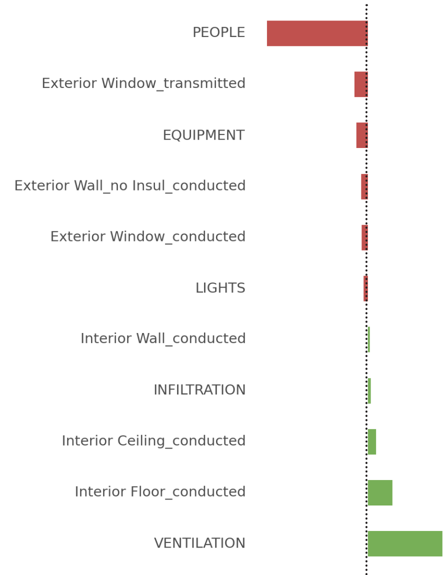
			Top Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2402	**27%**	**89%**
		w/ celing fans	525	6%	19%

** Including all 8760 hrs of the year, not only occupied hours*

---------- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 89% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 19% too warm.*

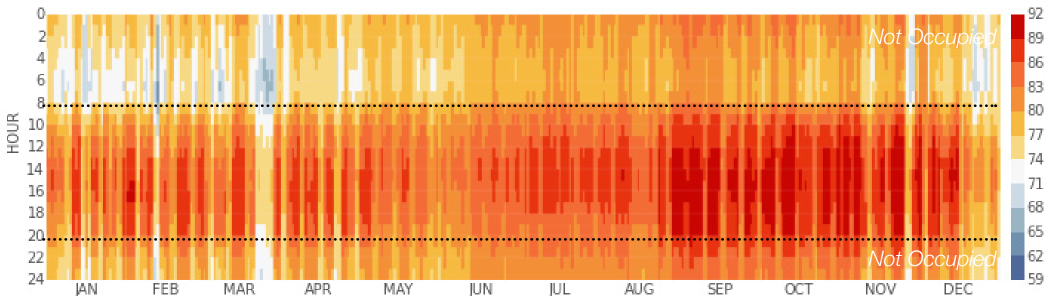


Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

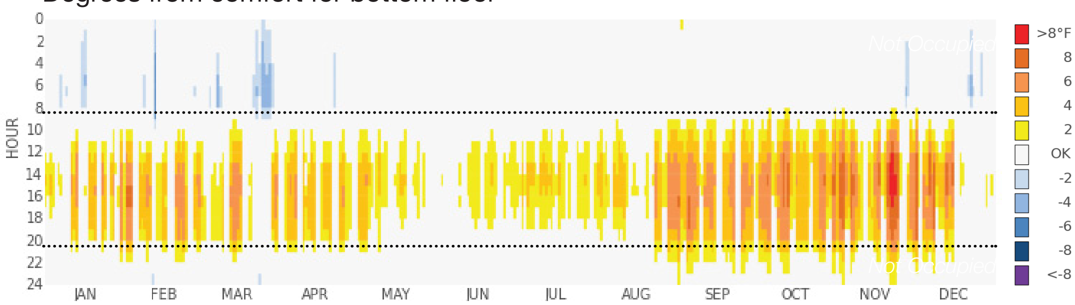
C.3.a.C. EXTERIOR OPAQUE SURFACE PARAMETRICS:: CODE SUITE

C.3.a.C.2 IMPROVED SUITE + IECC Walls

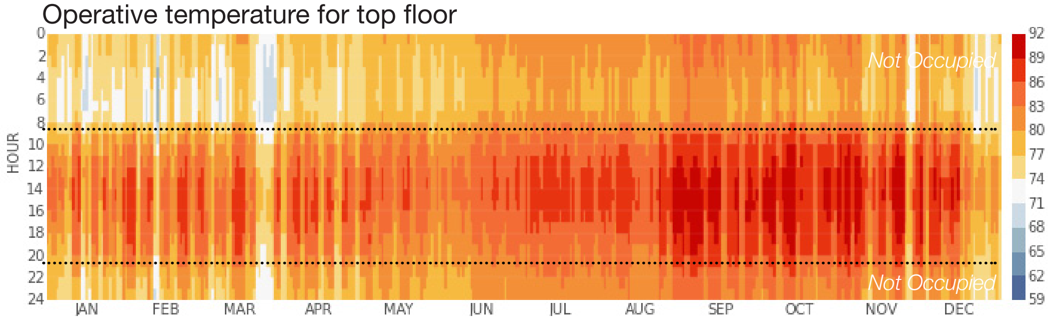
Operative temperature for bottom floor



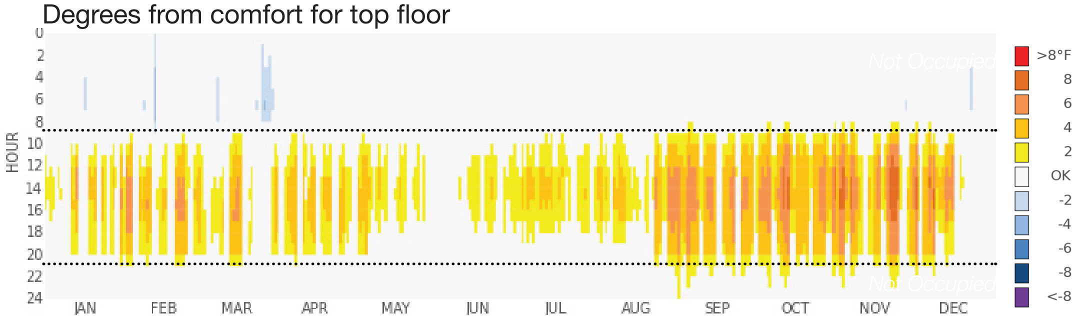
Degrees from comfort for bottom floor



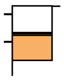
Operative temperature for top floor



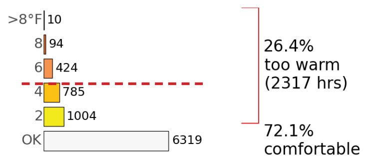
Degrees from comfort for top floor

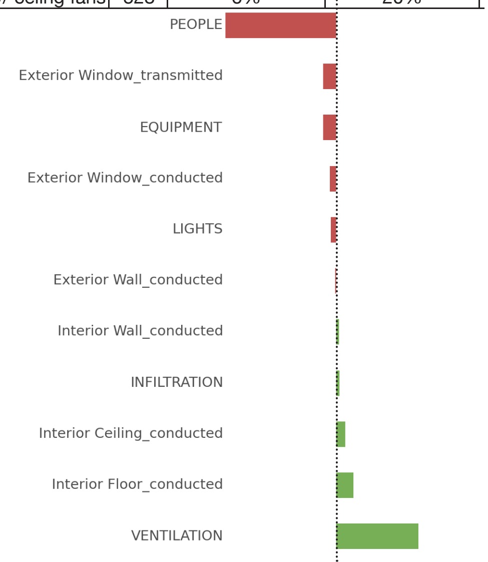


Add/C.3.a.C.2 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2317	**26%**	**86%**
		w/ celing fans	528	6%	20%



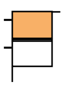


** Including all 8760 hrs of the year, not only occupied hours*

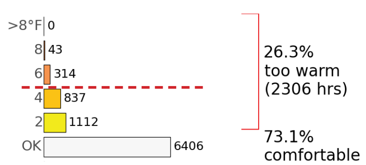
- - - - - *Ceiling Fans Effective*

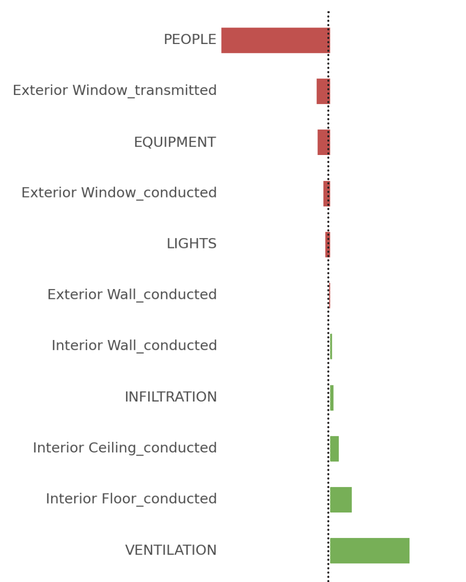
*** If considering only occupied hours (M-F 8am-8pm):: 86% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 20% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2306	**26%**	**85%**
		w/ celing fans	357	4%	13%





** Including all 8760 hrs of the year, not only occupied hours*

- - - - - - - - - *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 85% too warm.*

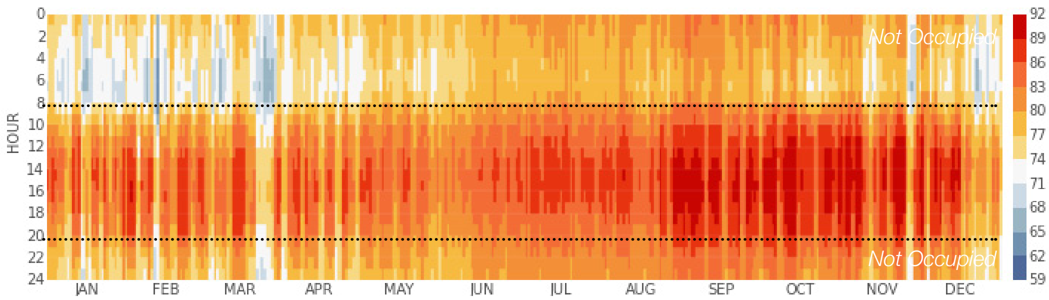
**** With ceiling fans (M-F 8am-8pm):: 13% too warm.*

Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

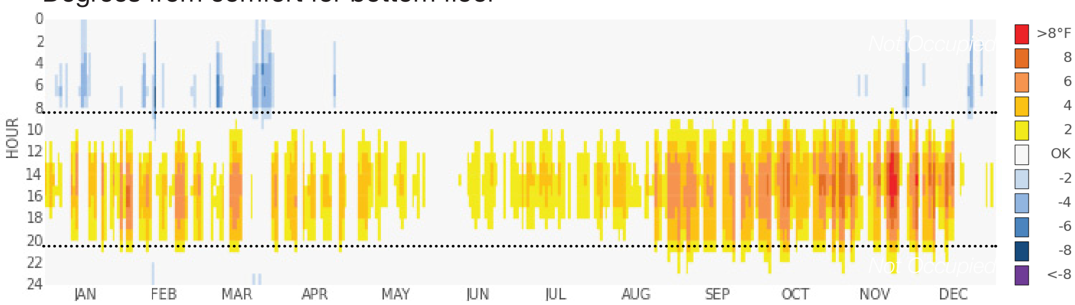
C.3.a.D. VENTILATION PARAMETRICS

C.3.a.D.1 MINIMUM SUITE +2ACH

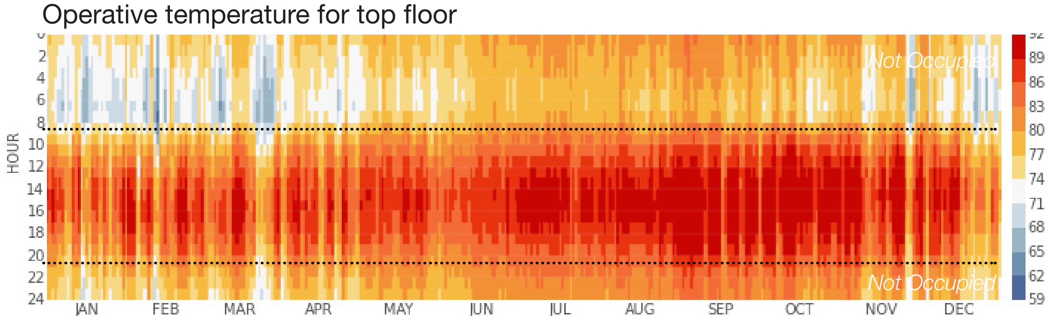
Operative temperature for bottom floor



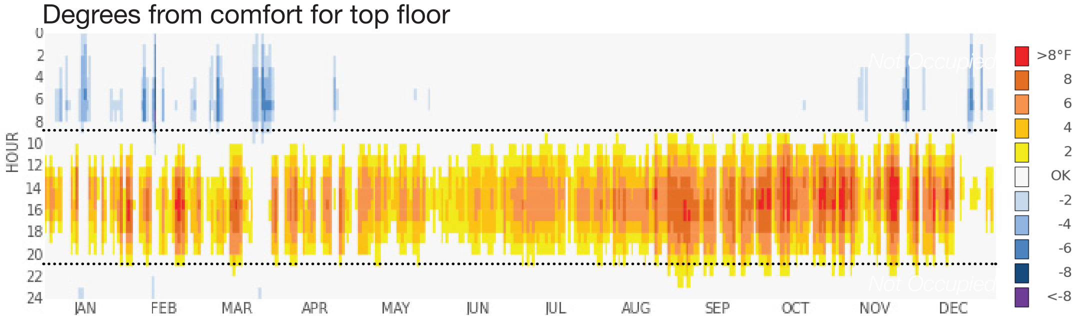
Degrees from comfort for bottom floor



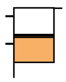
Operative temperature for top floor



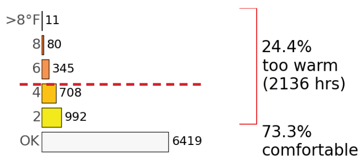
Degrees from comfort for top floor



Add/C.3.a.D.1 Classroom Analysis:: South Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
D-1 MINIMUM SUITE + 2 ACH	too warm	2136	**24%**	**79%**
	w/ celing fans	436	5%	16%

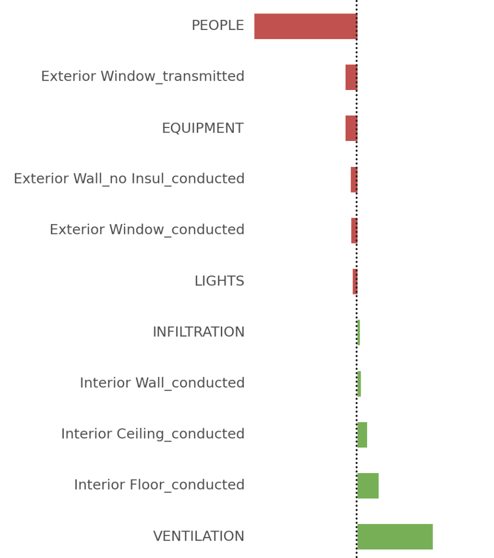


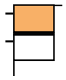
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

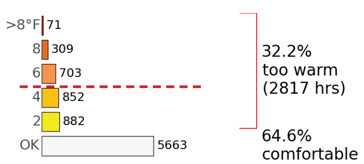
*** If considering only occupied hours (M-F 8am-8pm):: 79% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 16% too warm.*





		Top Floor		
		hours	% of the whole year	% of occupied time
D-1 MINIMUM SUITE + 2 ACH	too warm	2817	**32%**	**100%**
	w/ celing fans	1083	12%	40%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

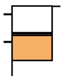
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 40% too warm.*

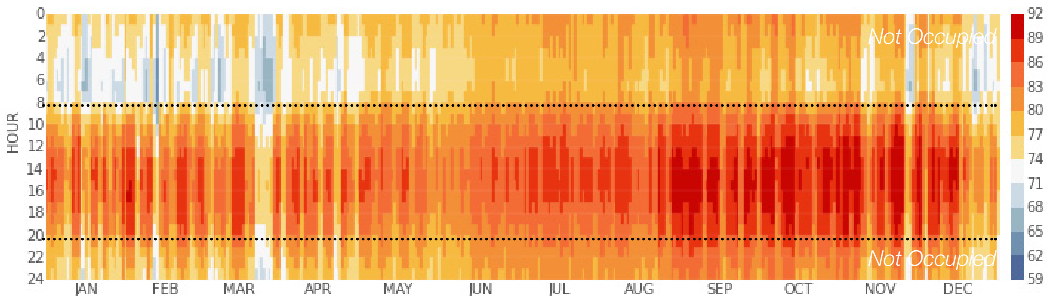
Add/C.3.a CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.D. VENTILATION PARAMETRICS

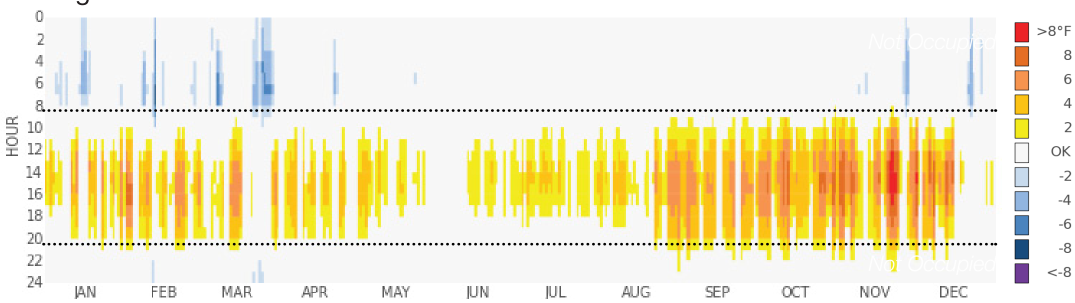
C.3.a.D.2 IMPROVED SUITE +2ACH

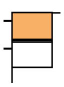


Operative temperature for bottom floor

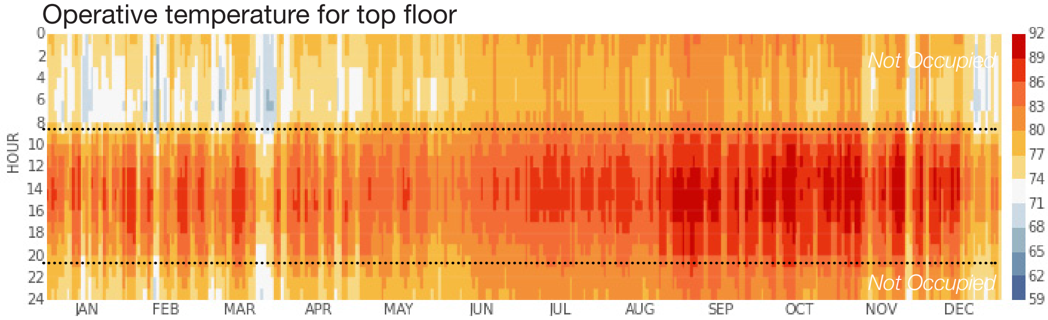


Degrees from comfort for bottom floor

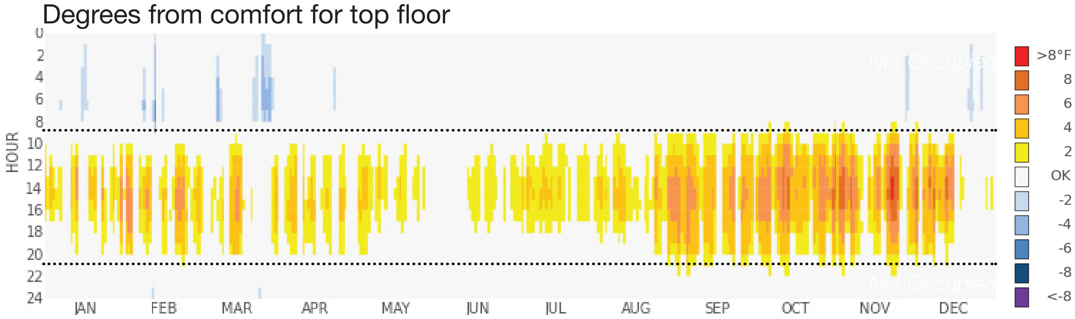




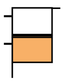
Operative temperature for top floor



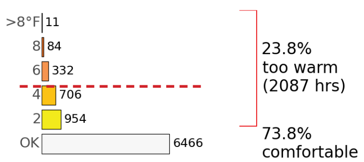
Degrees from comfort for top floor



Add/C.3.a.D.2 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2087	**24%**	**77%**
		w/ celing fans	427	5%	16%

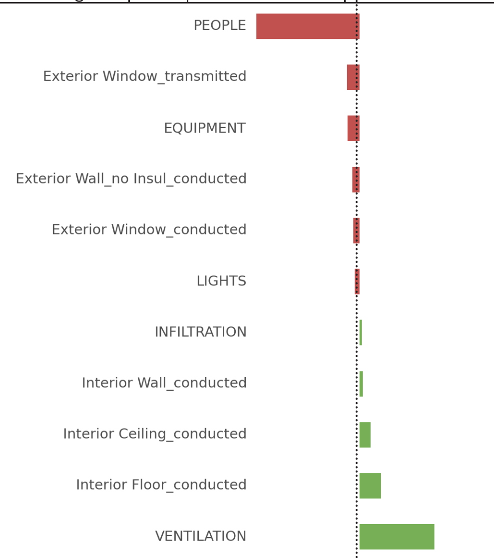


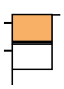
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

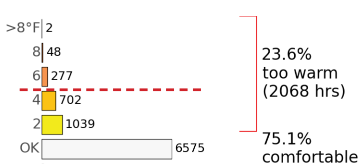
*** If considering only occupied hours (M-F 8am-8pm):: 77% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 16% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2068	**24%**	**77%**
		w/ celing fans	327	4%	12%

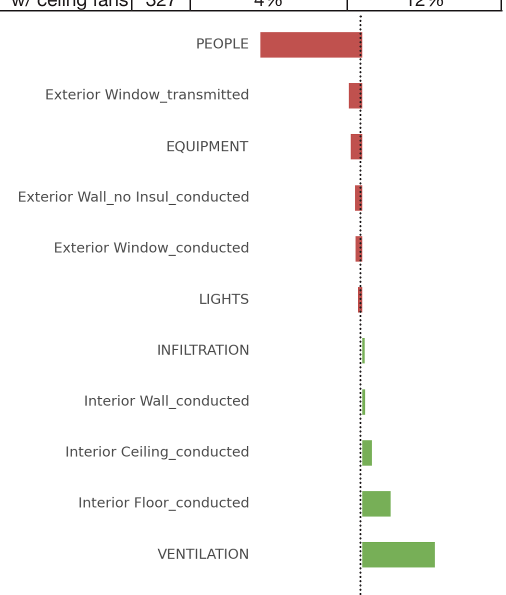


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 77% too warm.*

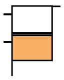
**** With ceiling fans (M-F 8am-8pm):: 12% too warm.*



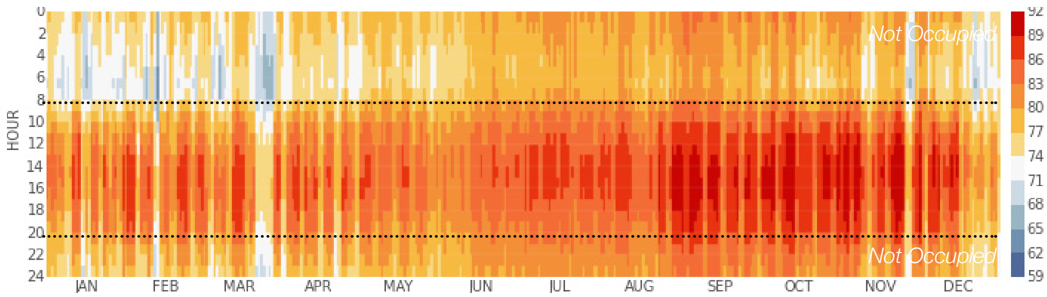
Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.D. VENTILATION PARAMETRICS

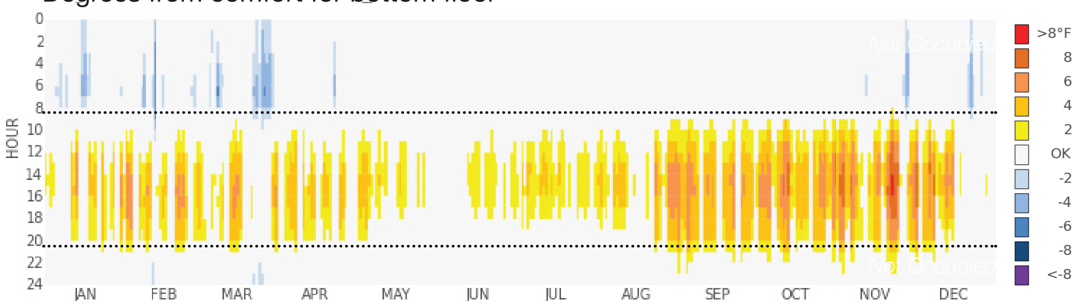
C.3.a.D.3 CODE SUITE +2ACH

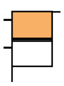


Operative temperature for bottom floor

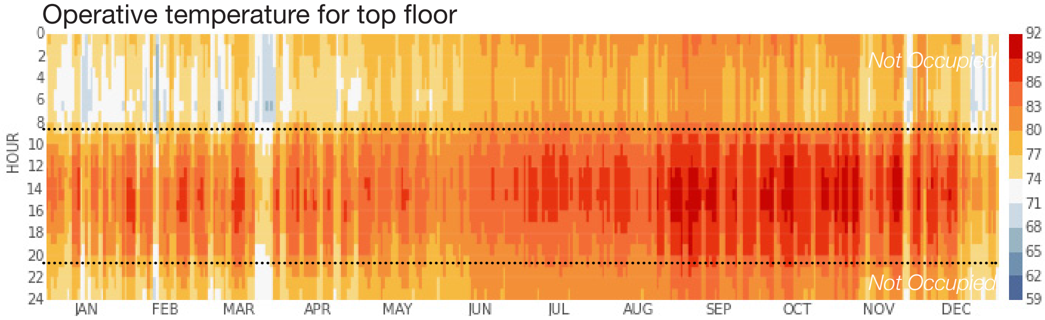


Degrees from comfort for bottom floor

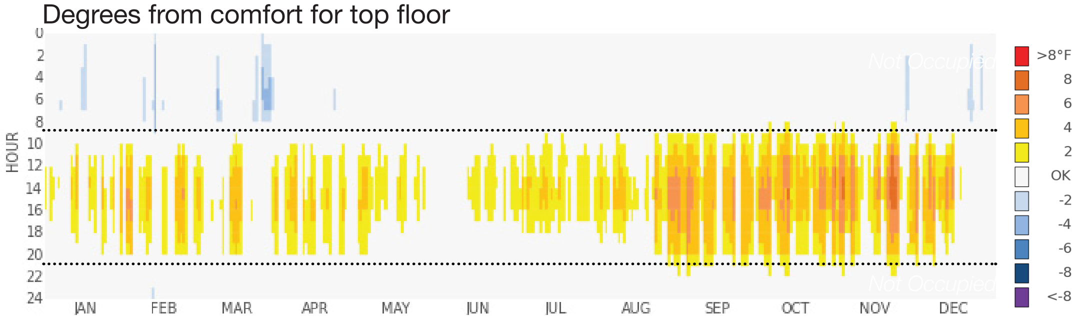




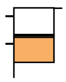
Operative temperature for top floor



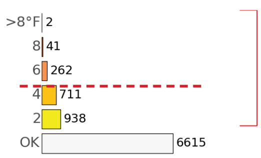
Degrees from comfort for top floor



Add/C.3.a.D.3 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-3	CODE SUITE + 2 ACH	too warm	1954	**22%**	**72%**
		w/ celing fans	305	3%	11%

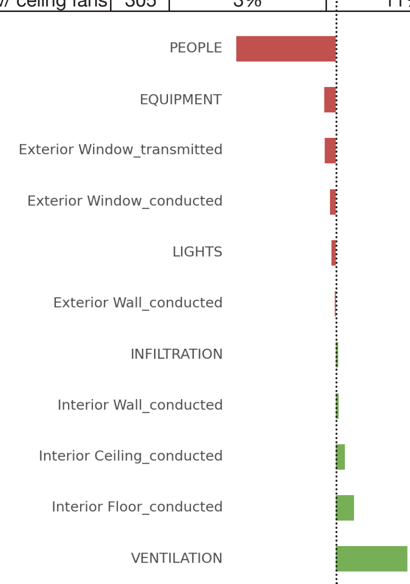


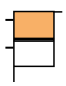
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

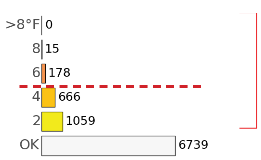
*** If considering only occupied hours (M-F 8am-8pm):: 72% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 11% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
D-3	CODE SUITE + 2 ACH	too warm	1918	**22%**	**71%**
		w/ celing fans	193	2%	7%

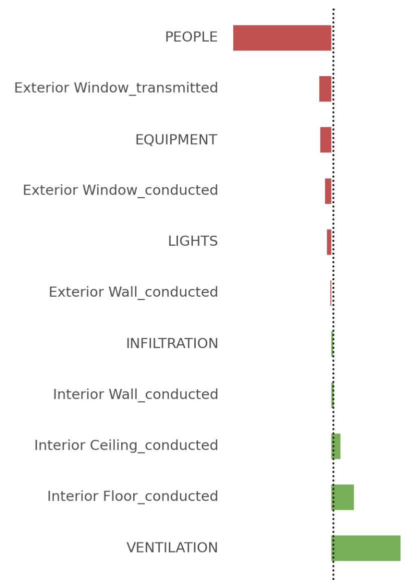


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 71% too warm.*

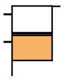
**** With ceiling fans (M-F 8am-8pm):: 7% too warm.*



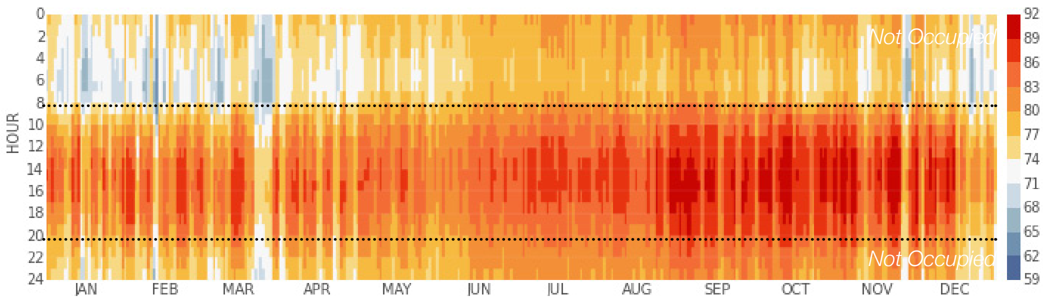
Add/C.3.a_ CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.D. VENTILATION PARAMETRICS

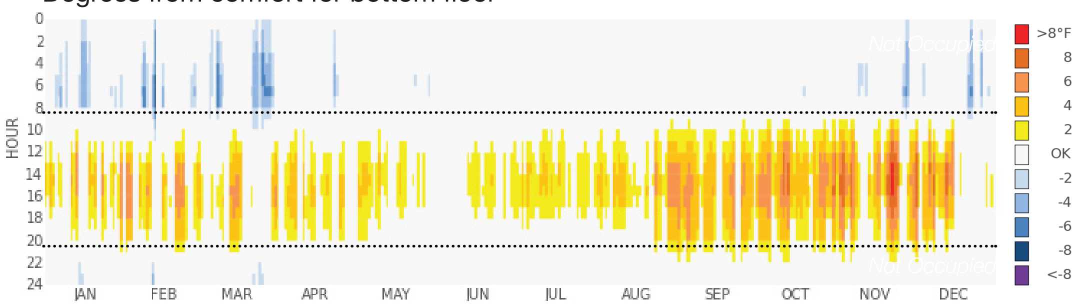
C.3.a.D.4 MINIMUM SUITE +3ACH

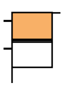


Operative temperature for bottom floor

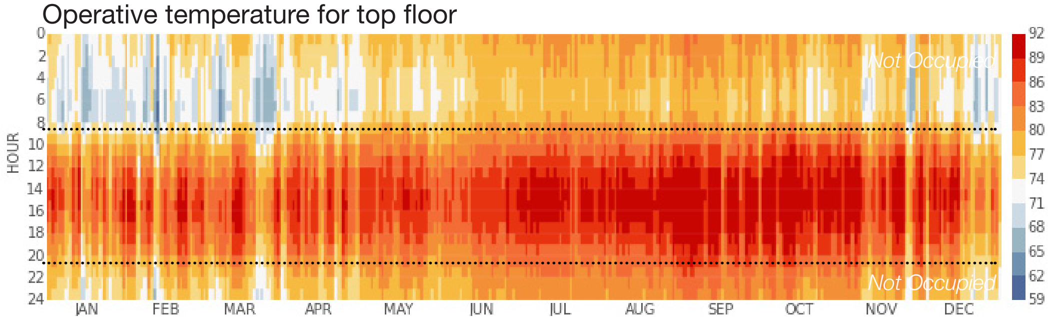


Degrees from comfort for bottom floor

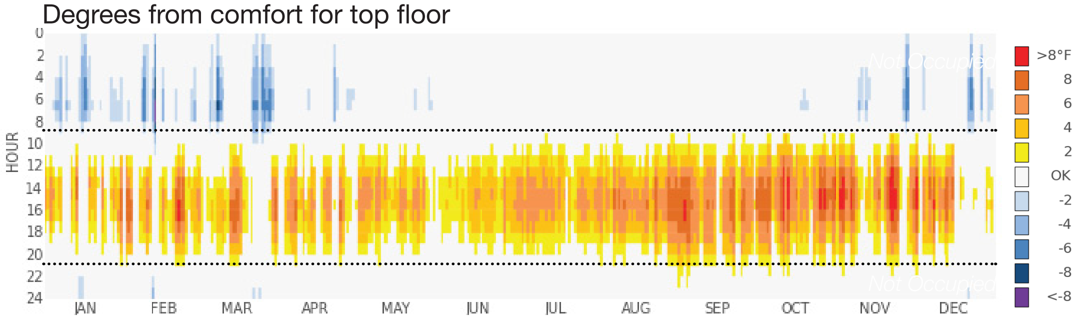




Operative temperature for top floor

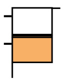


Degrees from comfort for top floor

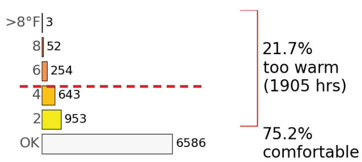


LOISOS + UBBELOHDE

Add/C.3.a.D.4 Classroom Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-4	MINIMUM SUITE + 3 ACH	too warm	1905	**22%**	**71%**
		w/ celing fans	309	4%	11%

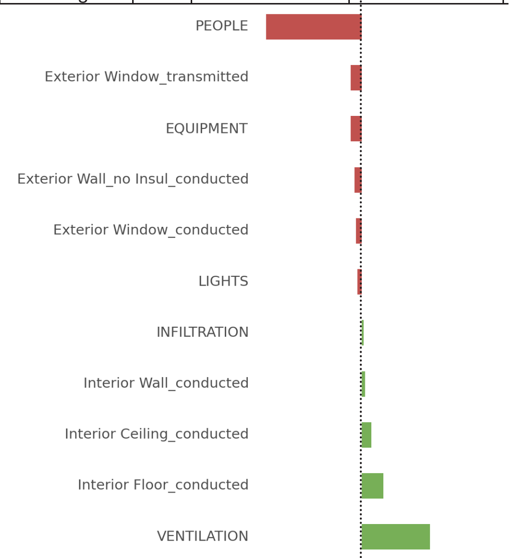


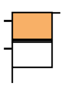
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

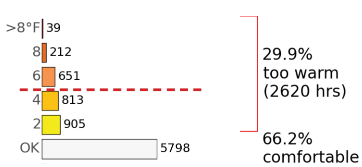
*** If considering only occupied hours (M-F 8am-8pm):: 71% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 11% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
D-4	MINIMUM SUITE + 3 ACH	too warm	2620	**30%**	**97%**
		w/ celing fans	902	10%	33%

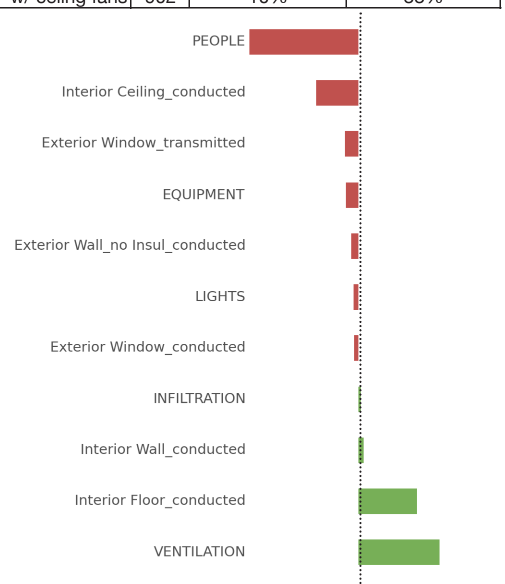


** Including all 8760 hrs of the year, not only occupied hours*

---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 97% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 33% too warm.*

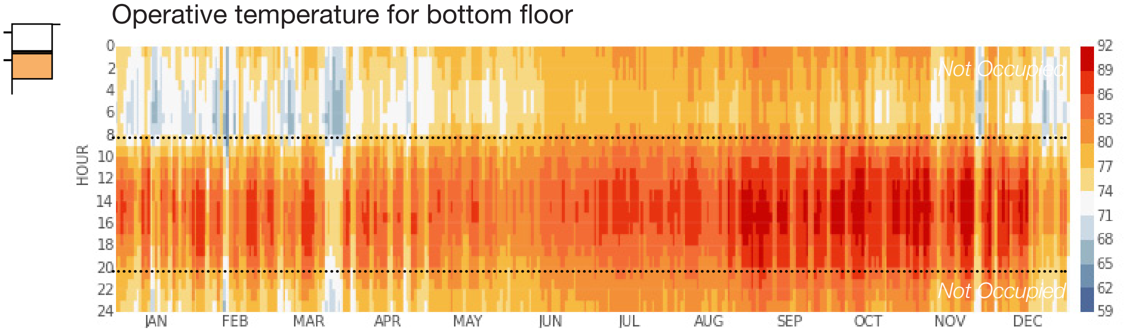


Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

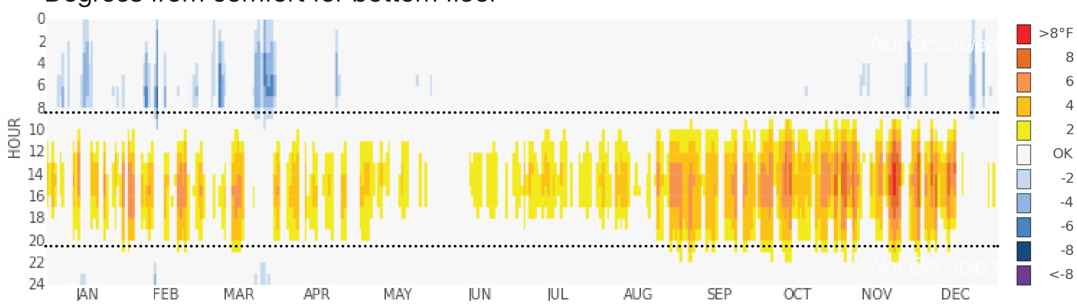
C.3.a.D. VENTILATION PARAMETRICS

C.3.a.D.5 IMPROVED SUITE +3ACH

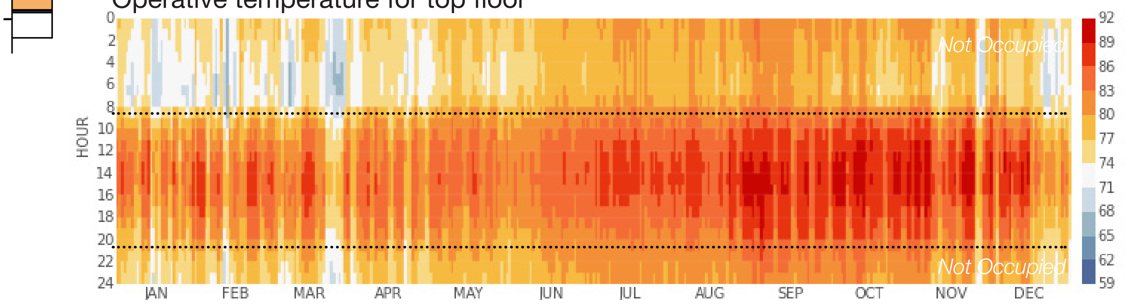
Operative temperature for bottom floor



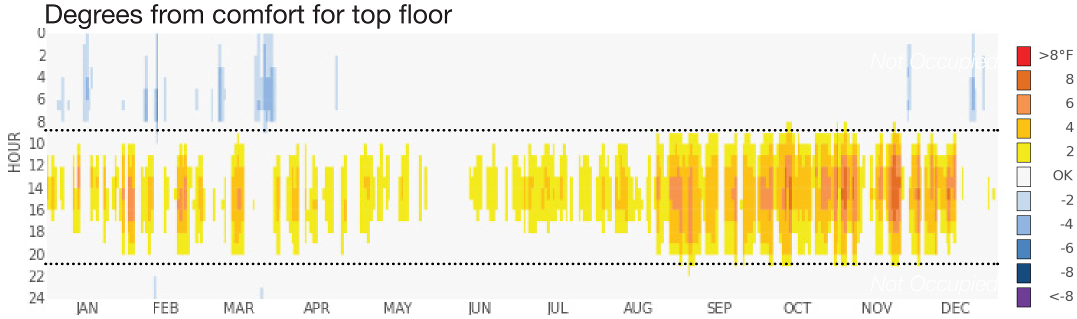
Degrees from comfort for bottom floor



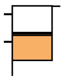
Operative temperature for top floor



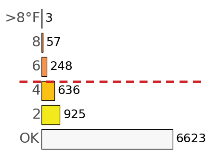
Degrees from comfort for top floor



AAdd/C.3.a.D.5 Classroom Analysis:: South Facing (Continued)

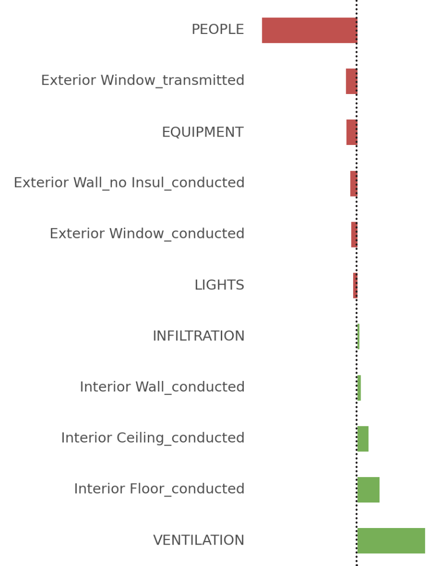


			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-5	IIMPROVED SUITE + 3 ACH	too warm	1869	**21%**	**69%**
		w/ celing fans	308	4%	11%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

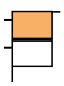


*** If considering only occupied hours*

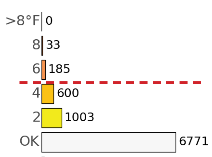
(M-F 8am-8pm):: 69% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

11% too warm.

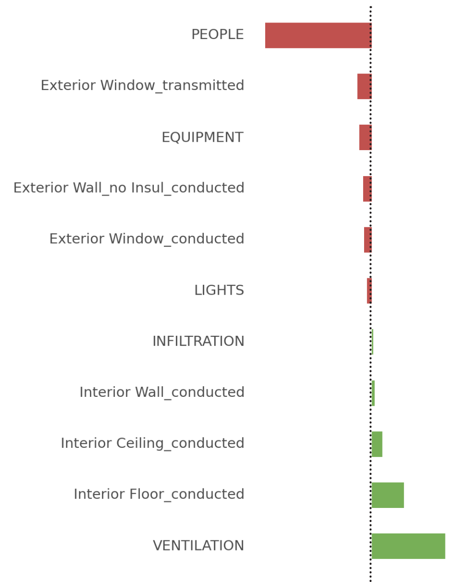


			Top Floor		
			hours	% of the whole year	% of occupied time
D-5	IIMPROVED SUITE + 3 ACH	too warm	1821	**21%**	**67%**
		w/ celing fans	218	2%	8%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



*** If considering only occupied hours*

(M-F 8am-8pm):: 67% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

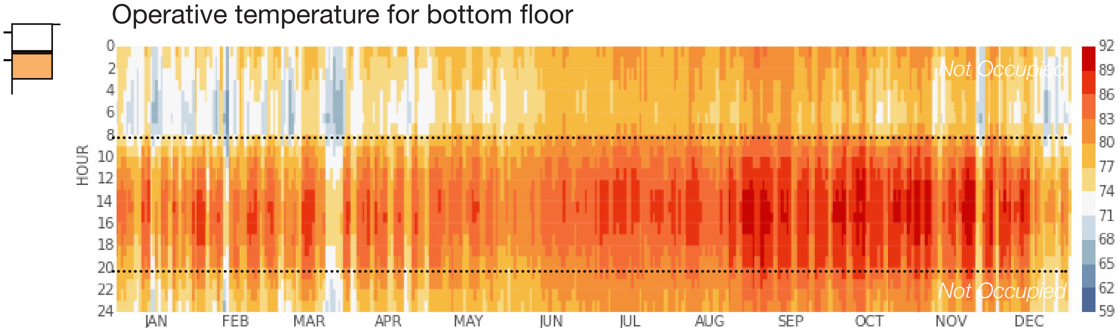
8% too warm.

Add/C.3.a_CLASSROOM ANALYSIS:: SOUTH FACING

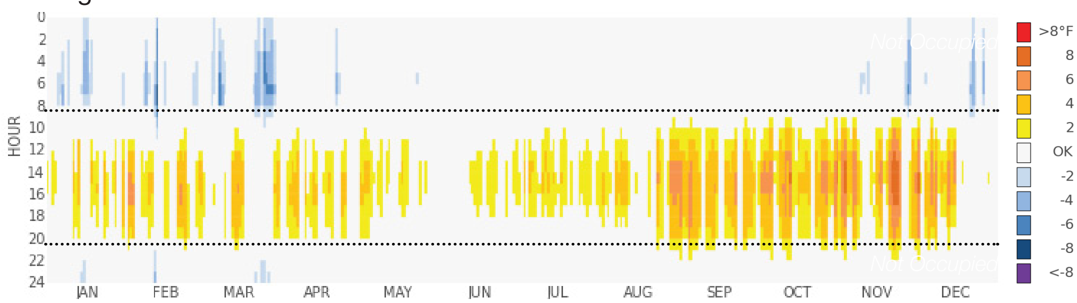
C.3.a.D. VENTILATION PARAMETRICS

C.3.a.D.6 CODE SUITE +3ACH

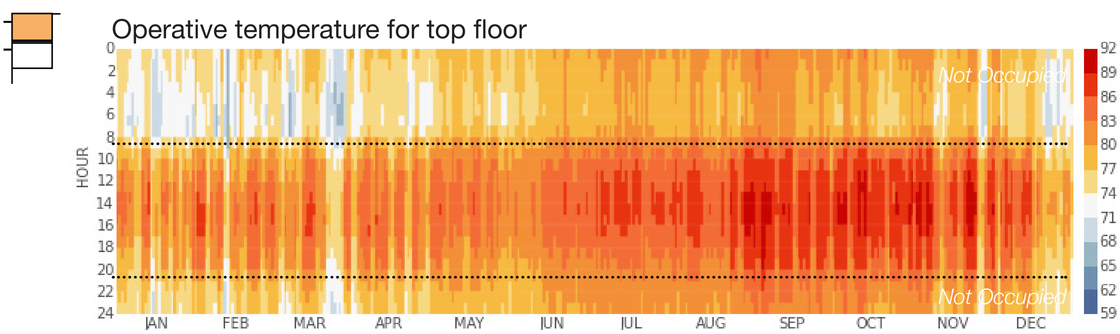
Operative temperature for bottom floor



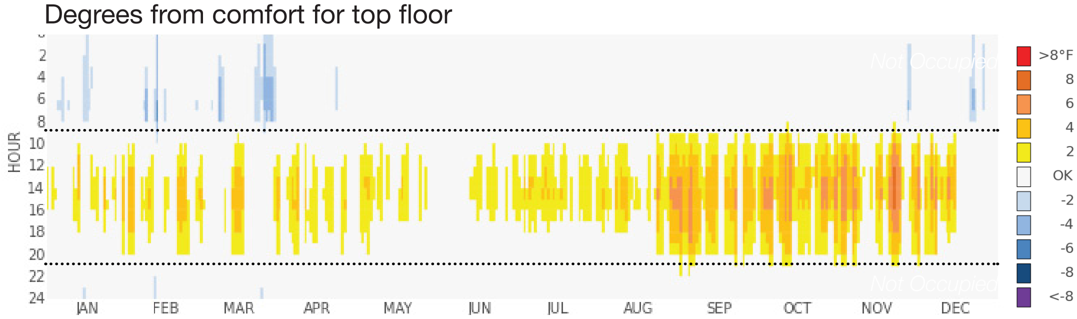
Degrees from comfort for bottom floor



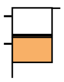
Operative temperature for top floor



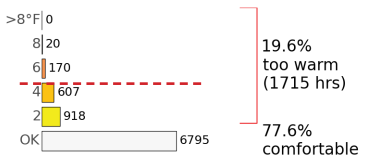
Degrees from comfort for top floor



Add/C.3.a.D.6 Classroom Analysis:: South Facing (Continued)

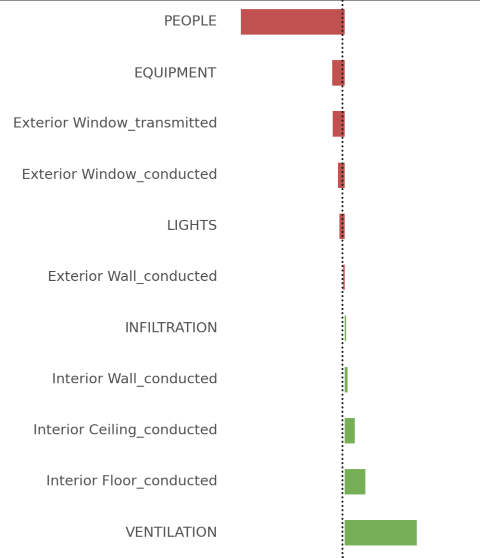


			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-6	CODE SUITE + 3 ACH	too warm	1715	**20%**	**64%**
		w/ celing fans	190	2%	7%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

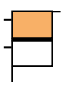


*** If considering only occupied hours*

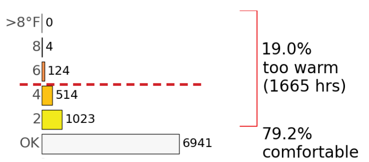
(M-F 8am-8pm):: 64% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

7% too warm.

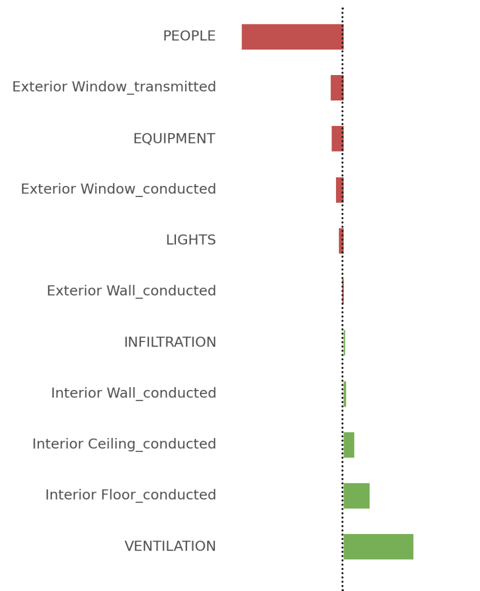


			Top Floor		
			hours	% of the whole year	% of occupied time
D-6	CODE SUITE + 3 ACH	too warm	1665	**19%**	**62%**
		w/ celing fans	128	1%	5%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



*** If considering only occupied hours*

(M-F 8am-8pm):: 62% too warm.

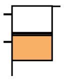
**** With ceiling fans (M-F 8am-8pm)::*

5% too warm.

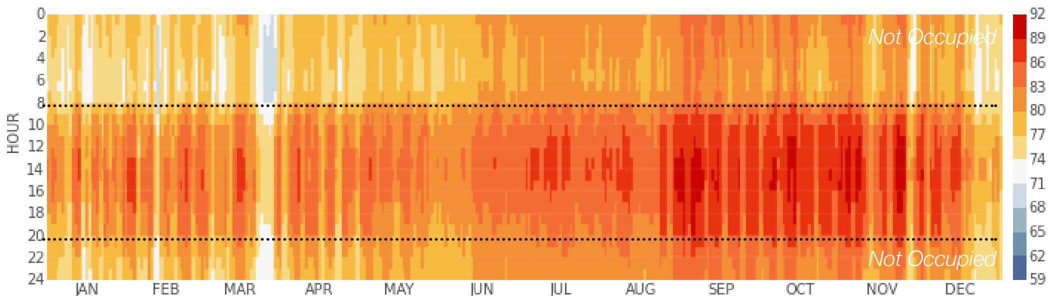
Add/C.3.a CLASSROOM ANALYSIS:: SOUTH FACING

C.3.a.E. THERMAL MASS:: IDEAL SUITE

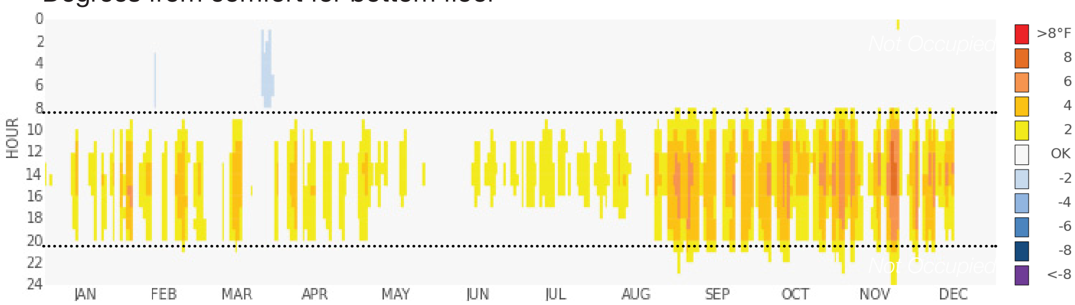
C.3.a.E.1 CODE SUITE + Thermal Mass

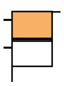


Operative temperature for bottom floor

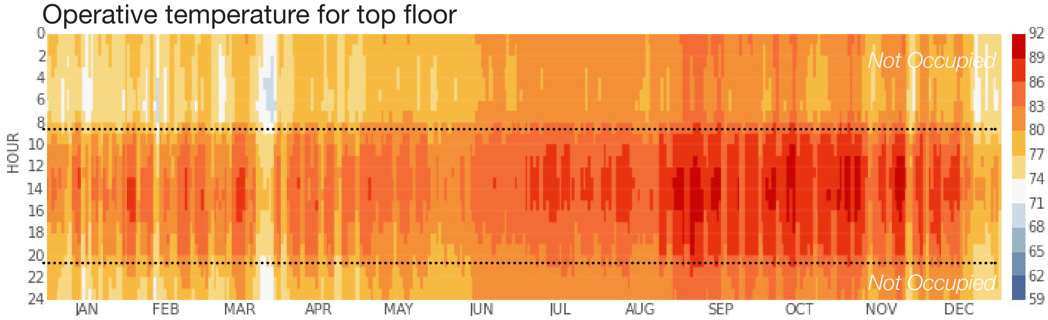


Degrees from comfort for bottom floor

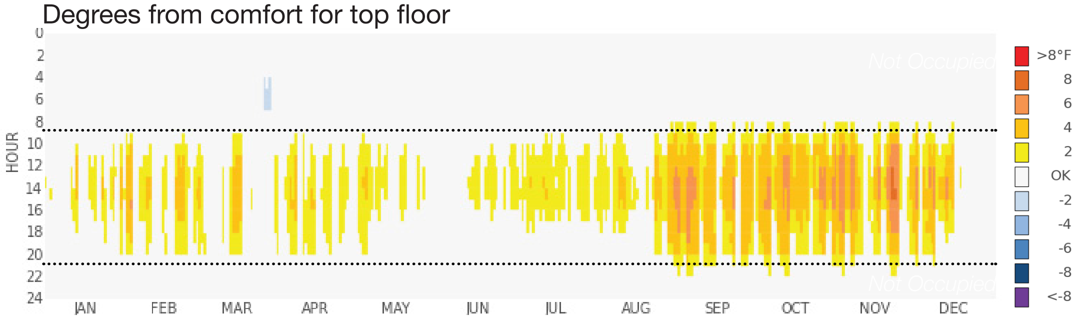




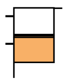
Operative temperature for top floor



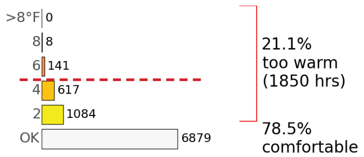
Degrees from comfort for top floor



Add/C.3.a.E.1 Classroom Analysis:: South Facing (Continued)

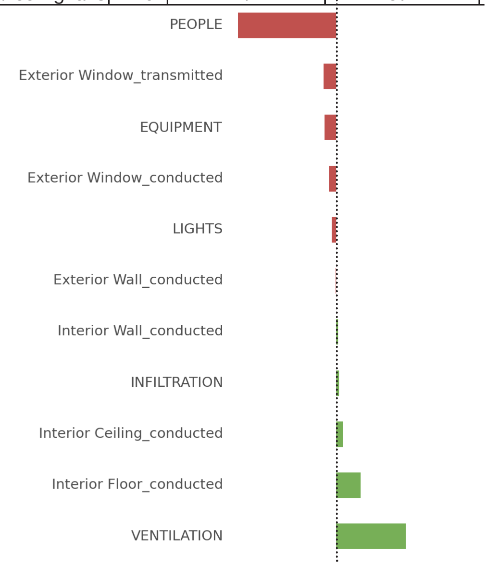


			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1850	**21%**	**69%**
		w/ celing fans	149	2%	6%



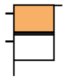
** Including all 8760 hrs of the year, not only occupied hours*

----- *Ceiling Fans Effective*



*** If considering only occupied hours (M-F 8am-8pm):: 69% too warm.*

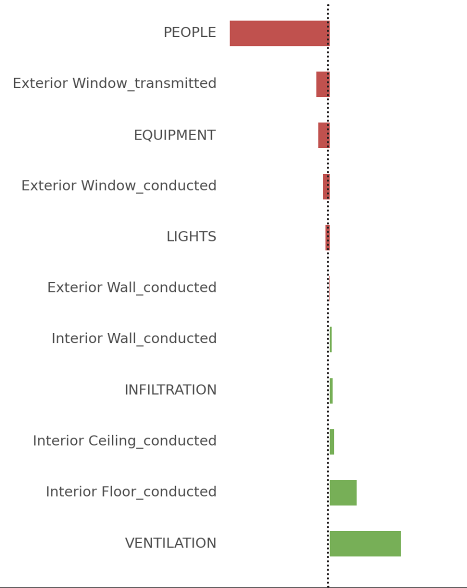
**** With ceiling fans (M-F 8am-8pm):: 6% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1944	**22%**	**72%**
		w/ celing fans	146	2%	5%

** Including all 8760 hrs of the year, not only occupied hours*

---------- *Ceiling Fans Effective*



*** If considering only occupied hours (M-F 8am-8pm):: 72% too warm.*

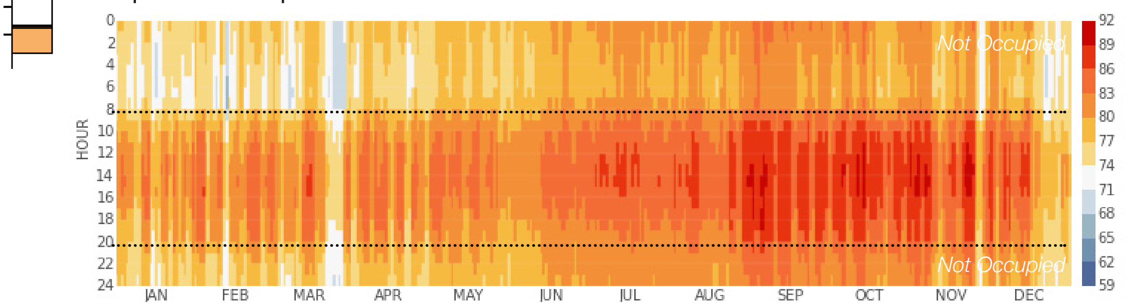
**** With ceiling fans (M-F 8am-8pm):: 5% too warm.*

Add/C.3.a CLASSROOM ANALYSIS:: SOUTH FACING

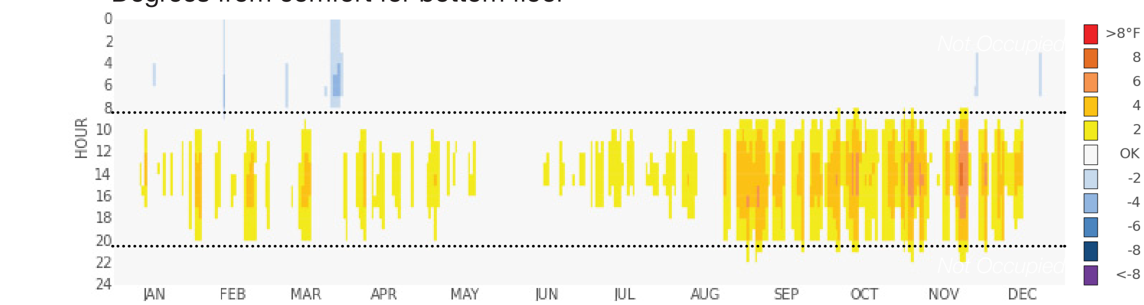
C.3.a.E. THERMAL MASS:: IDEAL SUITE

C.3.a.E.2 IDEAL SUITE + 2ACH

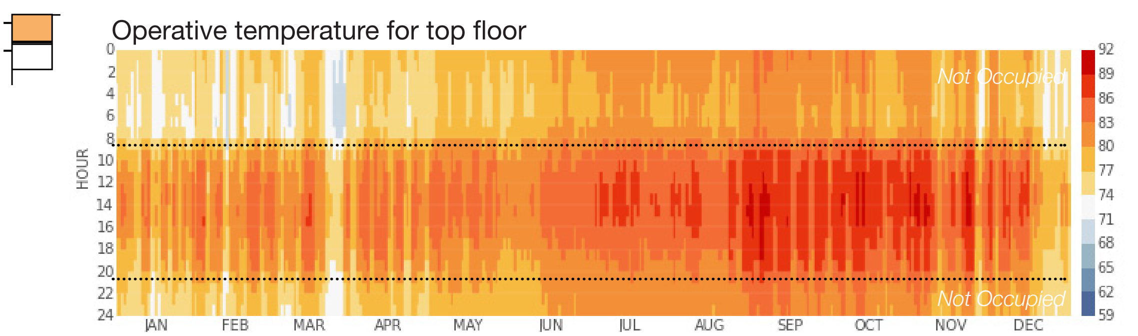
Operative temperature for bottom floor



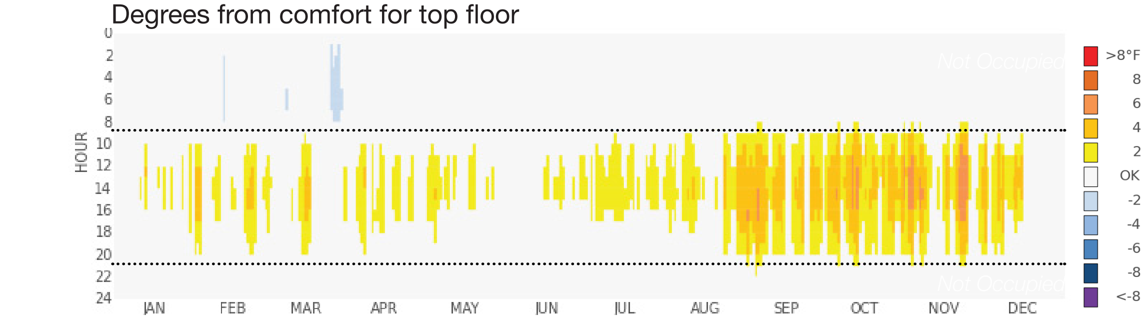
Degrees from comfort for bottom floor



Operative temperature for top floor

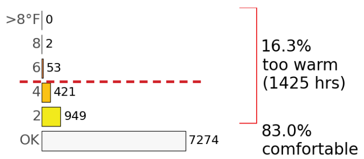


Degrees from comfort for top floor



Add/C.3.a.E.2 Classroom Analysis:: South Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + 2 ACH	too warm	1425	**16%**	**53%**
		w/ celing fans	55	1%	2%

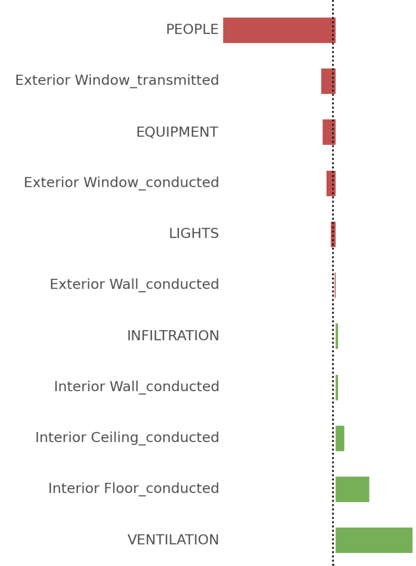


** Including all 8760 hrs of the year, not only occupied hours*

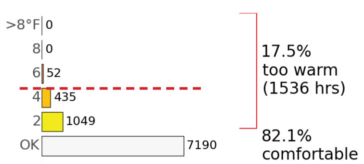
----- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 53% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 2% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + 2 ACH	too warm	1536	**18%**	**57%**
		w/ celing fans	52	1%	2%

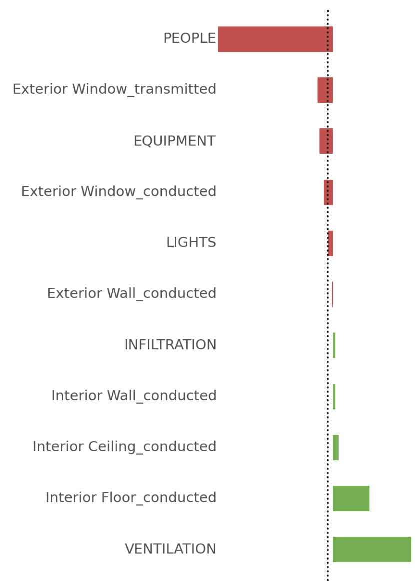


** Including all 8760 hrs of the year, not only occupied hours*

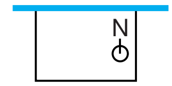
---------- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 57% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 2% too warm.*

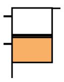


Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING

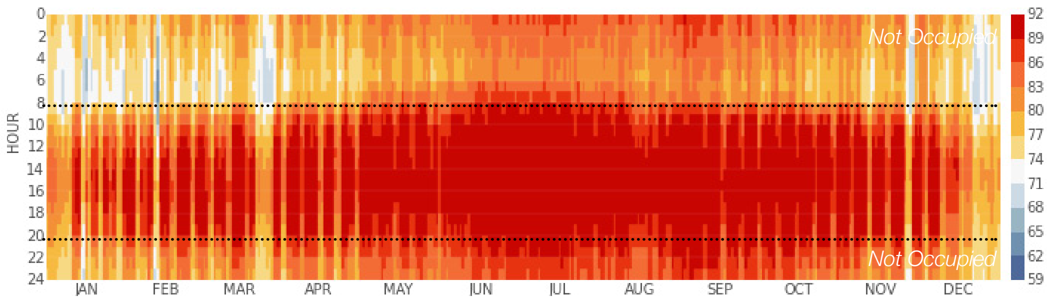


C.3.b.0. TYPICAL EXISTING

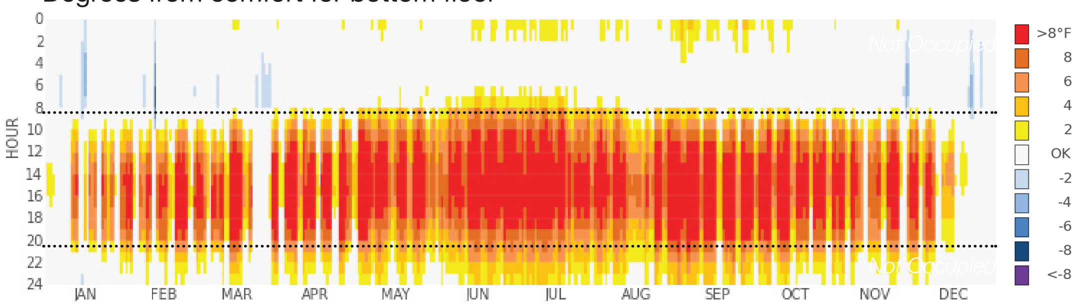
No Insulation in Opaque Surfaces and Single Pane Glass

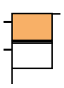


Operative temperature for bottom floor

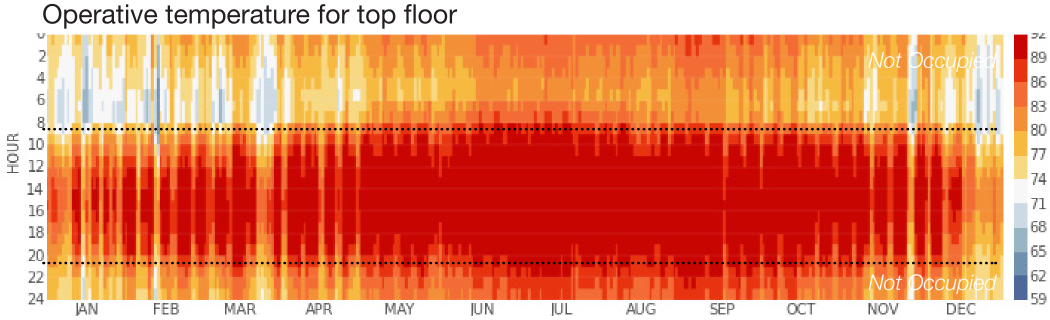


Degrees from comfort for bottom floor

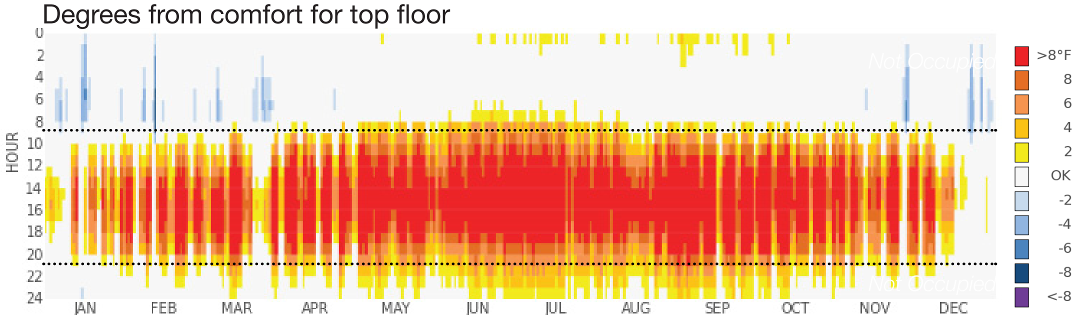




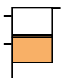
Operative temperature for top floor



Degrees from comfort for top floor



Add/C.3.b.0 Classroom Analysis:: North Facing (Continued)



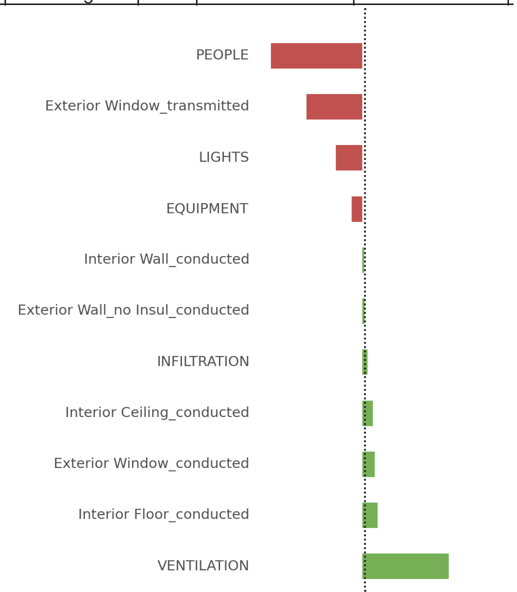
TYPICAL EXISTING		Bottom Floor hours	% of the whole year	% of occupied time
	too warm	4566	**52%**	**100%**
	w/ celing fans	2941	34%	100%

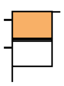
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

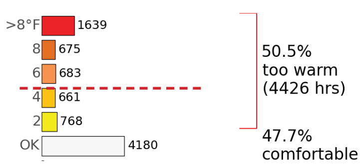
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*





TYPICAL EXISTING		Top Floor hours	% of the whole year	% of occupied time
	too warm	4426	**51%**	**100%**
	w/ celing fans	2997	34%	100%

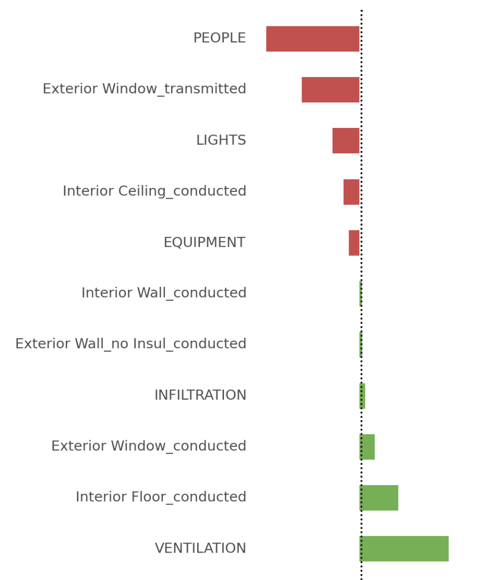


** Including all 8760 hrs of the year, not only occupied hours*

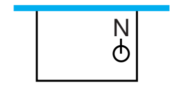
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

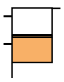


Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING

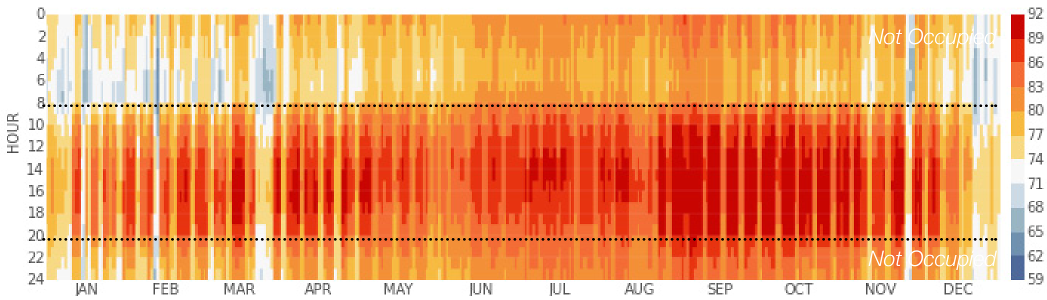


C.3.b.1. TYPICAL WITH WINDOW IMPROVEMENTS

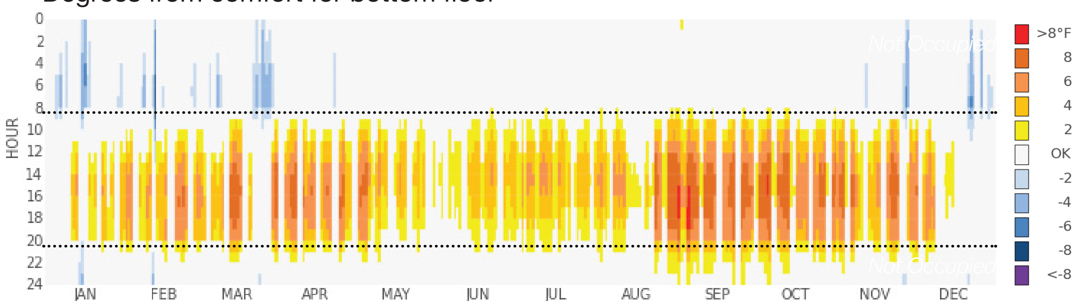
Equal to TYPICAL + 1ACH + Shading + IECC 2015 Windows

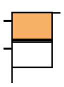


Operative temperature for bottom floor

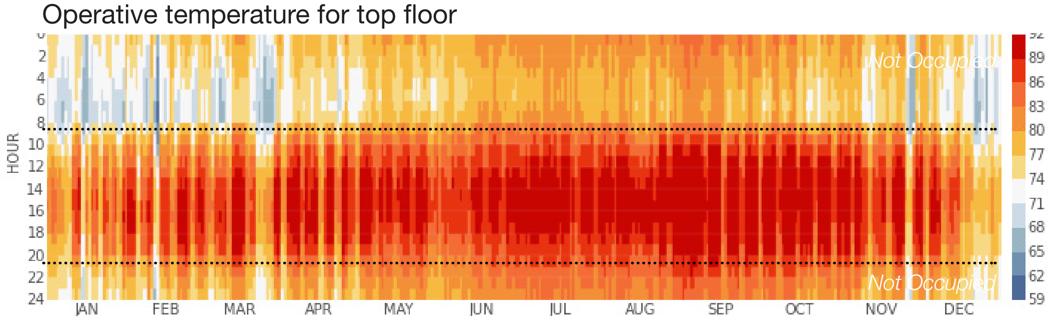


Degrees from comfort for bottom floor

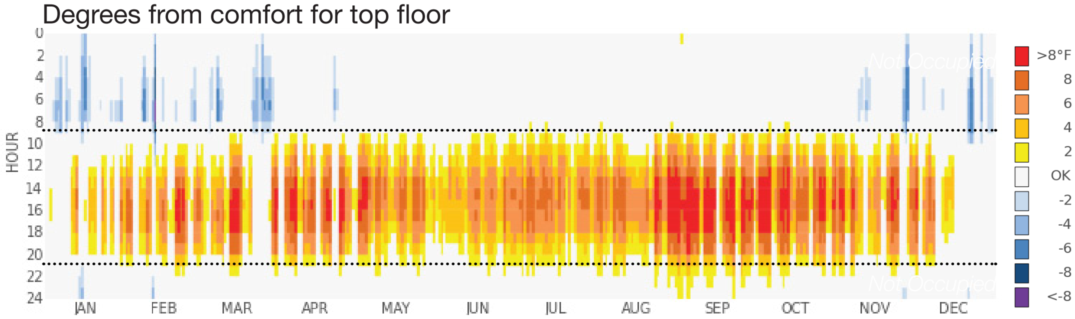




Operative temperature for top floor



Degrees from comfort for top floor

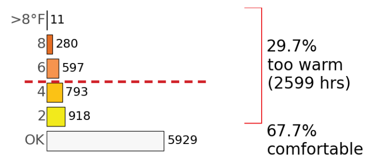


LOISOS + UBBELOHDE

Add/C.3.b.1 Classroom Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	2599	**30%**	**96%**
		w/ celing fans	888	10%	33%

A-3 TYPICAL +1ACH +

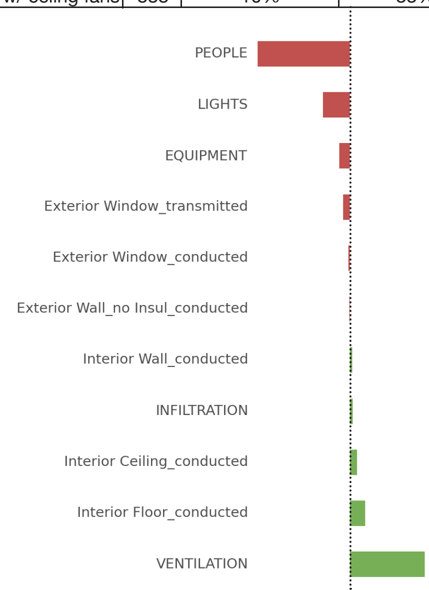


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 96% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 33% too warm.*



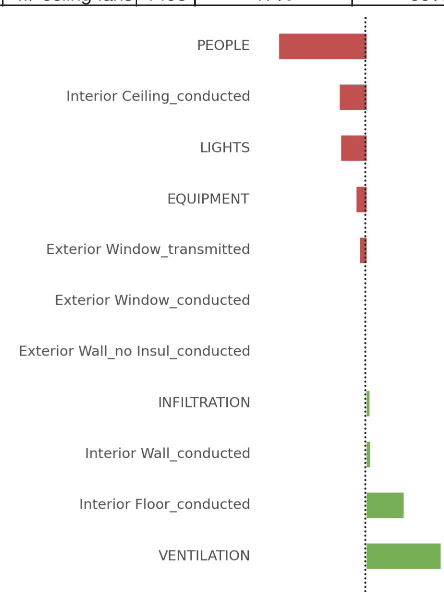
			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3087	**35%**	**100%**
		w/ celing fans	1498	17%	55%

** Including all 8760 hrs of the year, not only occupied hours*

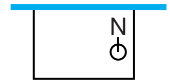
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 55% too warm.*

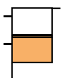


Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING

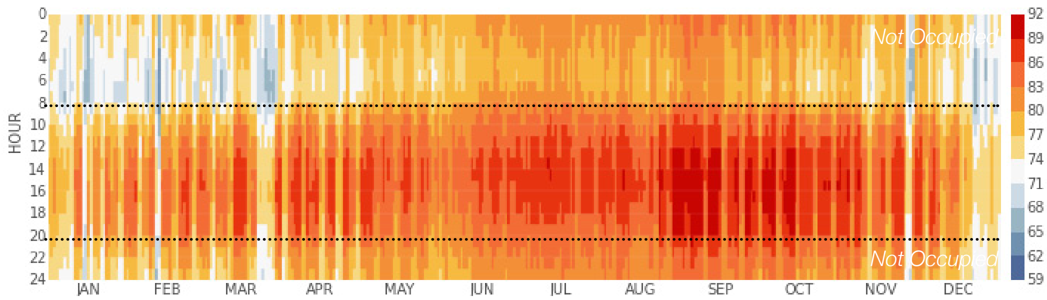


C.3.b.2. MINIMUM SUITE

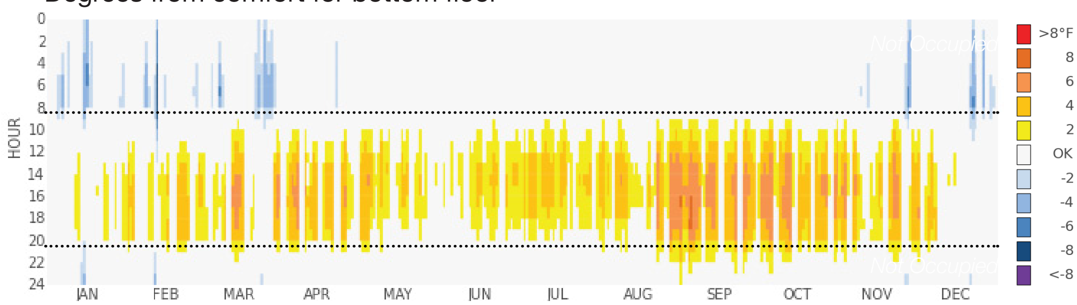
Equal to TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

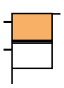


Operative temperature for bottom floor

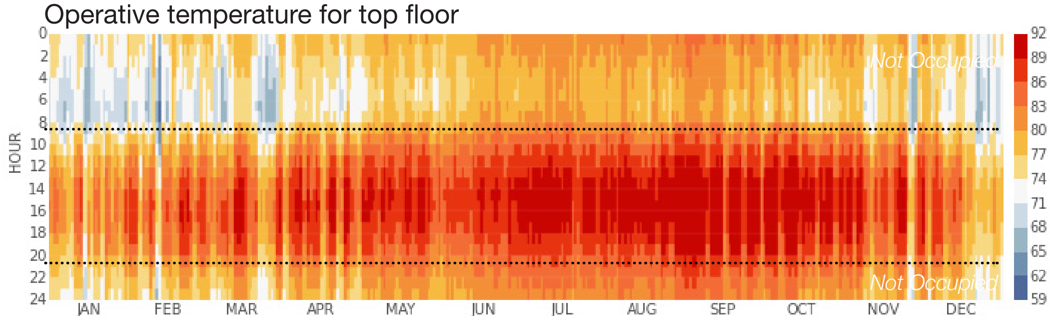


Degrees from comfort for bottom floor

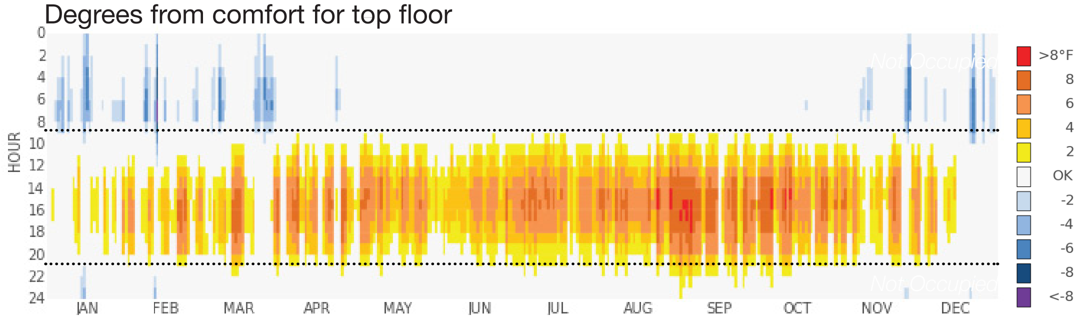




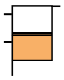
Operative temperature for top floor



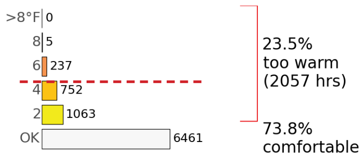
Degrees from comfort for top floor



Add/C.3.b.2 Classroom Analysis:: North Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	2057	**23%**	**76%**
		w/ celing fans	242	3%	9%

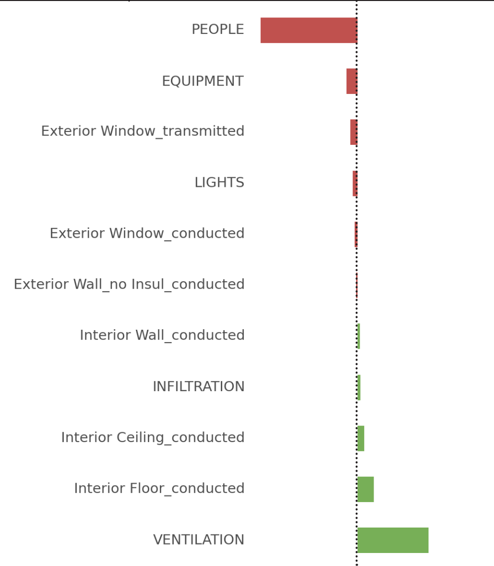


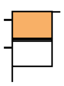
** Including all 8760 hrs of the year, not only occupied hours*

----- *Ceiling Fans Effective*

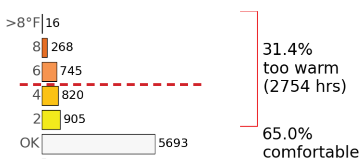
*** If considering only occupied hours (M-F 8am-8pm):: 76% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 9% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	2754	**31%**	**100%**
		w/ celing fans	1029	12%	38%

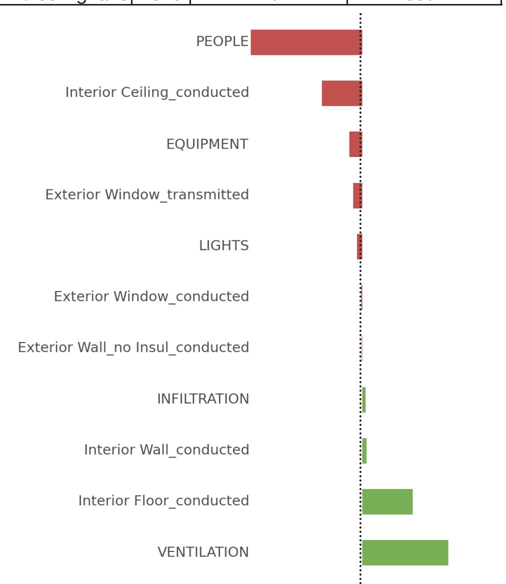


** Including all 8760 hrs of the year, not only occupied hours*

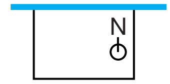
---------- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 38% too warm.*



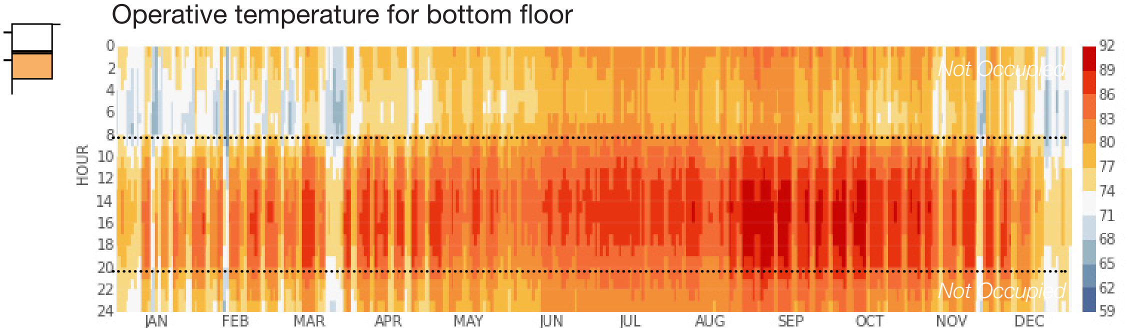
Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING



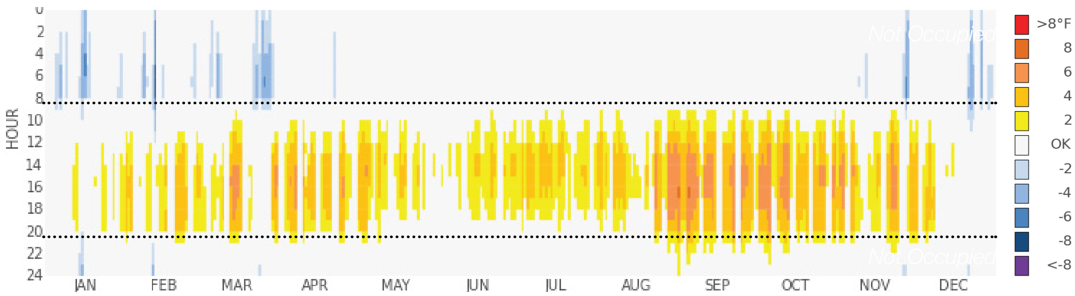
C.3.b.3. IMPROVED SUITE

Equal to MINIMUM SUITE + IECC Roof

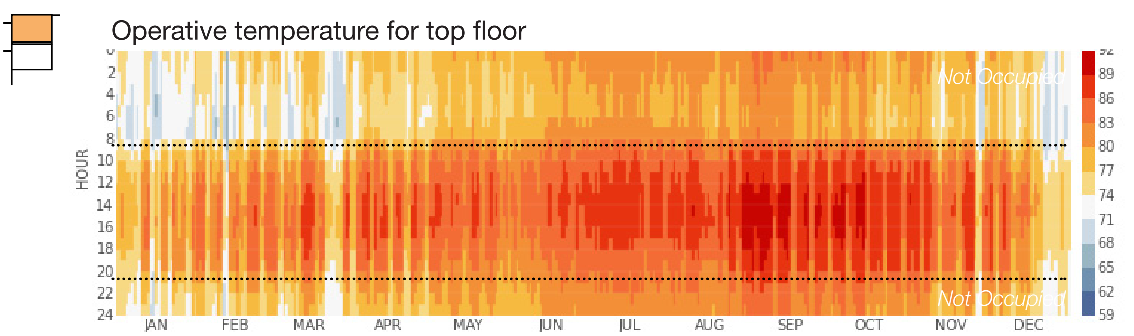
Operative temperature for bottom floor



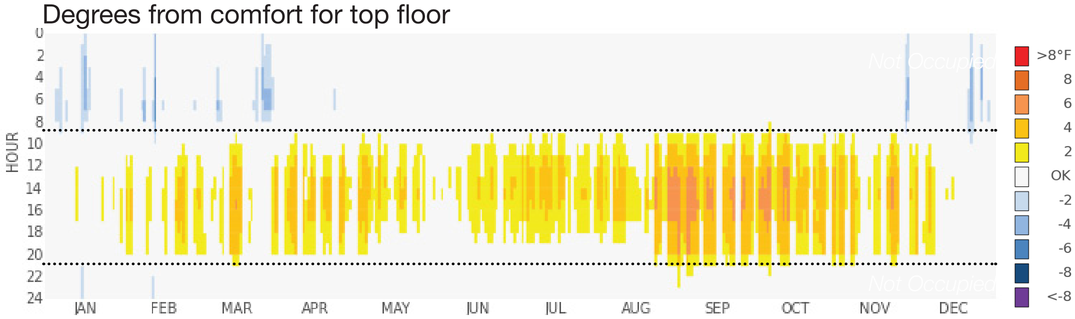
Degrees from comfort for bottom floor



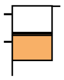
Operative temperature for top floor



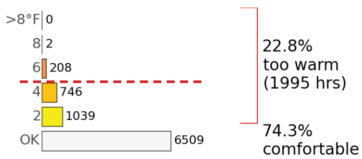
Degrees from comfort for top floor



Add/C.3.b.3 Classroom Analysis:: North Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	1995	**23%**	**74%**
		w/ celing fans	210	2%	8%

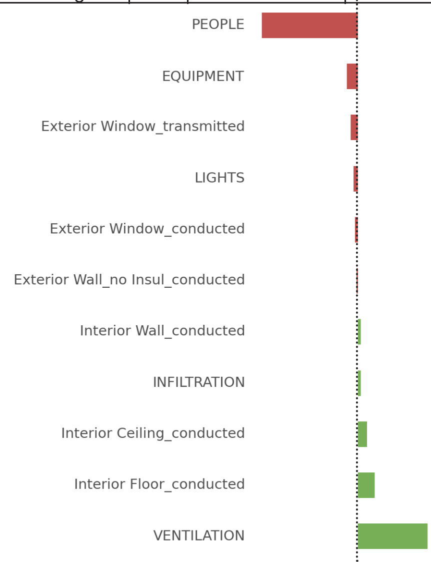


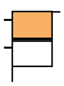
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

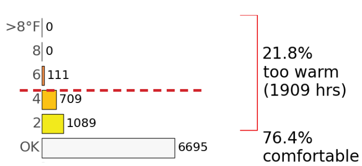
*** If considering only occupied hours (M-F 8am-8pm):: 74% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 8% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	1909	**22%**	**71%**
		w/ celing fans	111	1%	4%

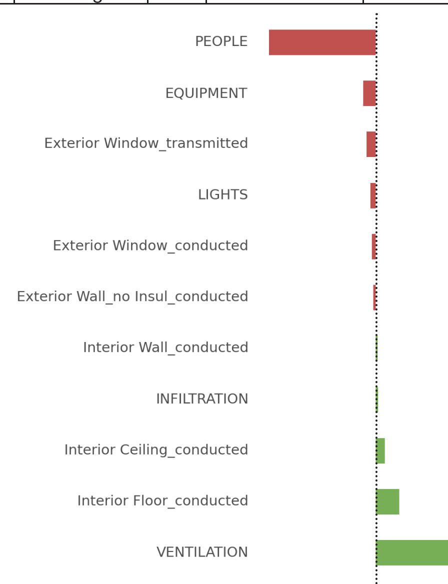


** Including all 8760 hrs of the year, not only occupied hours*

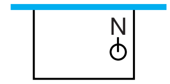
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 71% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 4% too warm.*

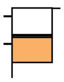


Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING

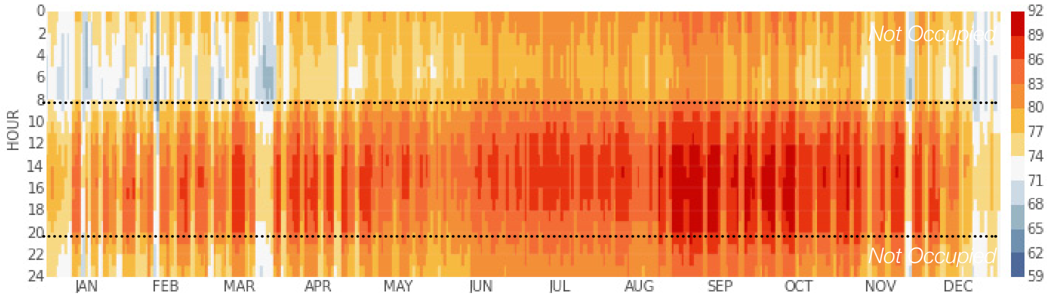


C.3.b.4. CODE SUITE

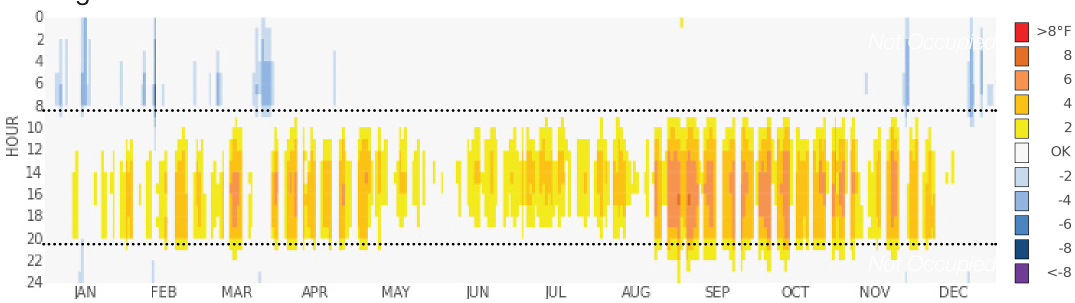
Equal to IMPROVED SUITE + IECC Walls

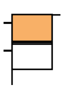


Operative temperature for bottom floor

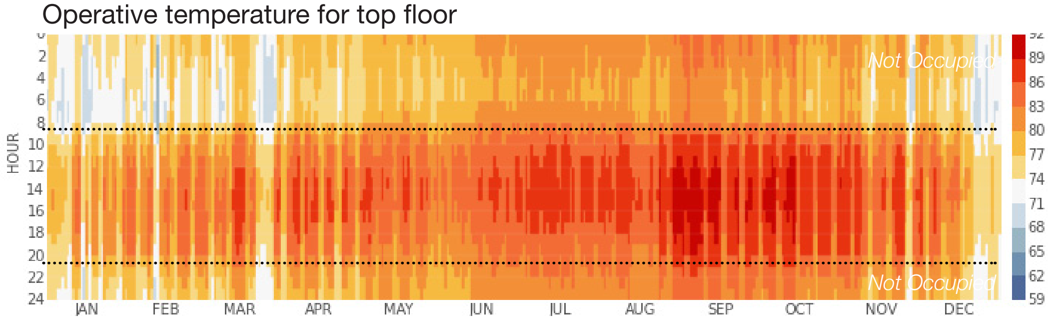


Degrees from comfort for bottom floor

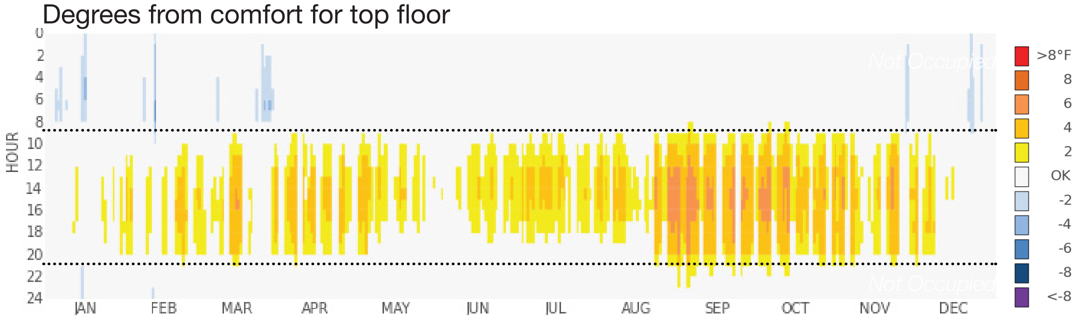




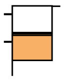
Operative temperature for top floor



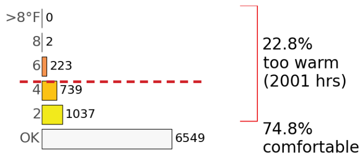
Degrees from comfort for top floor



Add/C.3.b.4 Classroom Analysis:: North Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
C-2 CODE SUITE (C-1+ IEACC walls)	too warm	2001	**23%**	**74%**
	w/ celing fans	225	3%	8%

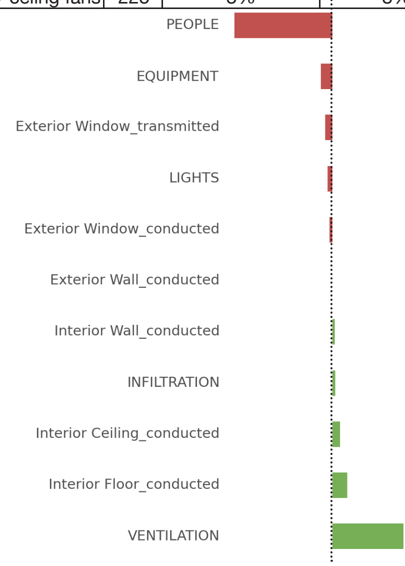


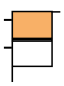
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

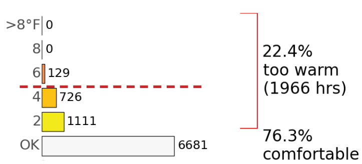
*** If considering only occupied hours (M-F 8am-8pm):: 74% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 8% too warm.*





		Top Floor		
		hours	% of the whole year	% of occupied time
C-2 CODE SUITE (C-1+ IEACC walls)	too warm	1966	**22%**	**73%**
	w/ celing fans	129	1%	5%

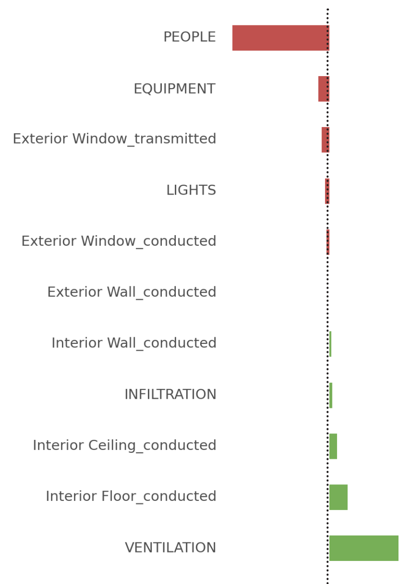


** Including all 8760 hrs of the year, not only occupied hours*

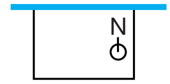
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 73% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 5% too warm.*

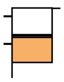


Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING

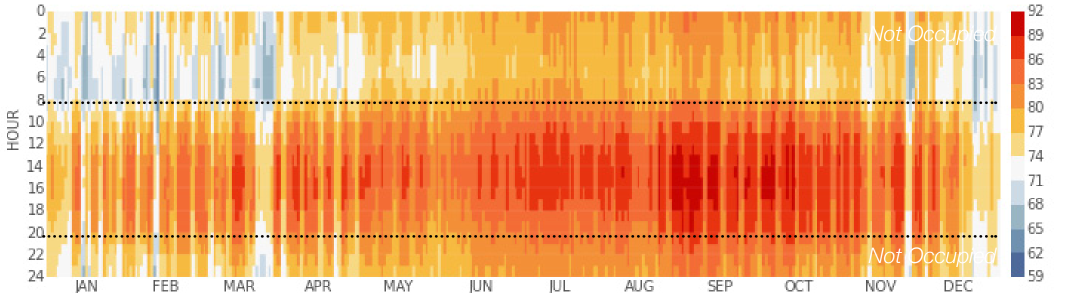


C.3.b.5. IMPROVED SUITE WITH VENTILATION

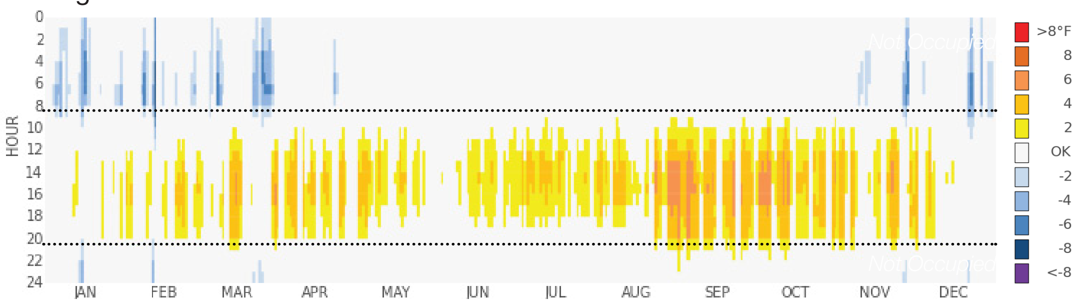
Equal to IMPROVED SUITE +2ACH

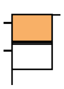


Operative temperature for bottom floor

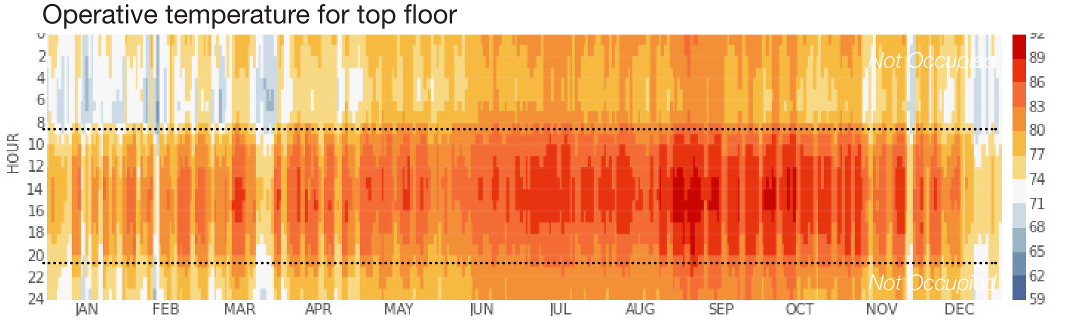


Degrees from comfort for bottom floor

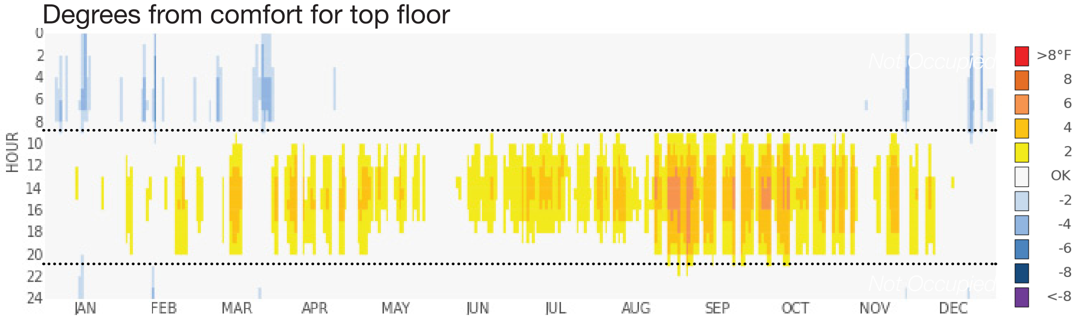




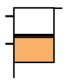
Operative temperature for top floor



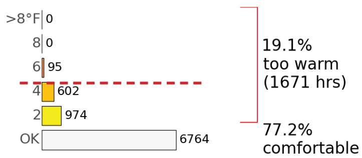
Degrees from comfort for top floor



Add/C.3.b.5 Classroom Analysis:: North Facing (Continued)

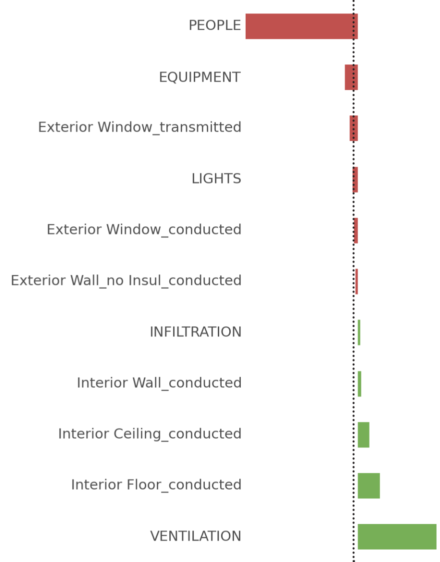


			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1671	**19%**	**62%**
		w/ celing fans	95	1%	4%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

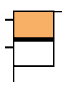


*** If considering only occupied hours*

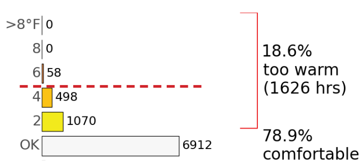
(M-F 8am-8pm):: 62% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

4% too warm.

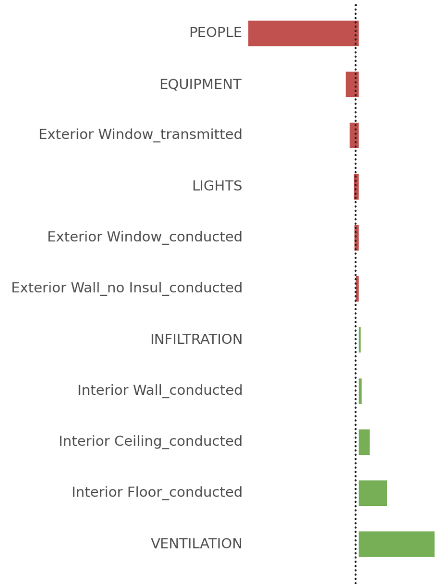


			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1626	**19%**	**60%**
		w/ celing fans	58	1%	2%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



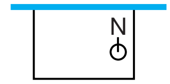
*** If considering only occupied hours*

(M-F 8am-8pm):: 60% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

2% too warm.

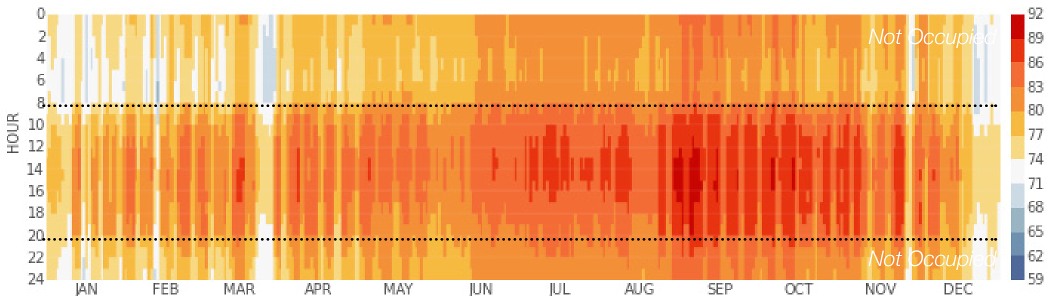
Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING



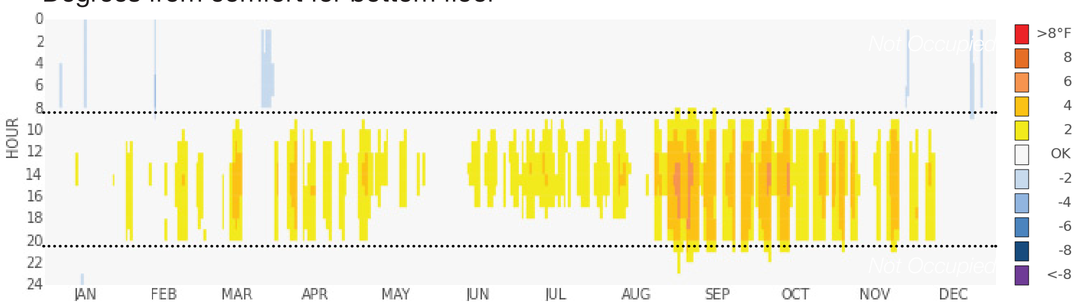
C.3.b.6. IDEAL SUITE

Equal to CODE SUITE + Thermal Mass

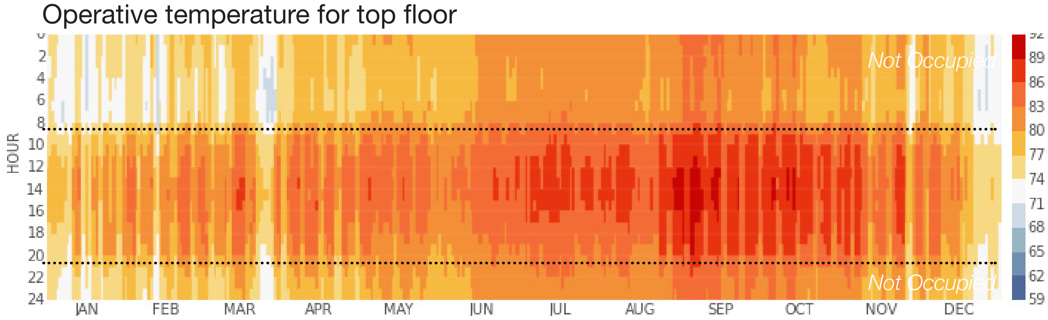
Operative temperature for bottom floor



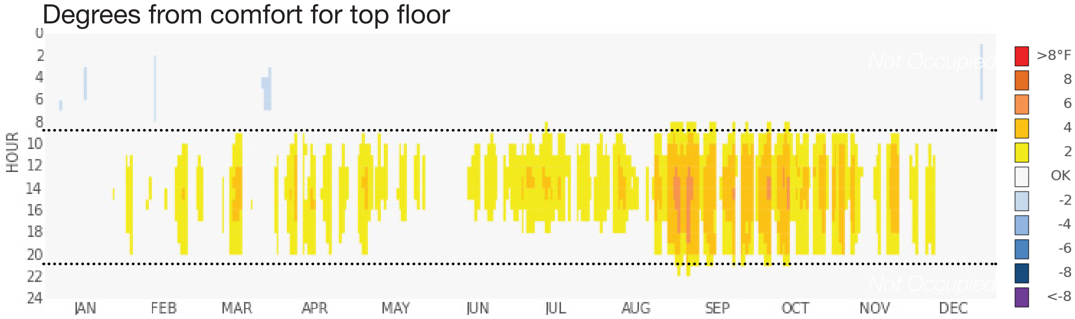
Degrees from comfort for bottom floor



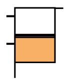
Operative temperature for top floor



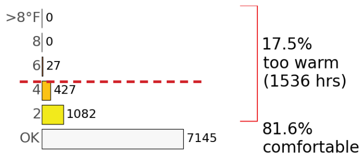
Degrees from comfort for top floor



Add/C.3.b.6 Classroom Analysis:: North Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1536	**18%**	**57%**
		w/ celing fans	27	0%	1%

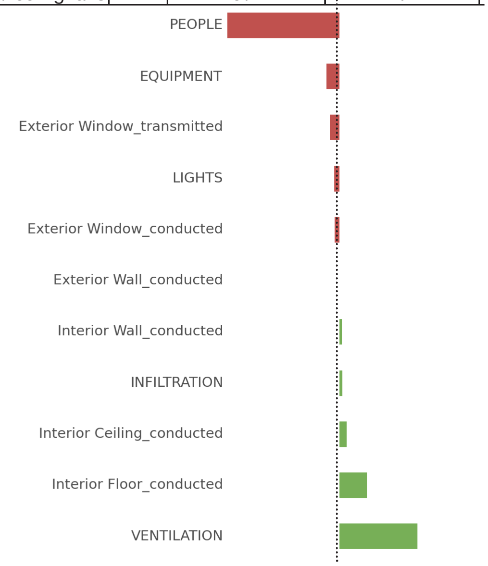


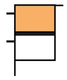
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

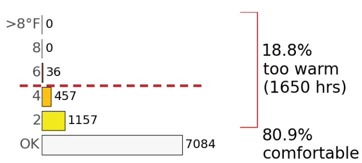
*** If considering only occupied hours (M-F 8am-8pm):: 57% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 1% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1650	**19%**	**61%**
		w/ celing fans	36	0%	1%

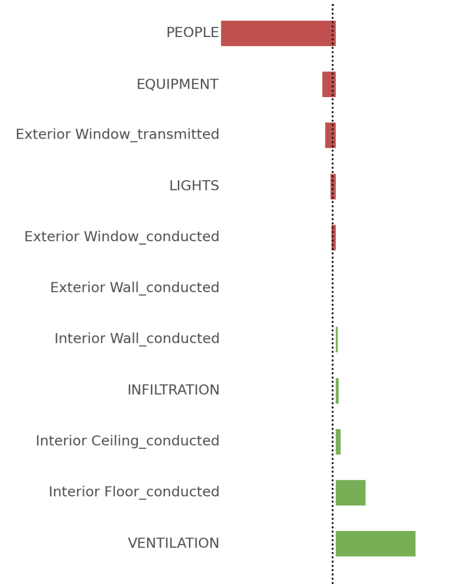


** Including all 8760 hrs of the year, not only occupied hours*

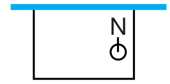
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 61% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 1% too warm.*

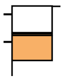


Add/C.3.b CLASSROOM ANALYSIS:: NORTH FACING

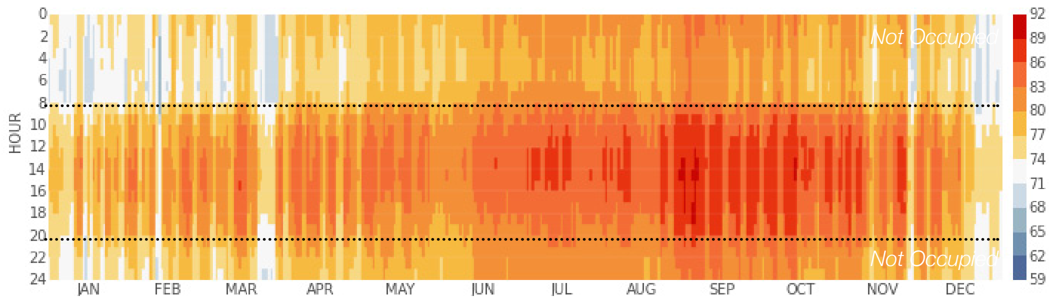


C.3.b.7. IDEAl SUITE WITH VENTILATION

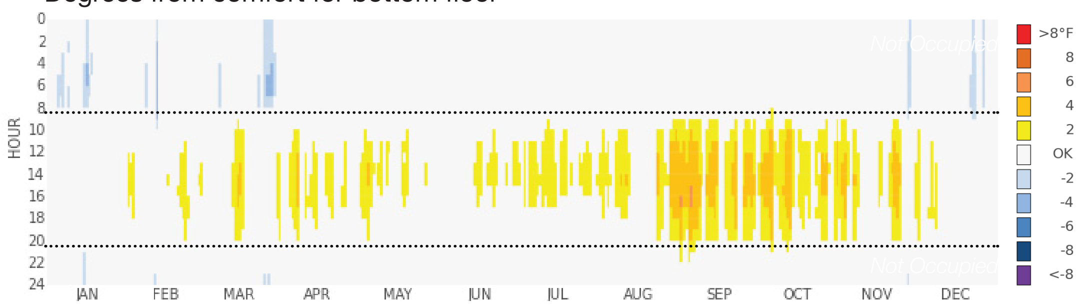
Equal to IDEAL SUITE + 2ACH

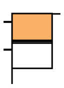


Operative temperature for bottom floor

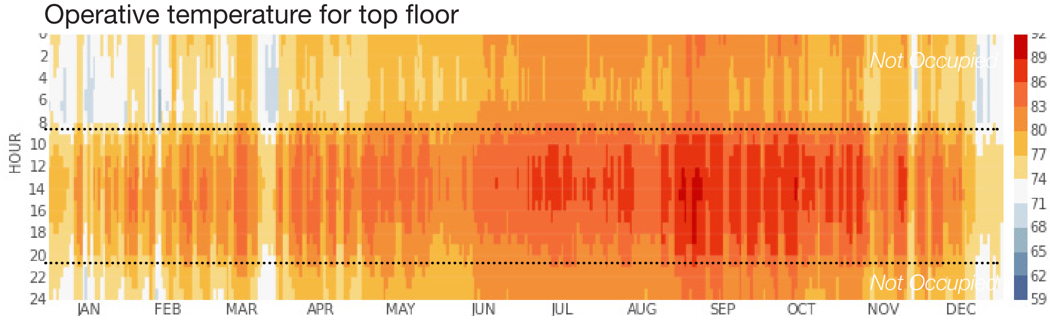


Degrees from comfort for bottom floor

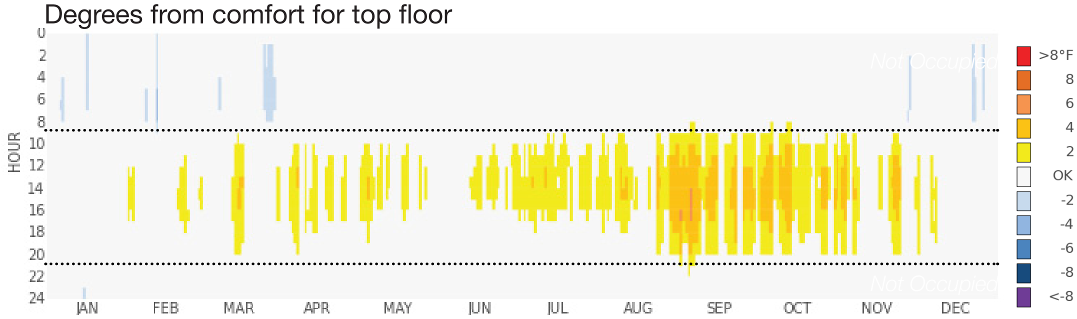




Operative temperature for top floor

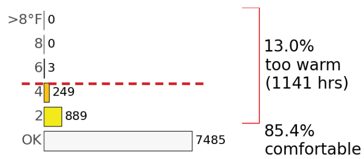


Degrees from comfort for top floor



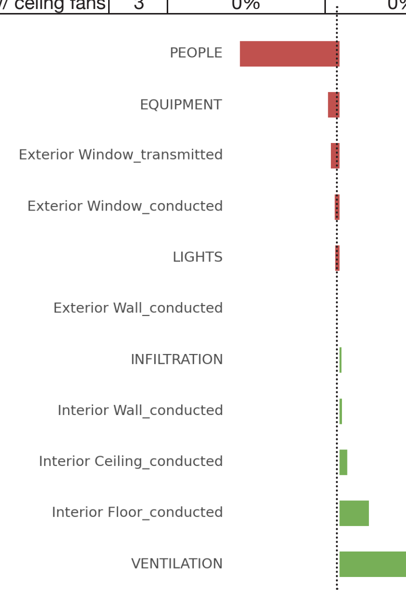
Add/C.3.b.7 Classroom Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL + 2 ACH	too warm	1141	**13%**	**42%**
		w/ celing fans	3	0%	0%



** Including all 8760 hrs of the year, not only occupied hours*

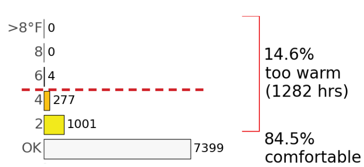
Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-8pm):: 42% too warm.*

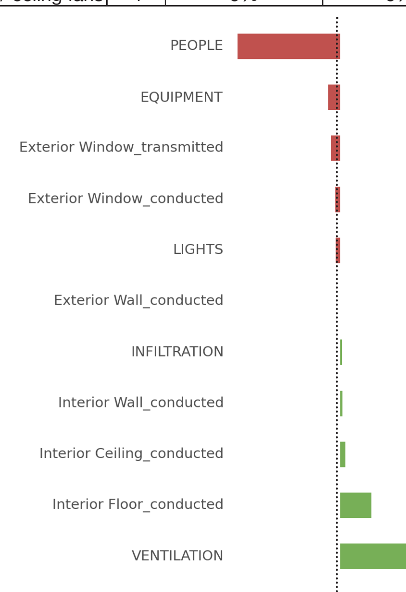
**** With ceiling fans (M-F 8am-8pm):: 0% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1282	**15%**	**47%**
		w/ celing fans	4	0%	0%



** Including all 8760 hrs of the year, not only occupied hours*

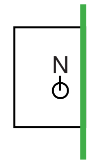
Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-8pm):: 47% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 0% too warm.*

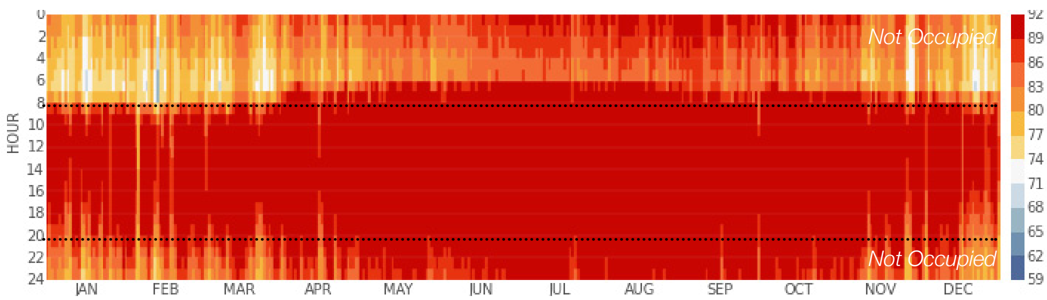
Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING



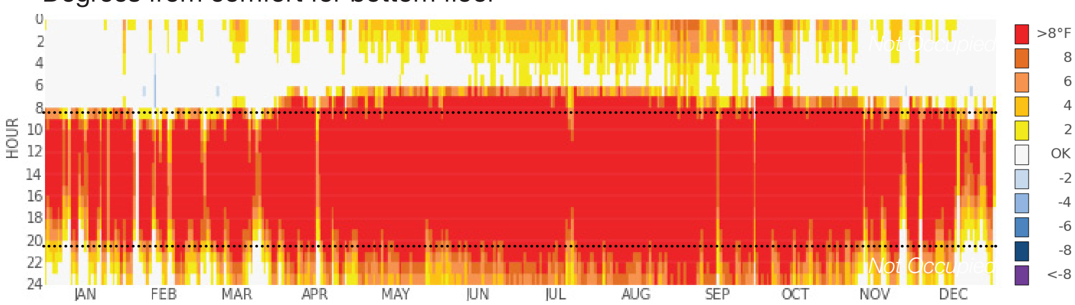
C.3.c.0. TYPICAL EXISTING

No Insulation in Opaque Surfaces and Single Pane Glass

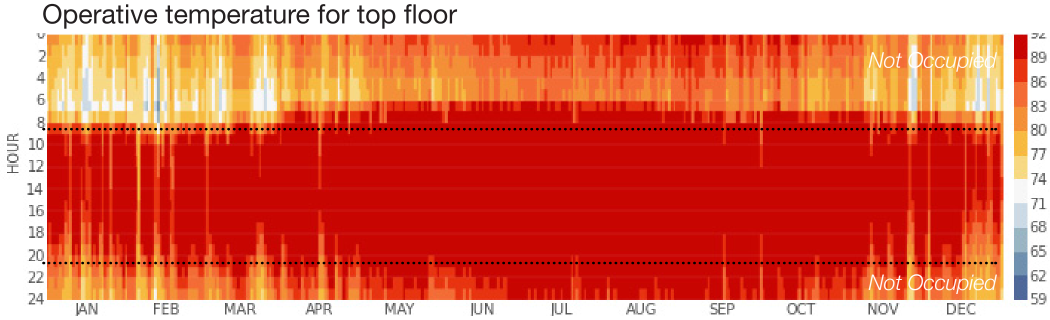
Operative temperature for bottom floor



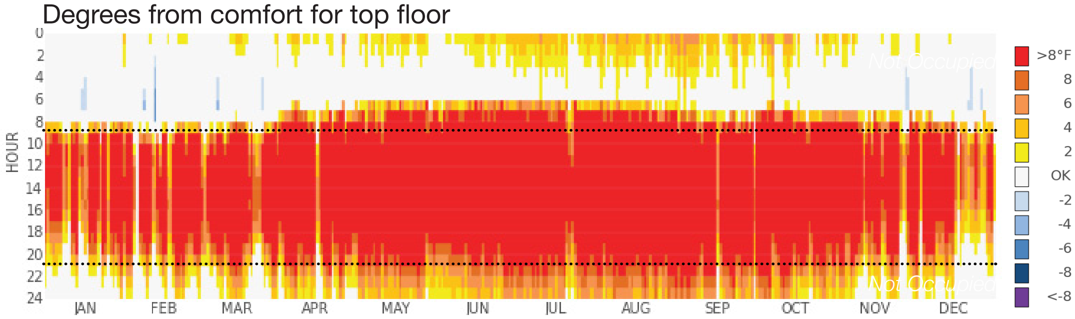
Degrees from comfort for bottom floor



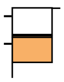
Operative temperature for top floor



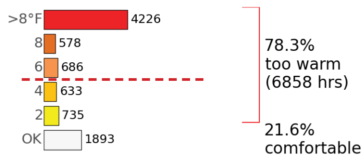
Degrees from comfort for top floor



Add/C.3.c.0 Classroom Analysis:: East Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	6858	**78%**	**100%**
	w/ celing fans	5490	63%	100%

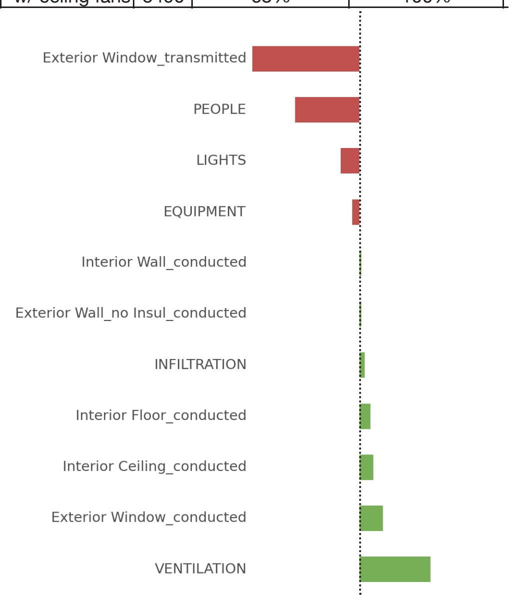


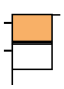
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

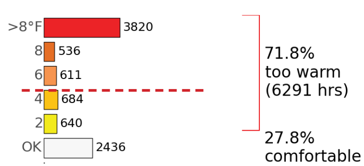
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*





		Top Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	6291	**72%**	**100%**
	w/ celing fans	5017	57%	100%

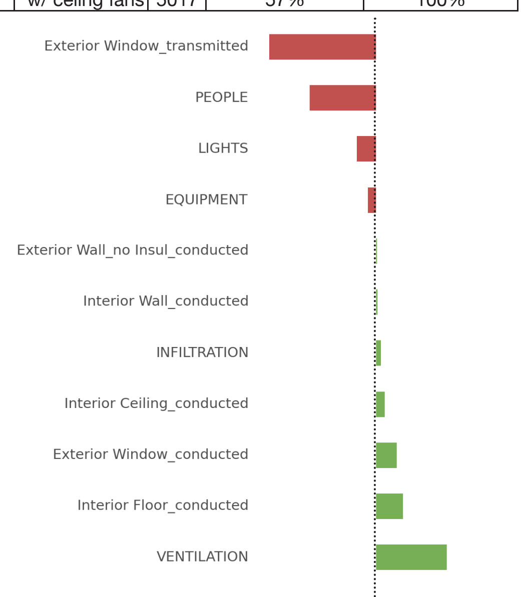


** Including all 8760 hrs of the year, not only occupied hours*

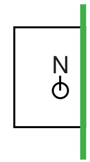
---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

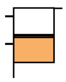


Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING

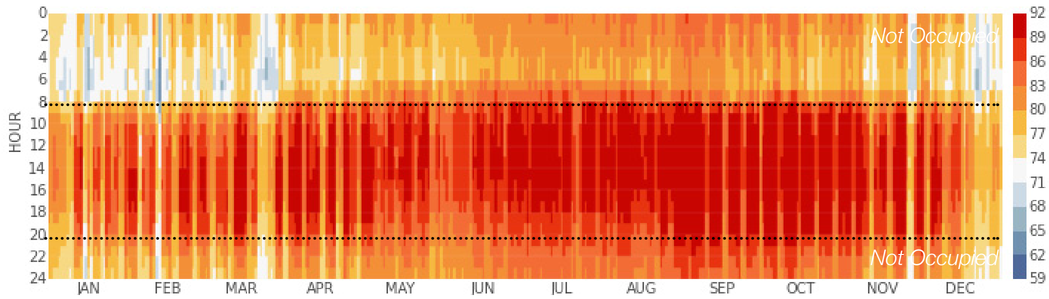


C.3.c.1. TYPICAL WITH WINDOW IMPROVEMENTS

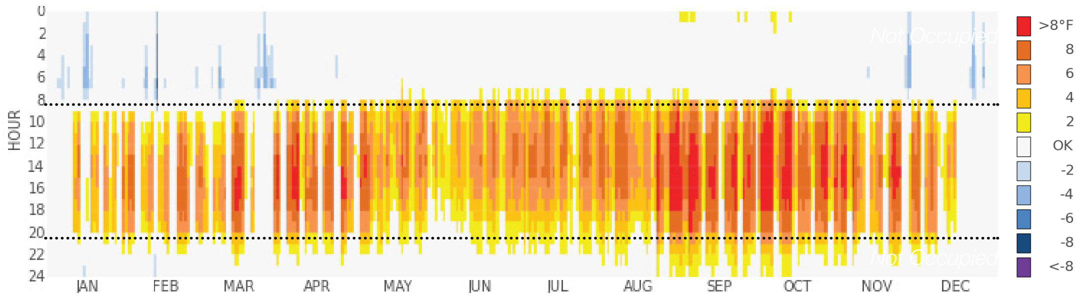
Equal to TYPICAL + 1ACH + Shading + IECC 2015 Windows

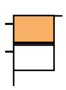


Operative temperature for bottom floor

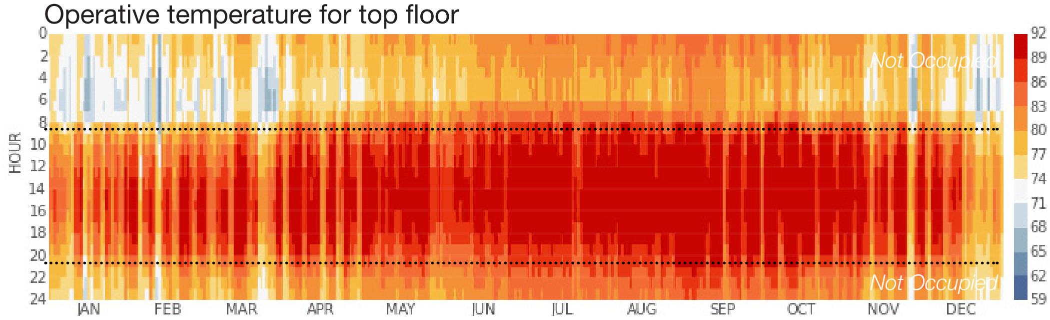


Degrees from comfort for bottom floor

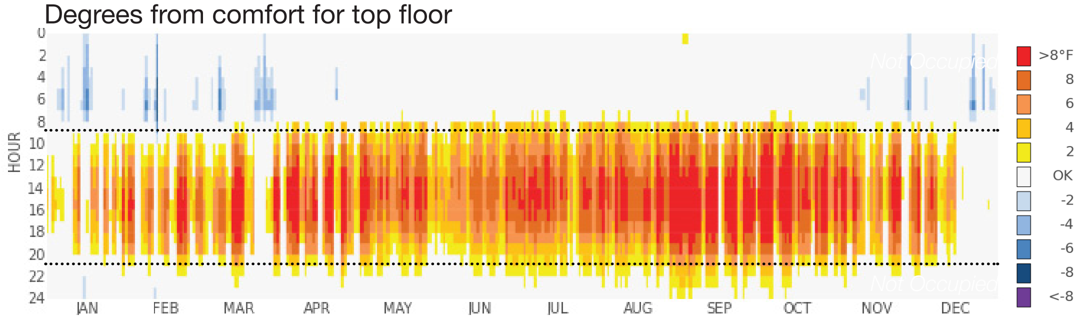




Operative temperature for top floor



Degrees from comfort for top floor



Add/C.3.c.1 Classroom Analysis:: East Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3673	**42%**	**100%**
		w/ celing fans	1883	21%	70%

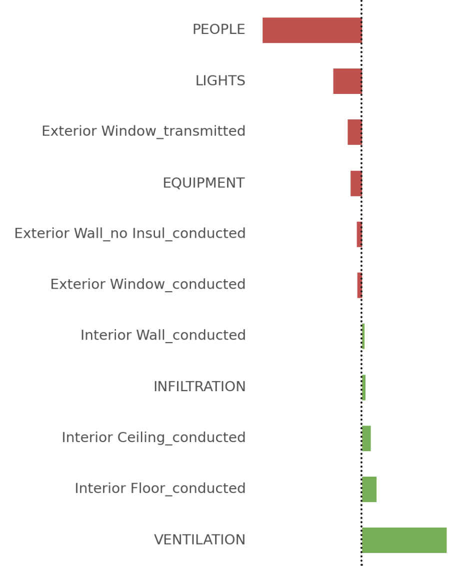
A-3 TYPICAL +1ACH +

** Including all 8760 hrs of the year, not only occupied hours*

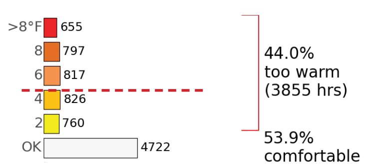
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 70% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3855	**44%**	**100%**
		w/ celing fans	2270	26%	84%

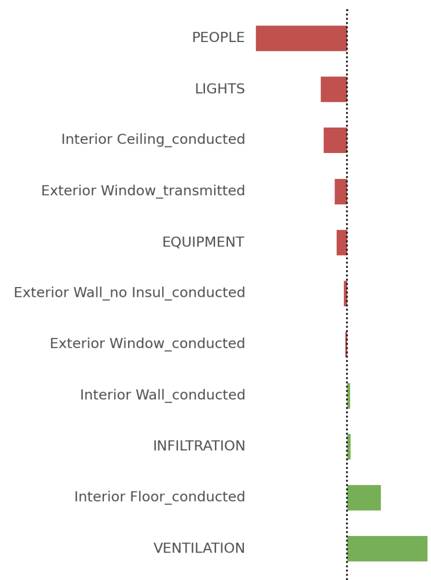


** Including all 8760 hrs of the year, not only occupied hours*

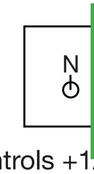
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 84% too warm.*



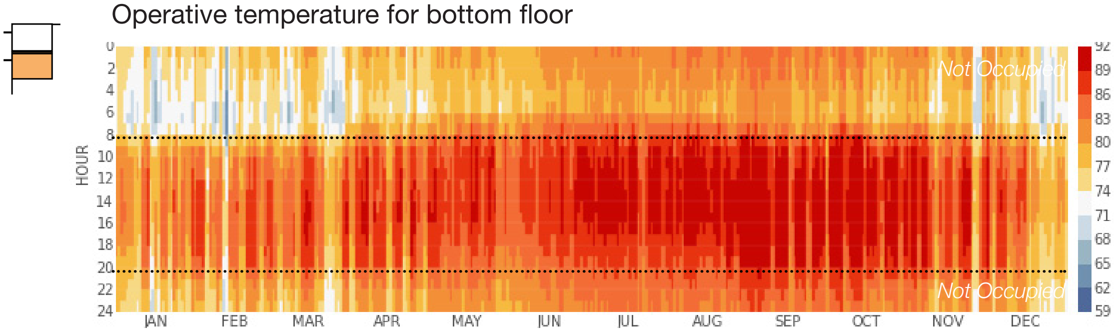
Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING



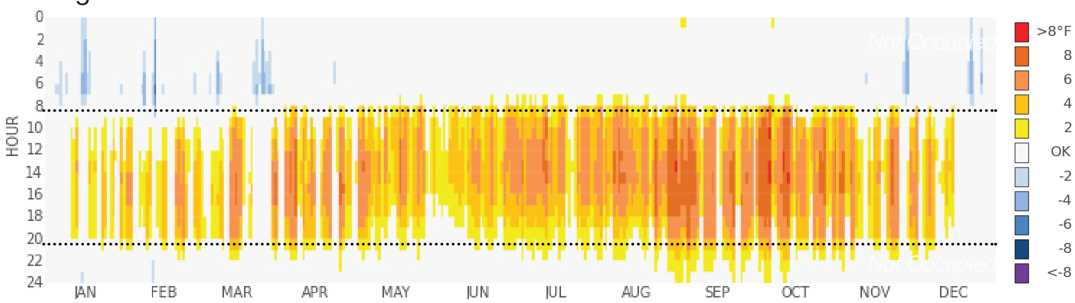
C.3.c.2. MINIMUM SUITE

Equalt to TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

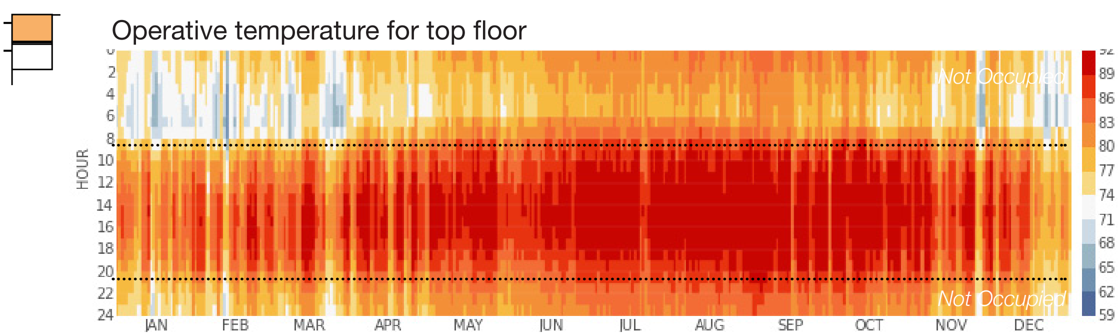
Operative temperature for bottom floor



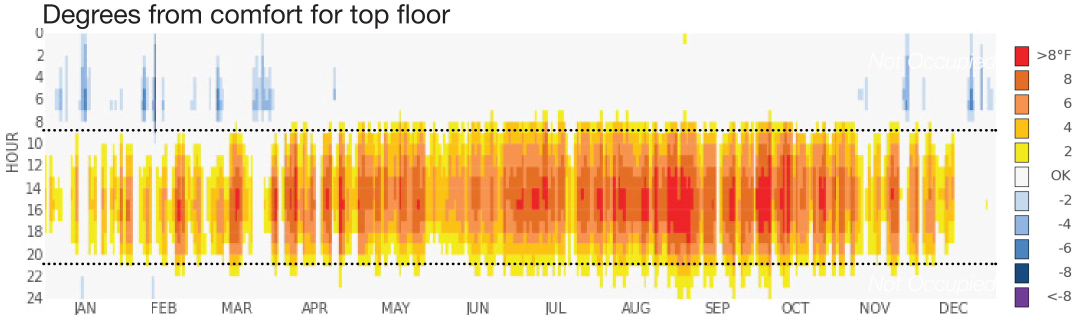
Degrees from comfort for bottom floor



Operative temperature for top floor

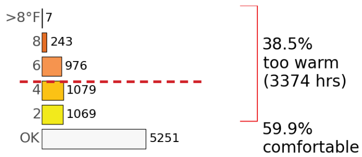


Degrees from comfort for top floor



Add/C.3.c.2 Classroom Analysis:: East Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	3374	**39%**	**100%**
		w/ celing fans	1226	14%	45%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

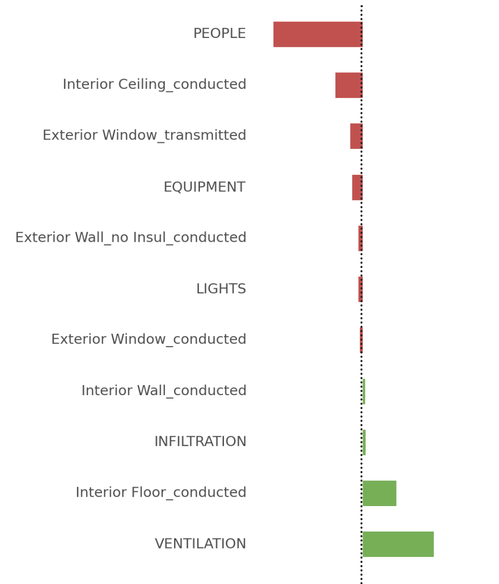
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 45% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	3632	**41%**	**100%**
		w/ celing fans	1799	21%	67%

** Including all 8760 hrs of the year, not only occupied hours*

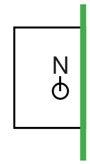
Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

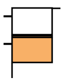
**** With ceiling fans (M-F 8am-8pm):: 67% too warm.*

Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING

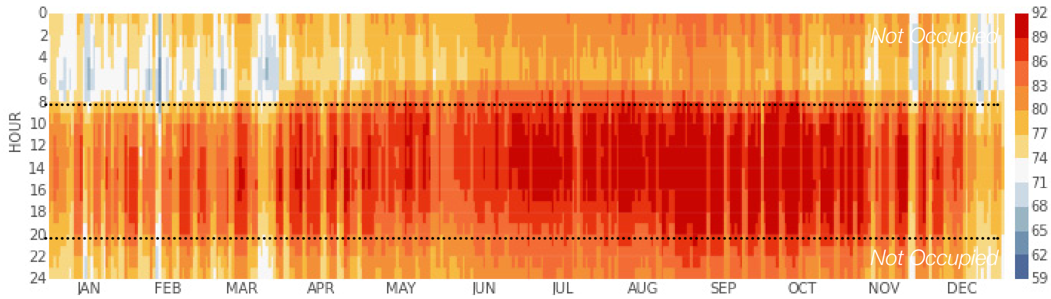


C.3.c.3. IMPROVED SUITE

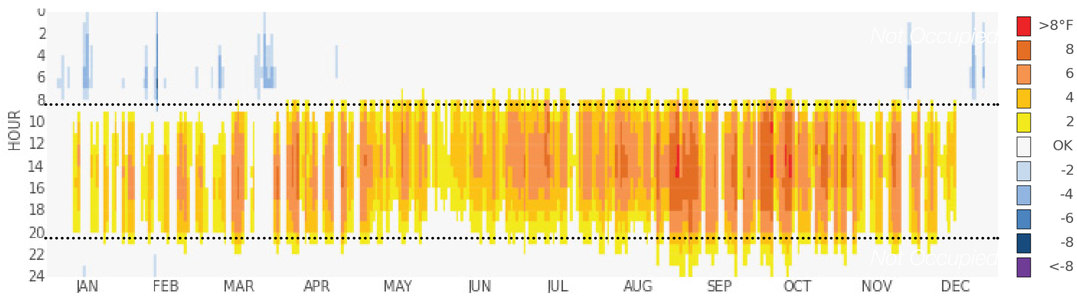
Equal to MINIMUM SUITE + IECC Roof

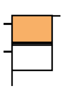


Operative temperature for bottom floor

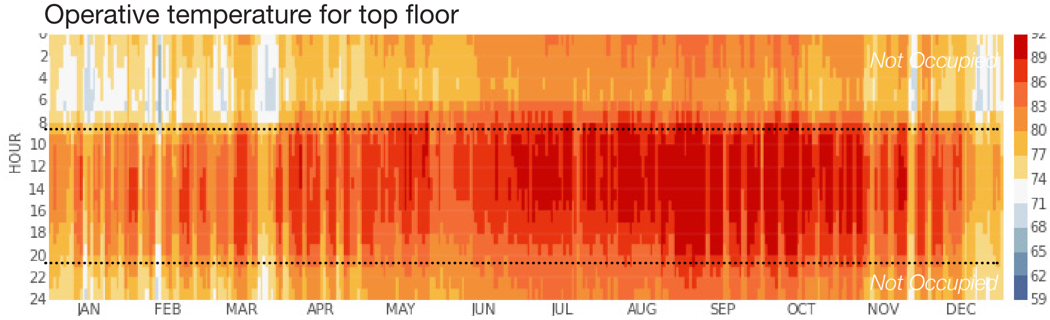


Degrees from comfort for bottom floor

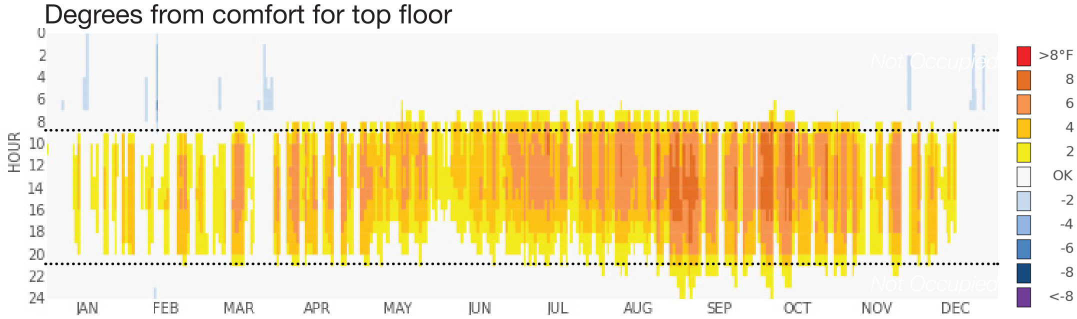




Operative temperature for top floor

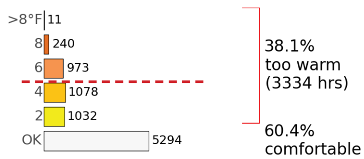


Degrees from comfort for top floor



Add/C.3.c.3 Classroom Analysis:: East Facing (Continued)

		Bottom Floor		
		hours	% of the whole year	% of occupied time
C-1 IMPROVED SUITE (B-3+ IECC Roof)	too warm	3334	**38%**	**100%**
	w/ celing fans	1226	14%	45%

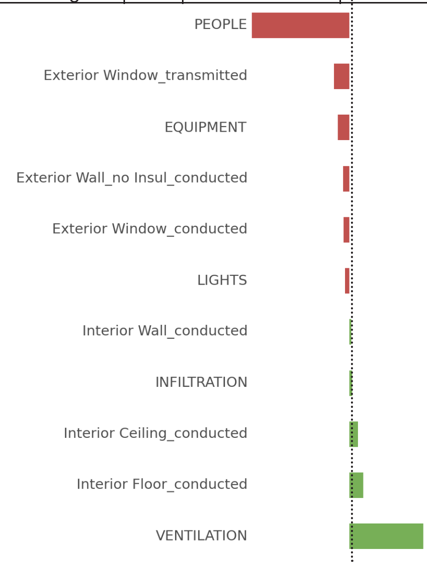


** Including all 8760 hrs of the year, not only occupied hours*

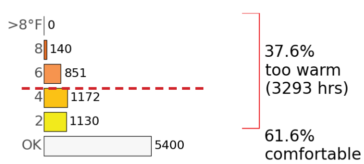
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 45% too warm.*



		Top Floor		
		hours	% of the whole year	% of occupied time
C-1 IMPROVED SUITE (B-3+ IECC Roof)	too warm	3293	**38%**	**100%**
	w/ celing fans	991	11%	37%

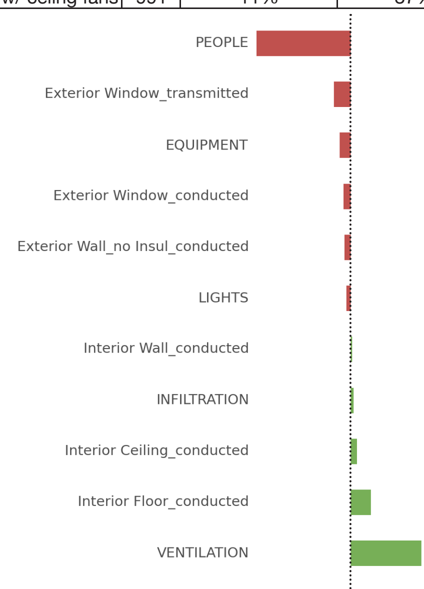


** Including all 8760 hrs of the year, not only occupied hours*

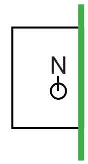
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 37% too warm.*

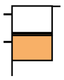


Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING

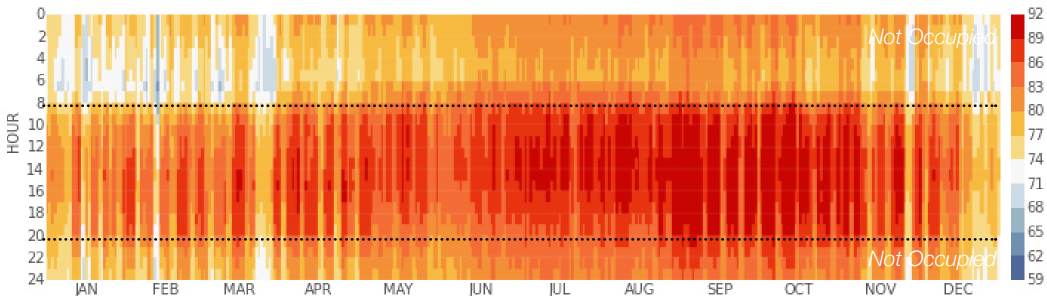


C.3.c.4. CODE SUITE

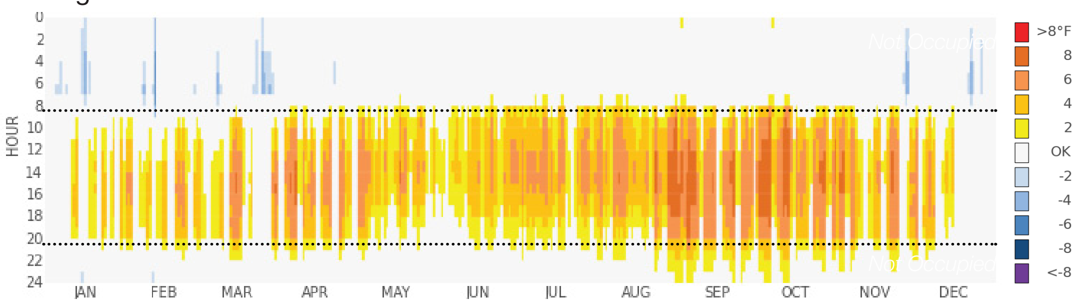
Equal to IMPROVED SUITE + IECC Walls

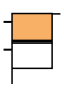


Operative temperature for bottom floor

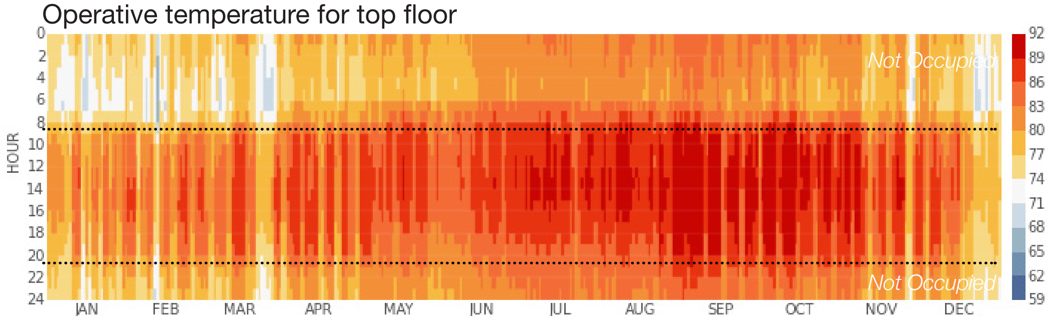


Degrees from comfort for bottom floor

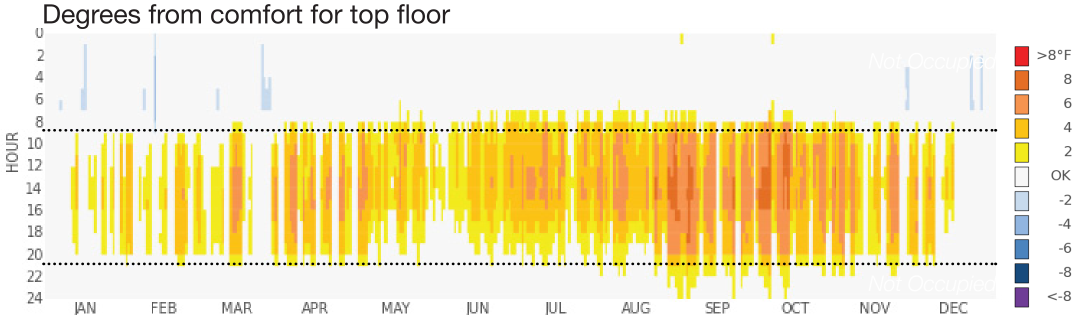




Operative temperature for top floor

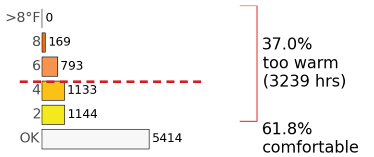


Degrees from comfort for top floor



Add/C.3.c.4 Classroom Analysis:: East Facing (Continued)

			Bottom Floor	
		hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls) too warm	3239	**37%**	**100%**
	w/ celing fans	962	11%	36%

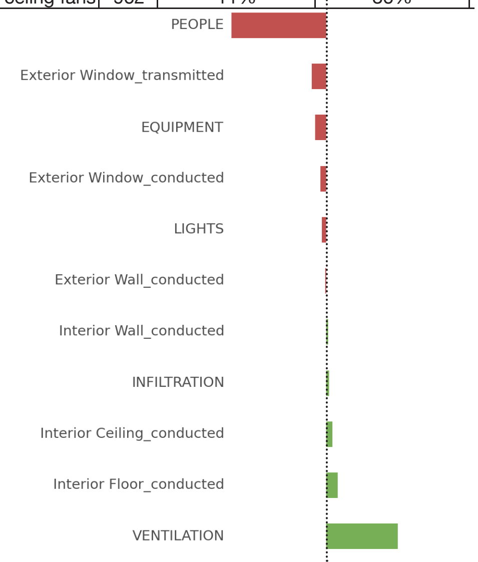


** Including all 8760 hrs of the year, not only occupied hours*

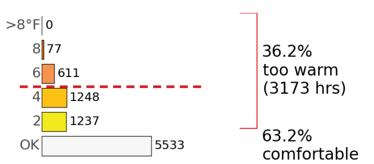
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 36% too warm.*



			Top Floor	
		hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls) too warm	3173	**36%**	**100%**
	w/ celing fans	718	8%	27%

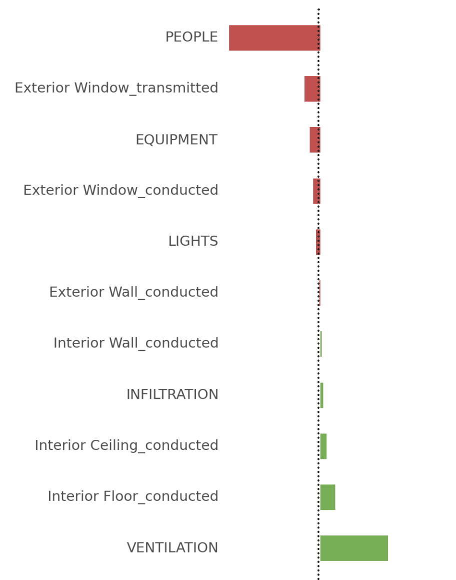


** Including all 8760 hrs of the year, not only occupied hours*

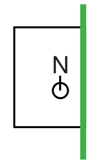
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 27% too warm.*

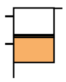


Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING

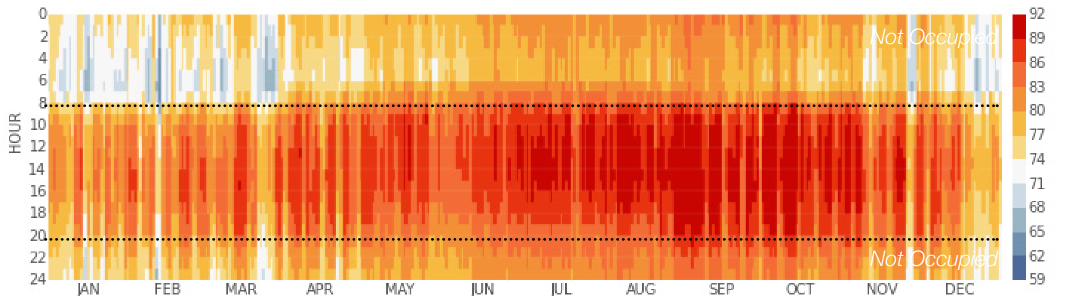


C.3.c.5. IMPROVED SUITE WITH VENTILATION

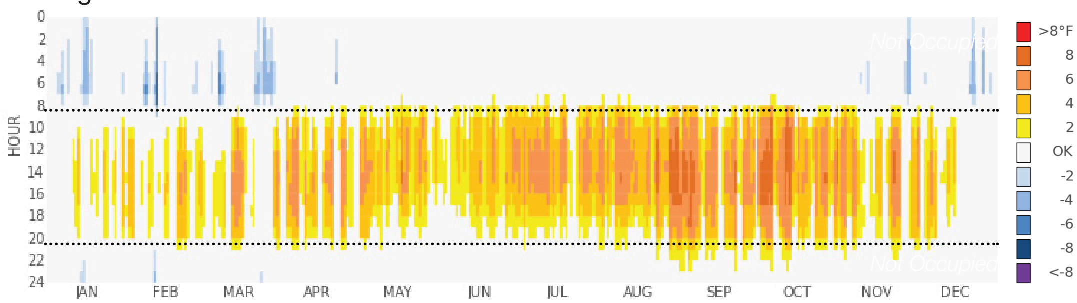
Equalt to IMPROVED SUITE +2ACH

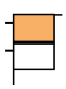


Operative temperature for bottom floor

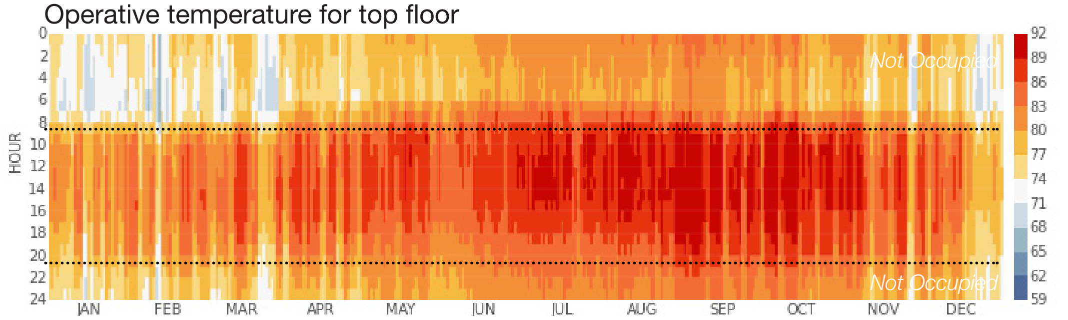


Degrees from comfort for bottom floor

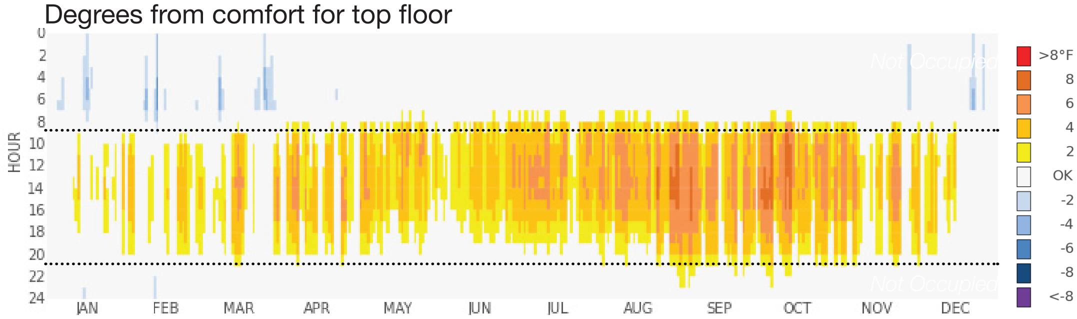




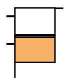
Operative temperature for top floor



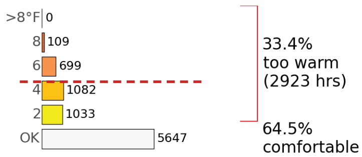
Degrees from comfort for top floor



Add/C.3.c.5 Classroom Analysis:: East Facing (Continued)

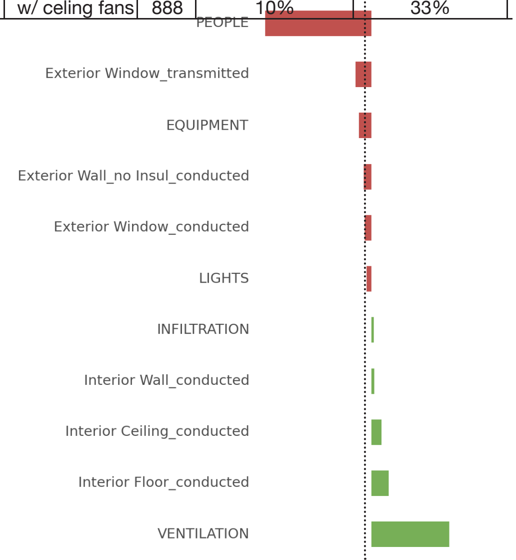


			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2923	**33%**	**100%**
		w/ celing fans	888	10%	33%



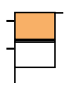
** Including all 8760 hrs of the year, not only occupied hours*

----- *Ceiling Fans Effective*

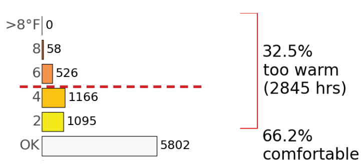


*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 33% too warm.*

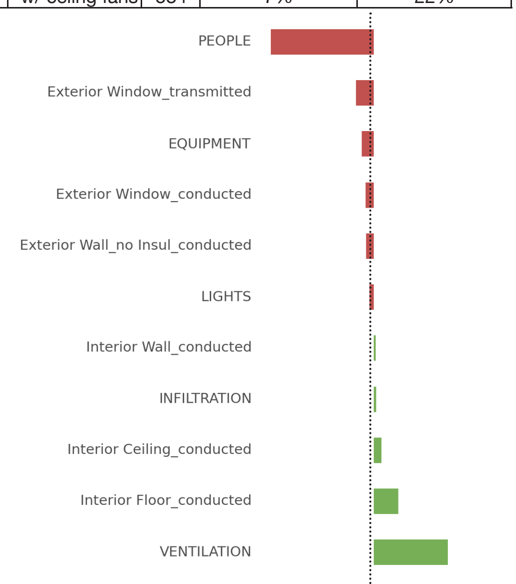


			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2845	**32%**	**100%**
		w/ celing fans	584	7%	22%



** Including all 8760 hrs of the year, not only occupied hours*

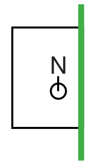
---------- *Ceiling Fans Effective*



*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

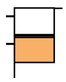
**** With ceiling fans (M-F 8am-8pm):: 22% too warm.*

Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING

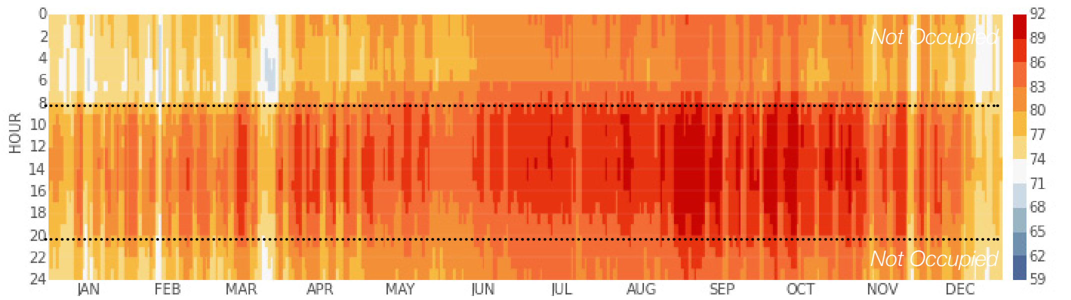


C.3.c.6. IDEAL SUITE

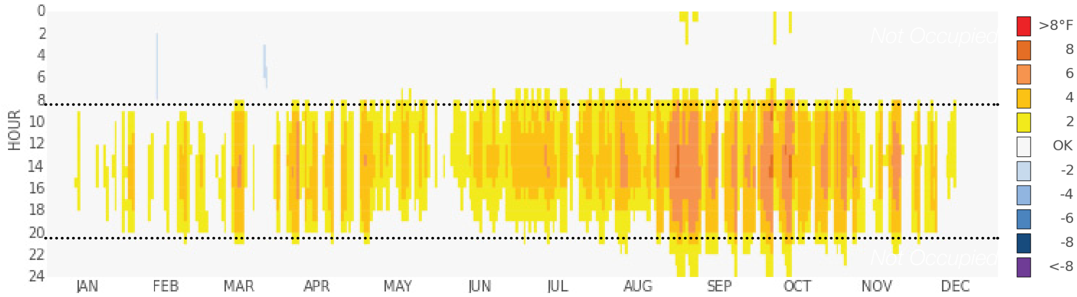
Equal to CODE SUITE + Thermal Mass

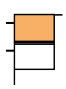


Operative temperature for bottom floor

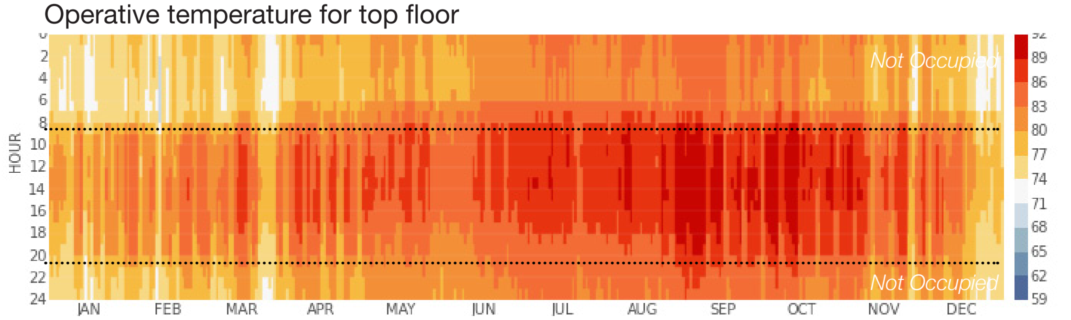


Degrees from comfort for bottom floor

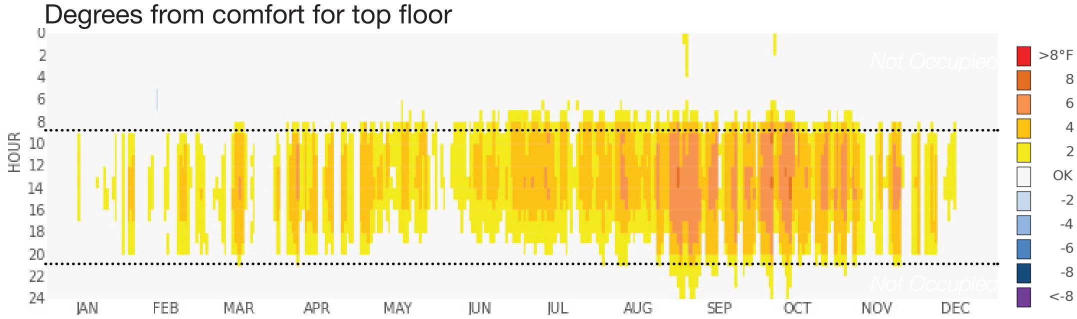




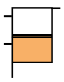
Operative temperature for top floor



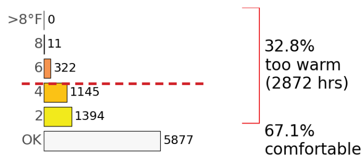
Degrees from comfort for top floor



Add/C.3.c.6 Classroom Analysis:: East Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2872	**33%**	**100%**
		w/ celing fans	333	4%	12%

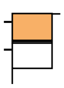


** Including all 8760 hrs of the year, not only occupied hours*

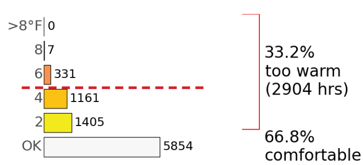
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 12% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2904	**33%**	**100%**
		w/ celing fans	338	4%	13%

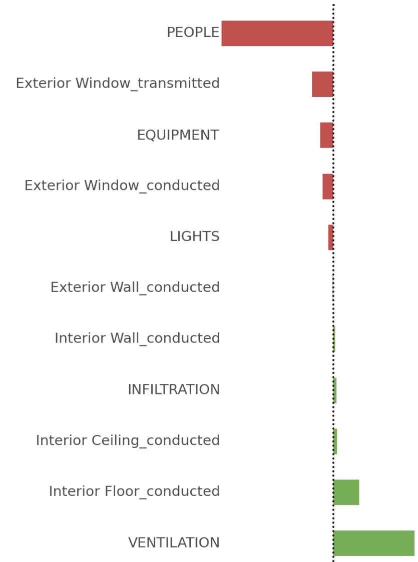


** Including all 8760 hrs of the year, not only occupied hours*

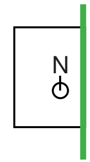
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 13% too warm.*

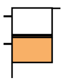


Add/C.3.c CLASSROOM ANALYSIS:: EAST FACING

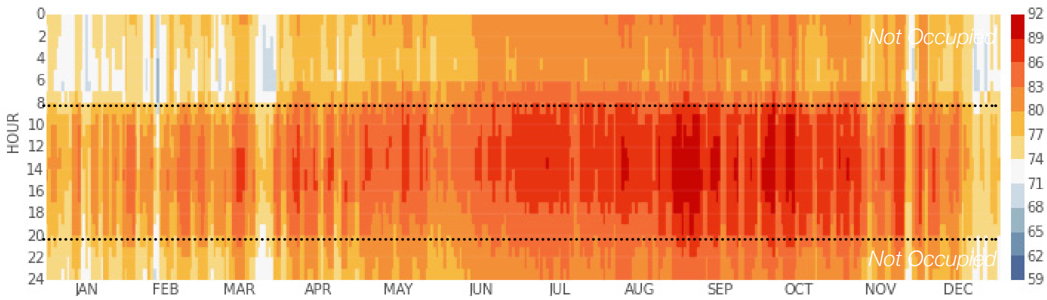


C.3.c.7. IDEAl SUITE WITH VENTILATION

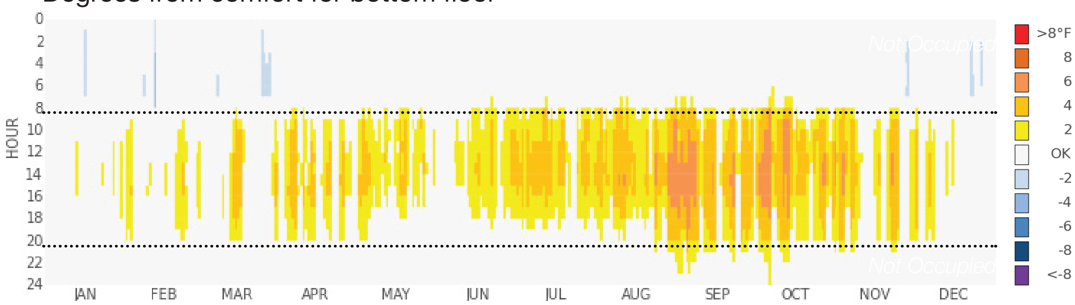
Equal to IDEAL SUITE + 2ACH

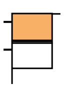


Operative temperature for bottom floor

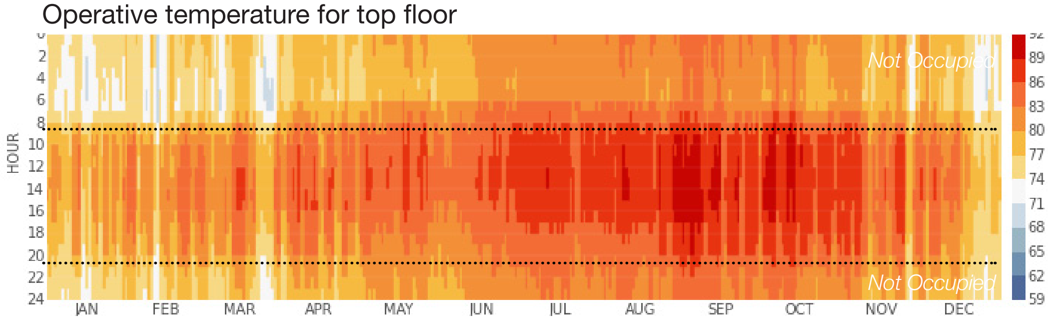


Degrees from comfort for bottom floor

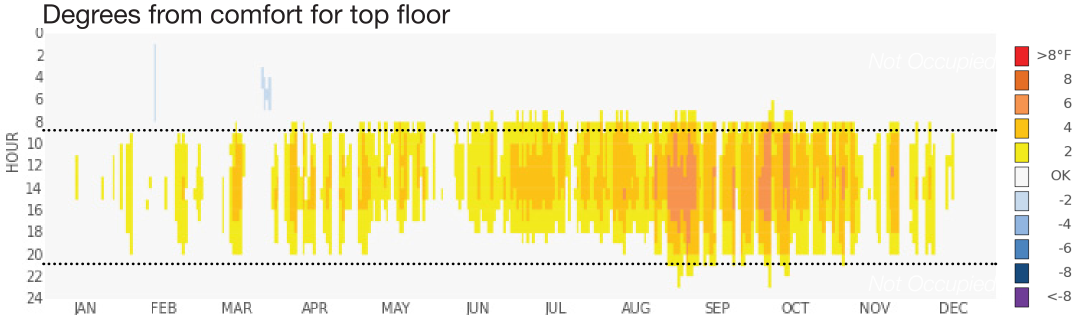




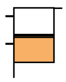
Operative temperature for top floor



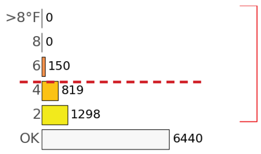
Degrees from comfort for top floor



Add/C.3.c.7 Classroom Analysis:: East Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL + 2 ACH	too warm	2267	**26%**	**84%**
		w/ celing fans	350	4%	13%

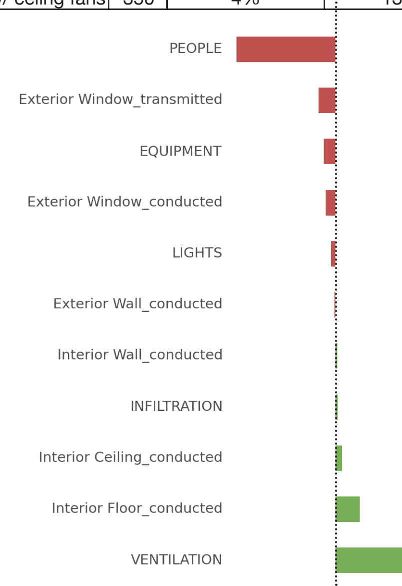


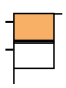
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

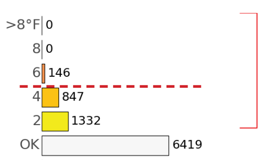
*** If considering only occupied hours (M-F 8am-8pm):: 84% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 13% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2325	**27%**	**86%**
		w/ celing fans	346	4%	13%

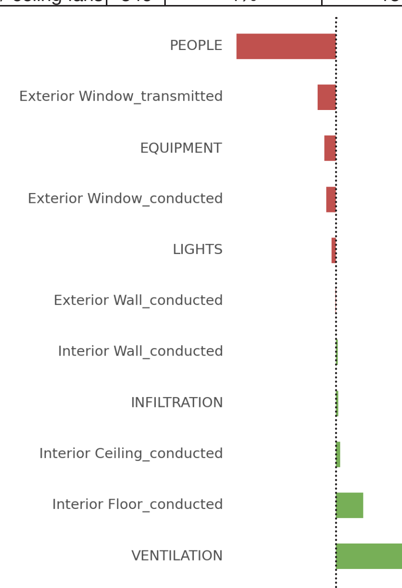


** Including all 8760 hrs of the year, not only occupied hours*

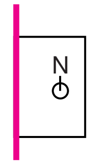
---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 86% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 13% too warm.*



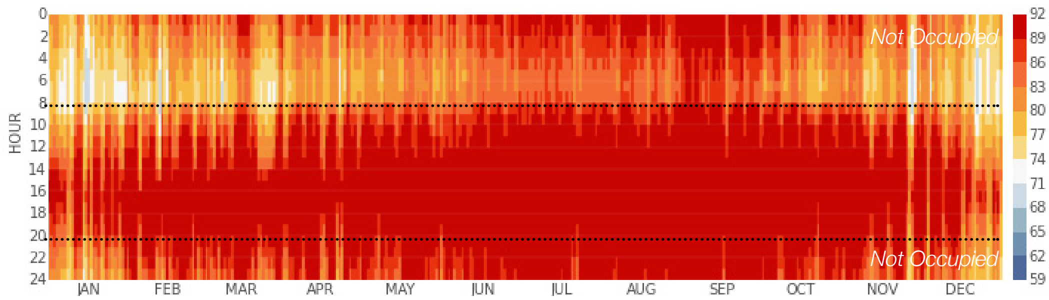
Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING



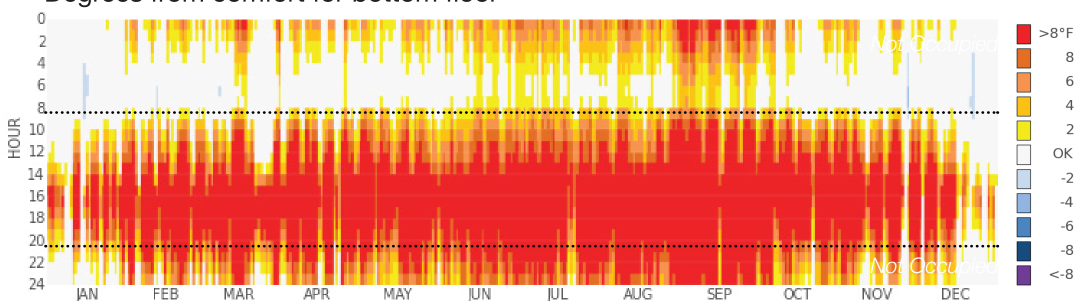
C.3.d.0. TYPICAL EXISTING

No Insulation in Opaque Surfaces and Single Pane Glass

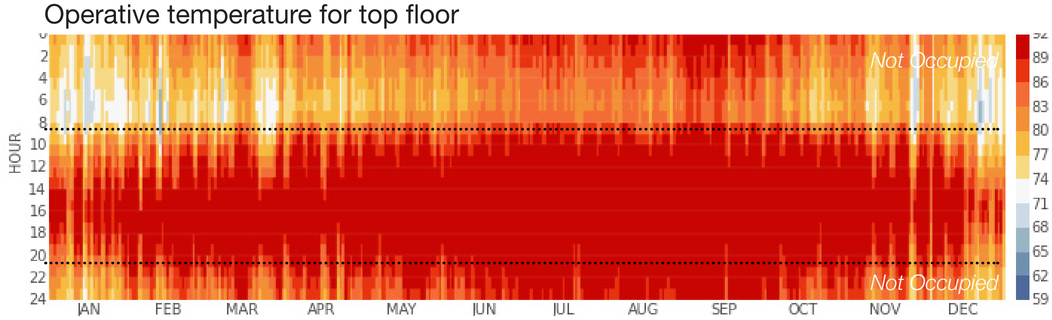
Operative temperature for bottom floor



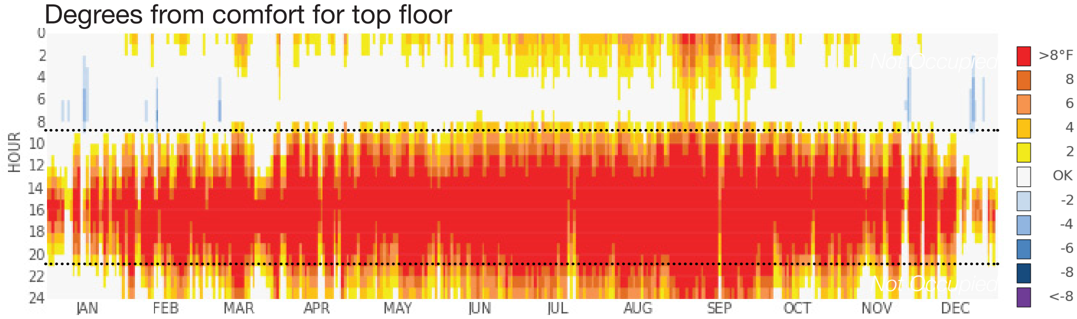
Degrees from comfort for bottom floor



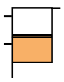
Operative temperature for top floor



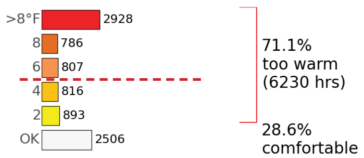
Degrees from comfort for top floor



Add/C.3.d.0 Classroom Analysis:: West Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	6230	**71%**	**100%**
	w/ celing fans	4521	52%	100%

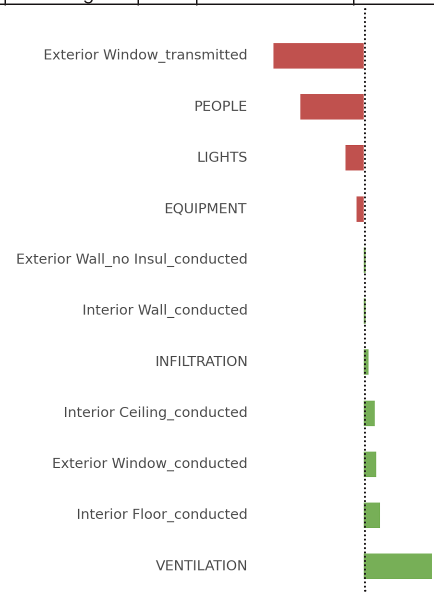


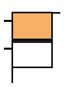
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*





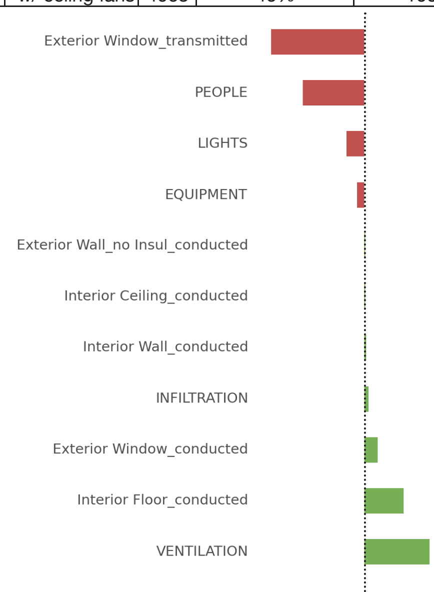
		Top Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	5580	**64%**	**100%**
	w/ celing fans	4063	46%	100%

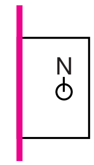
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

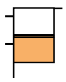




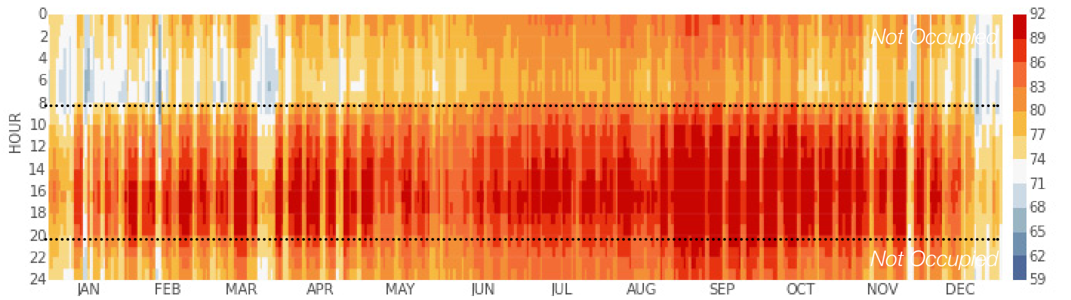
Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING

C.3.d.1. TYPICAL WITH WINDOW IMPROVEMENTS

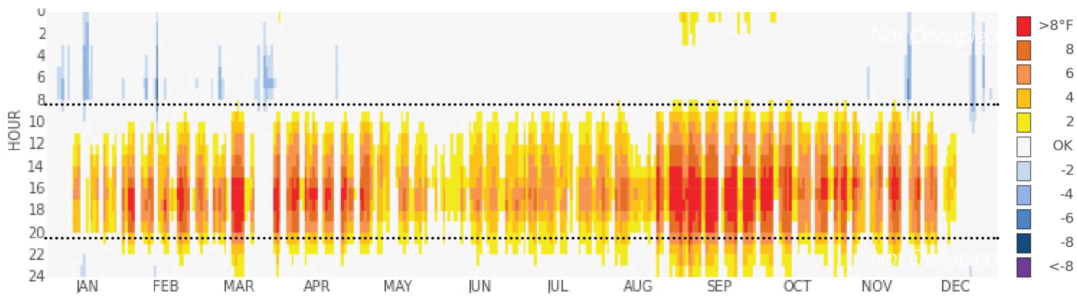
TYPICAL + 1ACH + Shading + IECC 2015 Windows

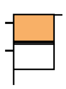


Operative temperature for bottom floor

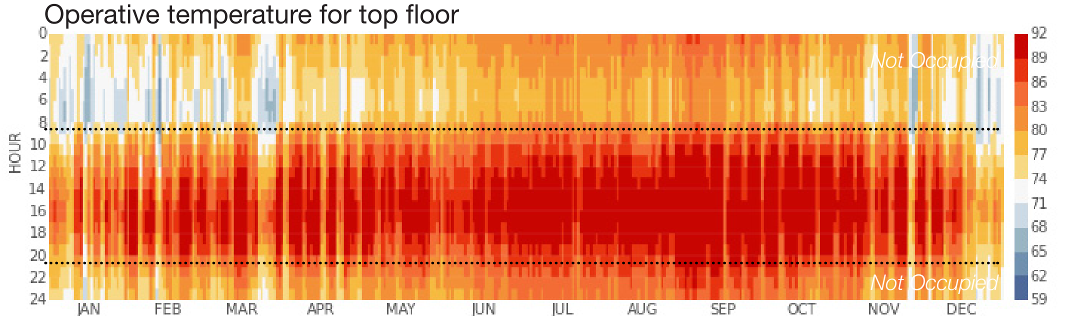


Degrees from comfort for bottom floor

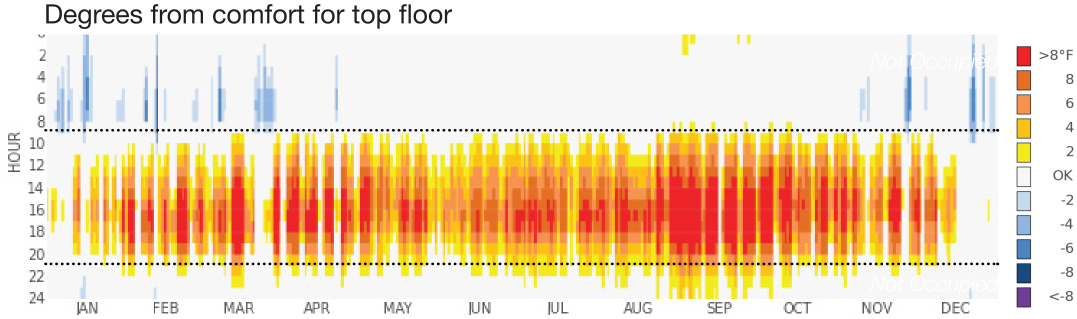




Operative temperature for top floor



Degrees from comfort for top floor

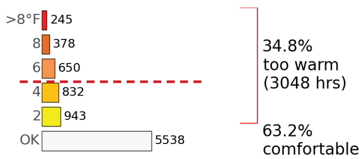


LOISOS + UBBELOHDE

Add/C.3.d.1 Classroom Analysis:: West Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3048	**35%**	**100%**
		w/ celing fans	1273	15%	47%

A-3 TYPICAL +1ACH +



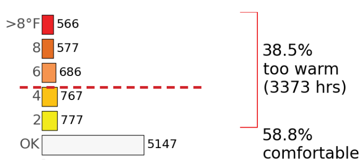
** Including all 8760 hrs of the year, not only occupied hours*

- - - - - Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

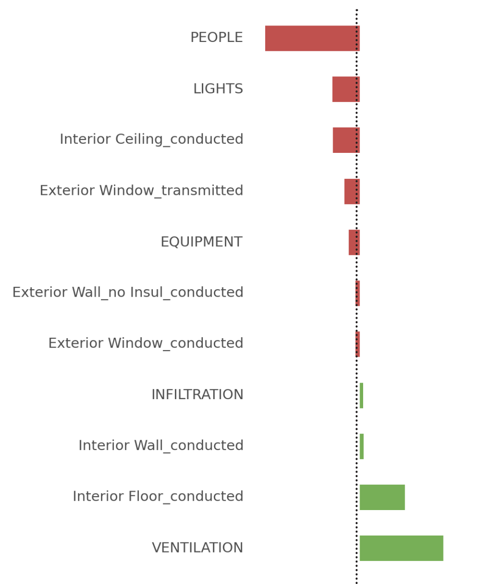
**** With ceiling fans (M-F 8am-8pm):: 47% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3373	**39%**	**100%**
		w/ celing fans	1829	21%	68%



** Including all 8760 hrs of the year, not only occupied hours*

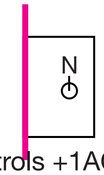
- - - - - - - - - - Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

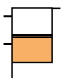
**** With ceiling fans (M-F 8am-8pm):: 68% too warm.*

Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING

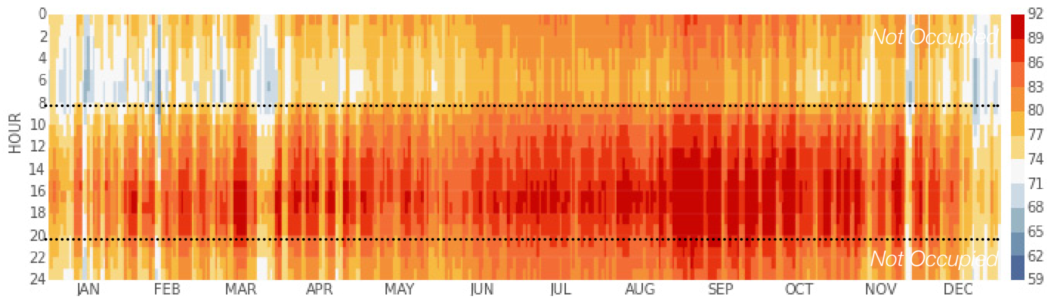


C.3.d.2. MINIMUM SUITE

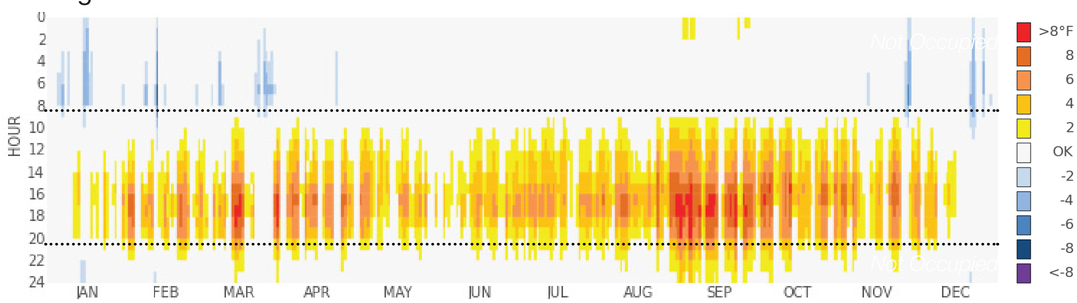
Equal to TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

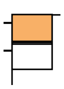


Operative temperature for bottom floor

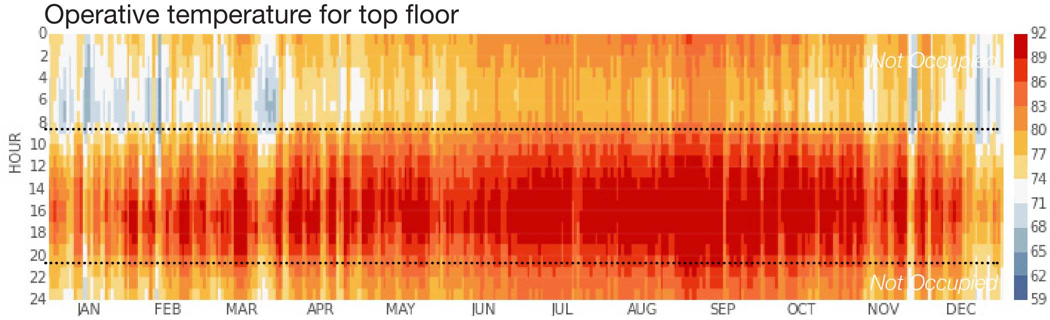


Degrees from comfort for bottom floor

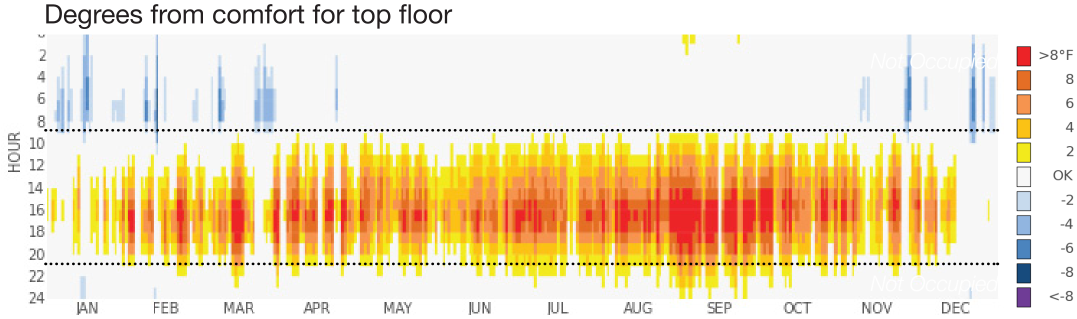




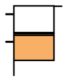
Operative temperature for top floor



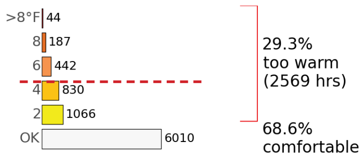
Degrees from comfort for top floor



Add/C.3.d.2 Classroom Analysis:: West Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	2569	**29%**	**95%**
		w/ celing fans	673	8%	25%

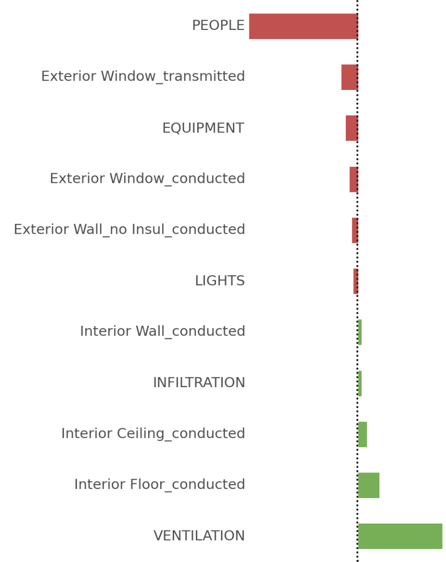


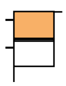
* Including all 8760 hrs of the year, not only occupied hours

----- *Ceiling Fans Effective*

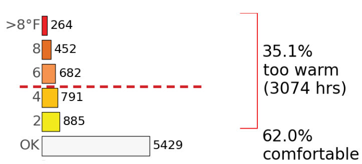
*** If considering only occupied hours (M-F 8am-8pm):: 95% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 25% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	3074	**35%**	**100%**
		w/ celing fans	1398	16%	52%

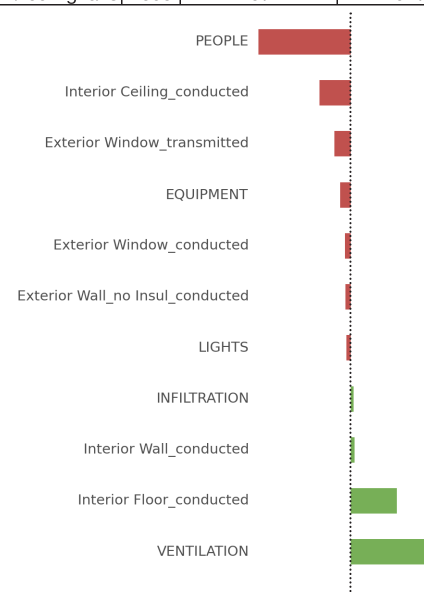


* Including all 8760 hrs of the year, not only occupied hours

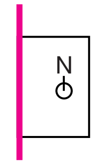
---------- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 52% too warm.*



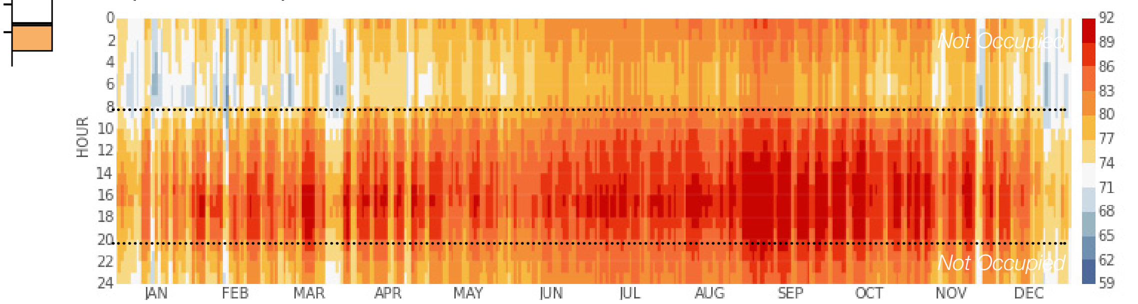
Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING



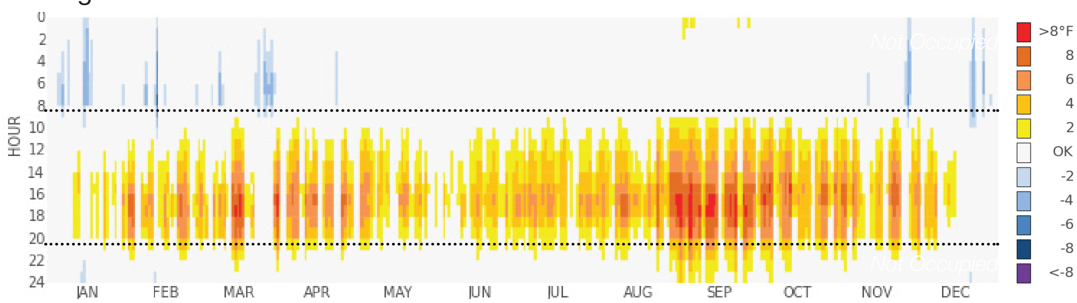
C.3.d.3. IMPROVED SUITE

Equal to MINIMUM SUITE + IECC Roof

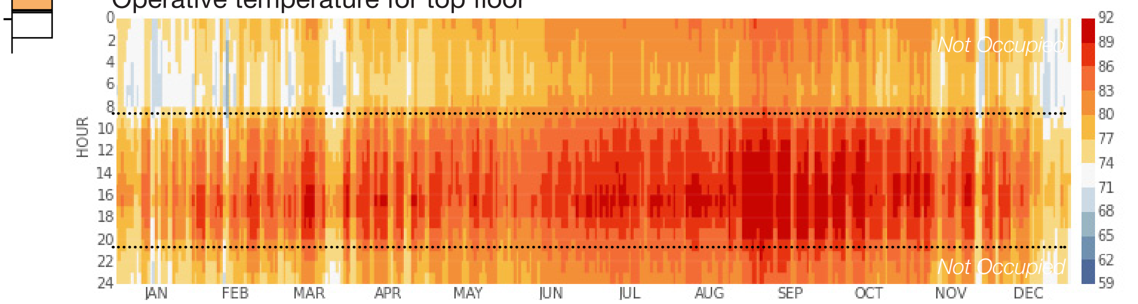
Operative temperature for bottom floor



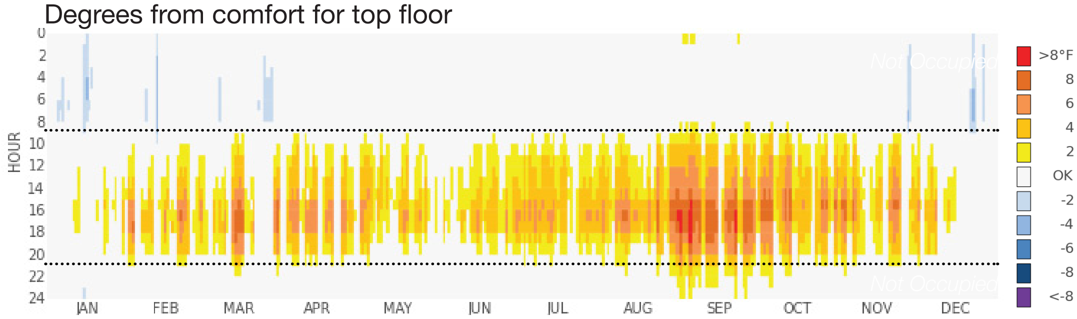
Degrees from comfort for bottom floor



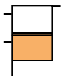
Operative temperature for top floor



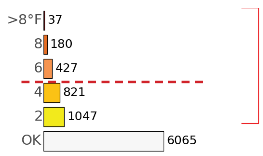
Degrees from comfort for top floor



Add/C.3.d.3 Classroom Analysis:: West Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2512	**29%**	**93%**
		w/ celing fans	644	7%	24%

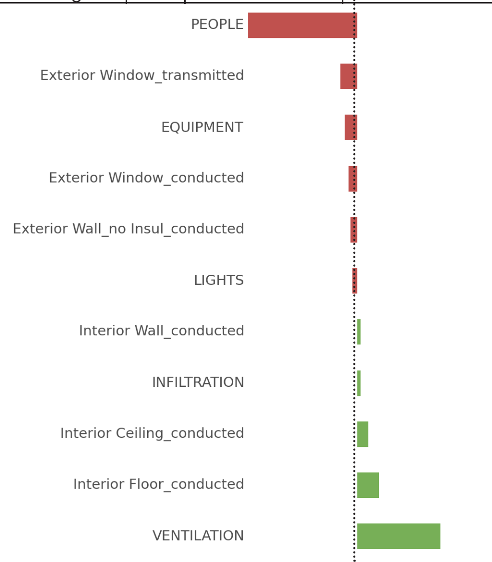


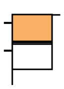
** Including all 8760 hrs of the year, not only occupied hours*

----- *Ceiling Fans Effective*

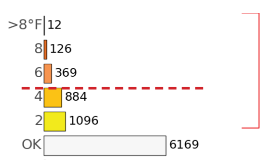
*** If considering only occupied hours (M-F 8am-8pm):: 93% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 24% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2487	**28%**	**92%**
		w/ celing fans	507	6%	19%

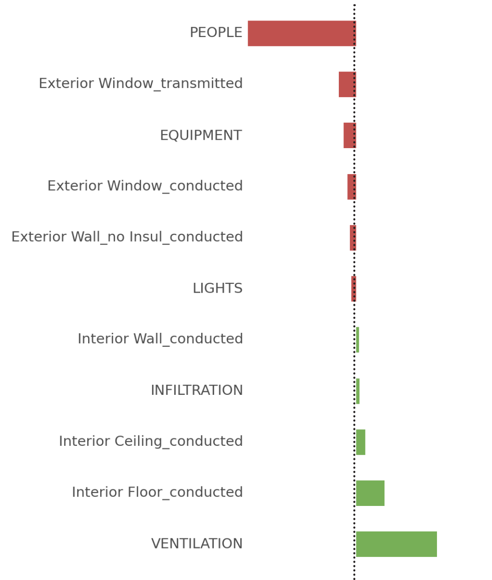


** Including all 8760 hrs of the year, not only occupied hours*

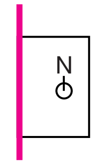
---------- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 92% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 19% too warm.*

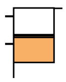


Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING

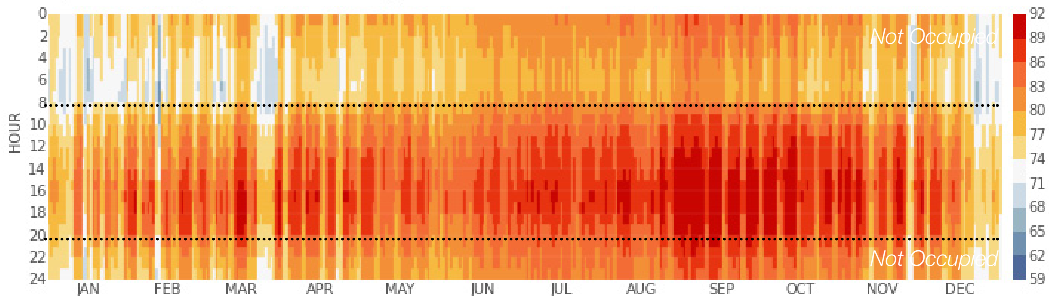


C.3.d.4. CODE SUITE

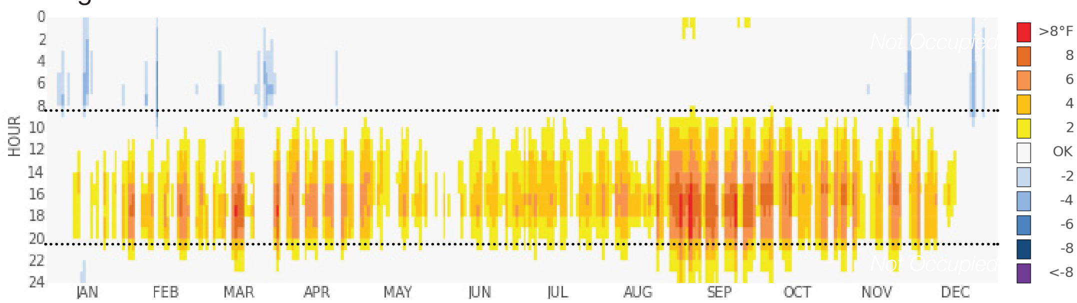
Equal to IMPROVED SUITE + IECC Walls

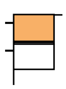


Operative temperature for bottom floor

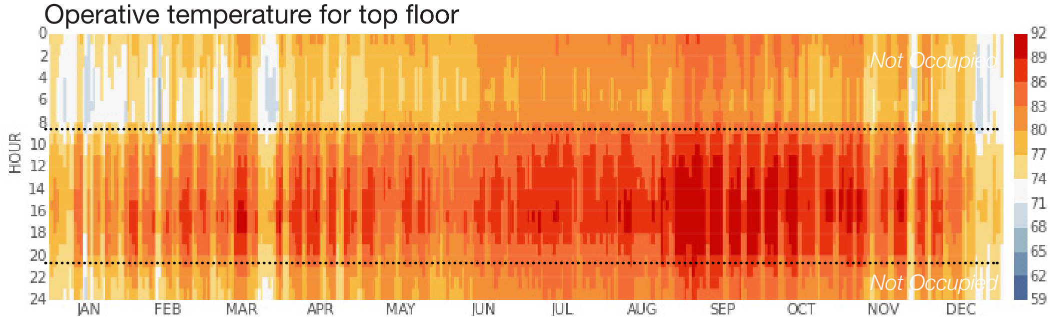


Degrees from comfort for bottom floor

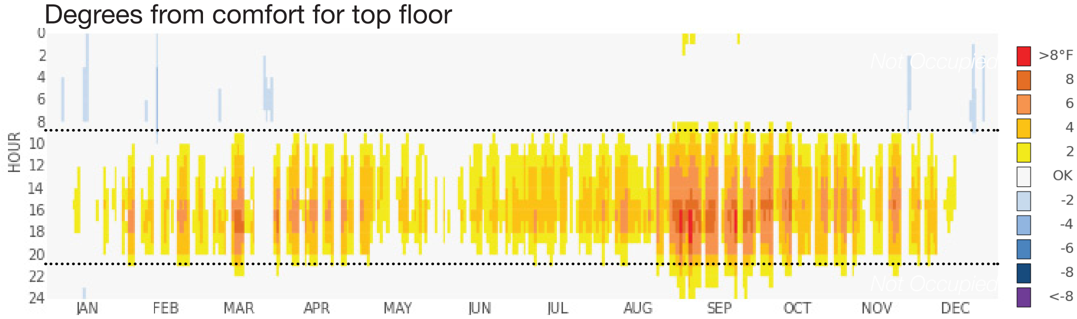




Operative temperature for top floor



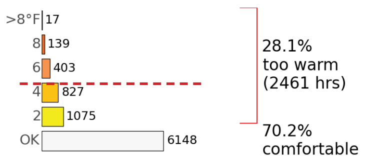
Degrees from comfort for top floor



LOISOS + UBBELOHDE

Add/C.3.d.4 Classroom Analysis:: West Facing (Continued)

		Bottom Floor		
		hours	% of the whole year	% of occupied time
C-2 CODE SUITE (C-1+ IEACC walls)	too warm	2461	**28%**	**91%**
	w/ celing fans	559	6%	21%

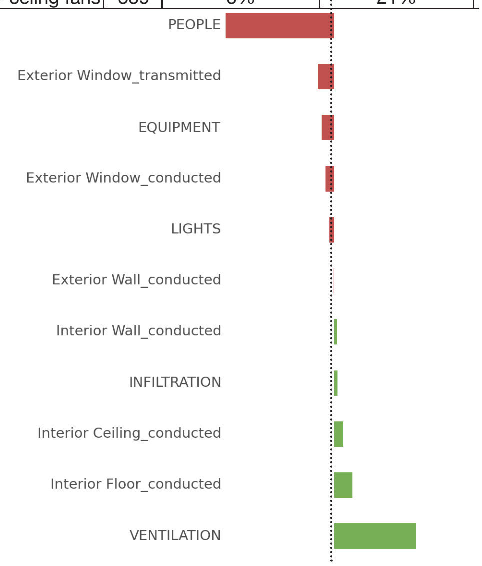


** Including all 8760 hrs of the year, not only occupied hours*

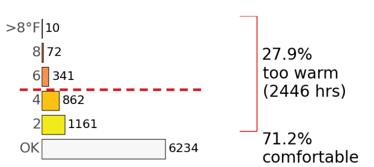
- - - - - Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 91% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 21% too warm.*



		Top Floor		
		hours	% of the whole year	% of occupied time
C-2 CODE SUITE (C-1+ IEACC walls)	too warm	2446	**28%**	**91%**
	w/ celing fans	423	5%	16%

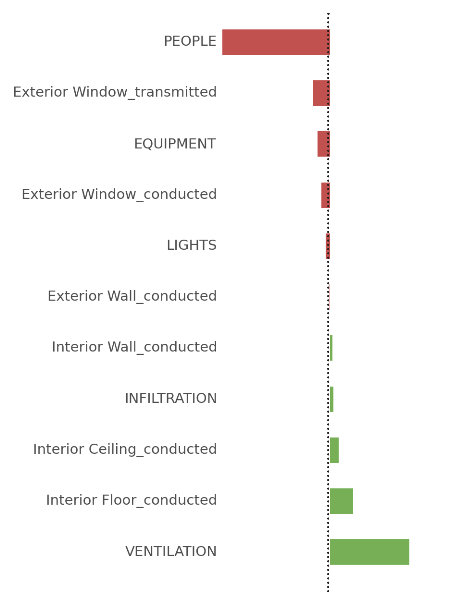


** Including all 8760 hrs of the year, not only occupied hours*

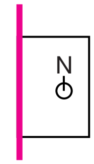
- - - - - - - - - - Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 91% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 16% too warm.*

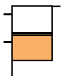


Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING

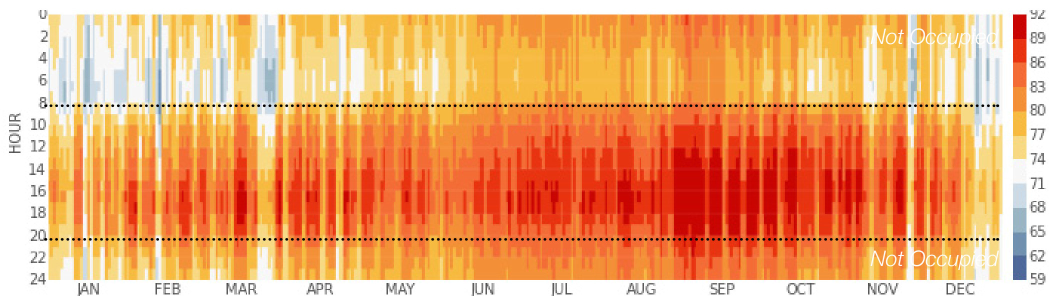


C.3.d.5. IMPROVED SUITE WITH VENTILATION

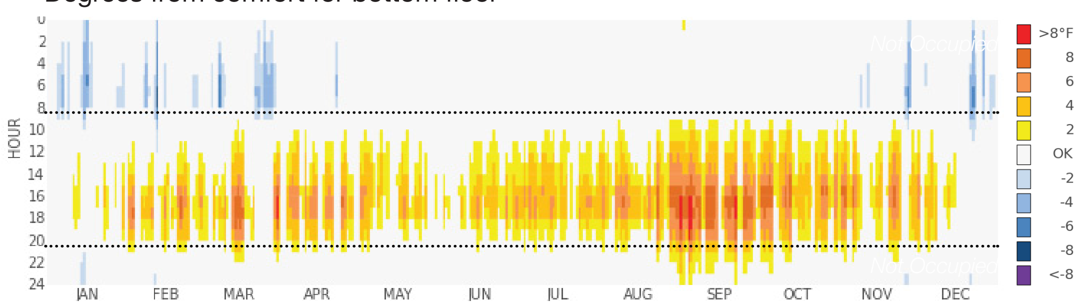
Equal to IMPROVED SUITE +2ACH

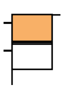


Operative temperature for bottom floor

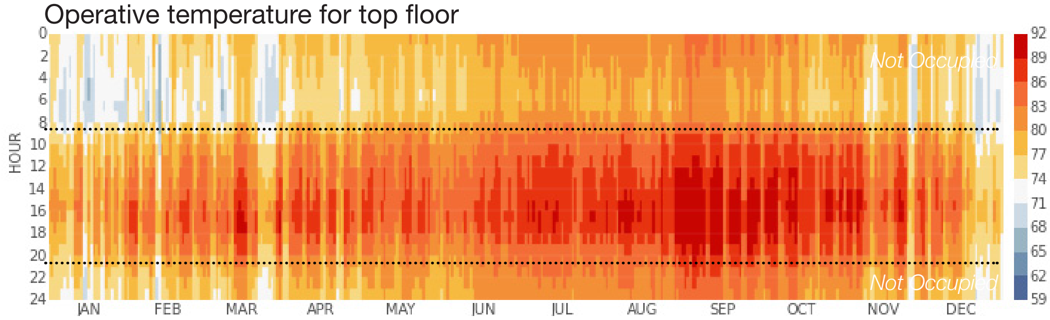


Degrees from comfort for bottom floor

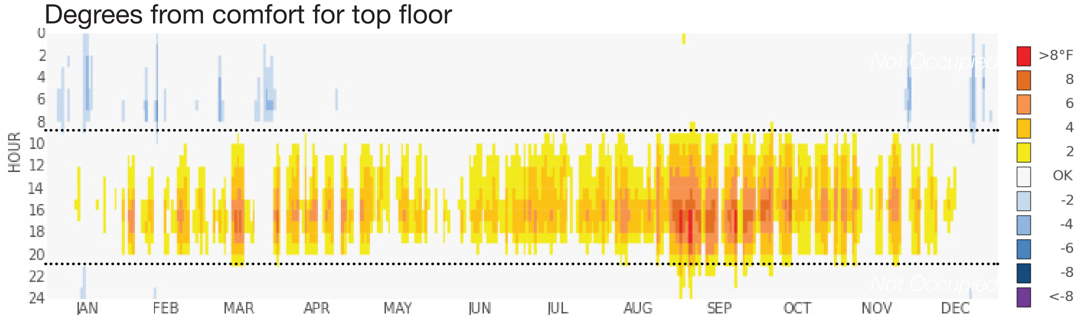




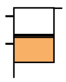
Operative temperature for top floor



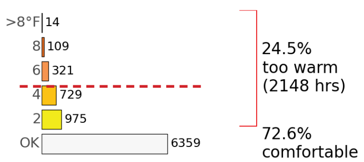
Degrees from comfort for top floor



Add/C.3.d.5 Classroom Analysis:: West Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2148	**25%**	**80%**
		w/ celing fans	444	5%	16%

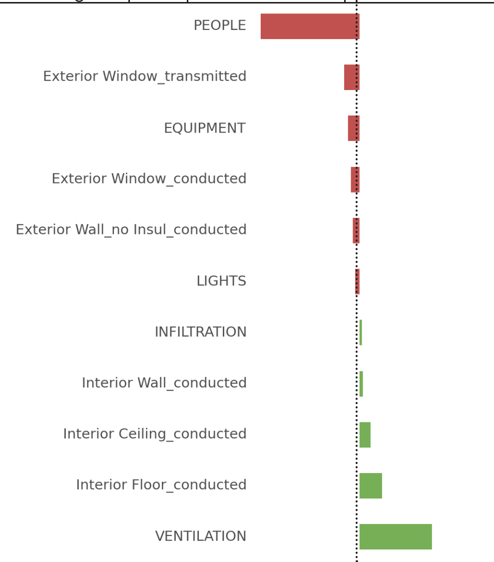


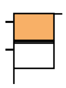
** Including all 8760 hrs of the year, not only occupied hours*

----- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 80% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 16% too warm.*





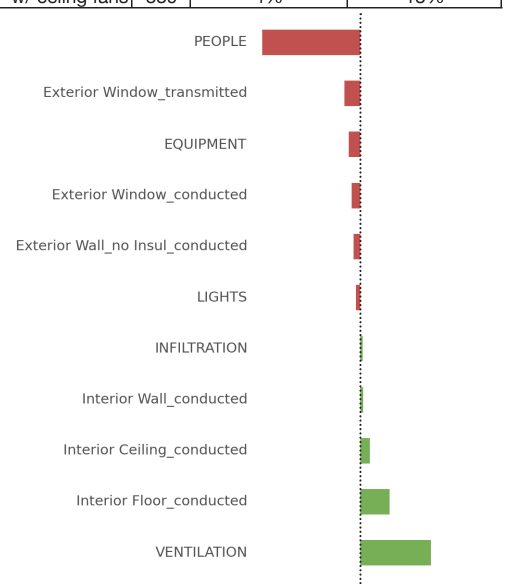
			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2120	**24%**	**79%**
		w/ celing fans	339	4%	13%

** Including all 8760 hrs of the year, not only occupied hours*

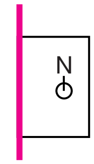
---------- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-8pm):: 79% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 13% too warm.*

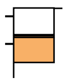


Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING

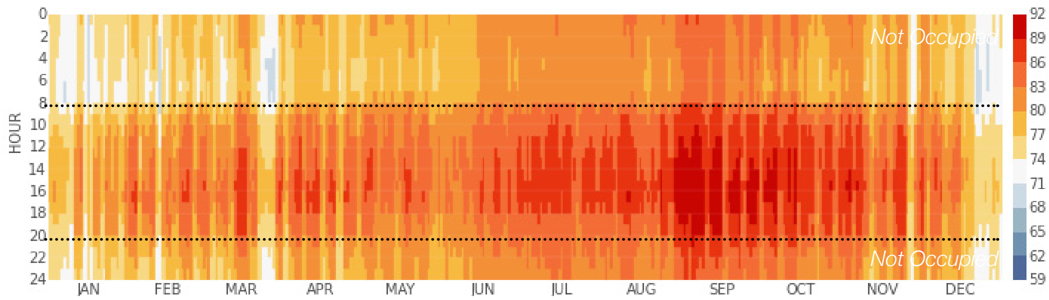


C.3.d.6. IDEAL SUITE

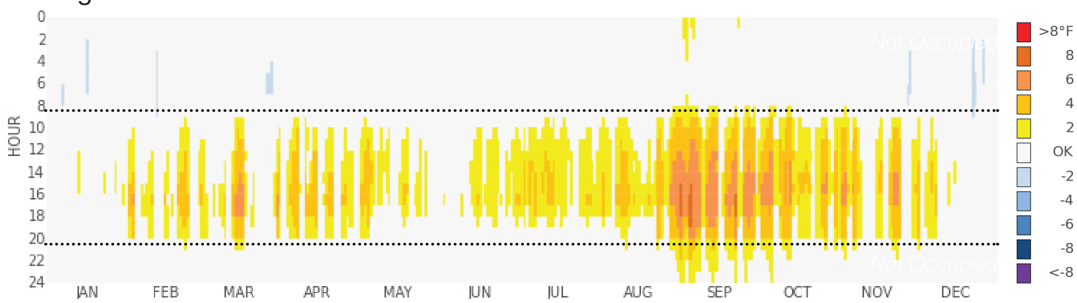
Equal to CODE SUITE + Thermal Mass

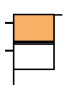


Operative temperature for bottom floor

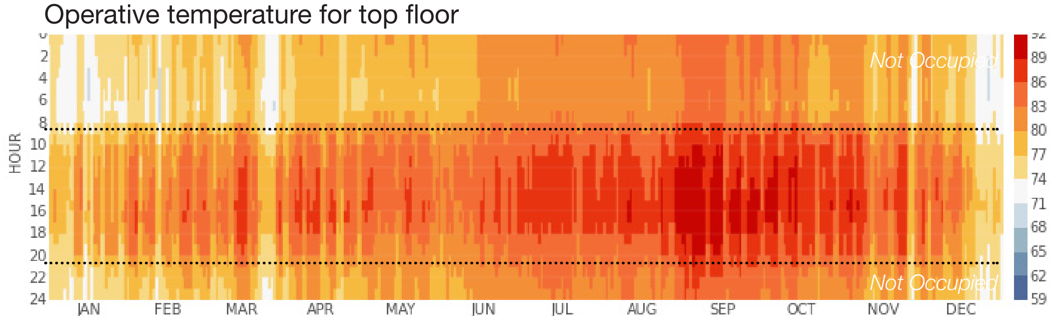


Degrees from comfort for bottom floor

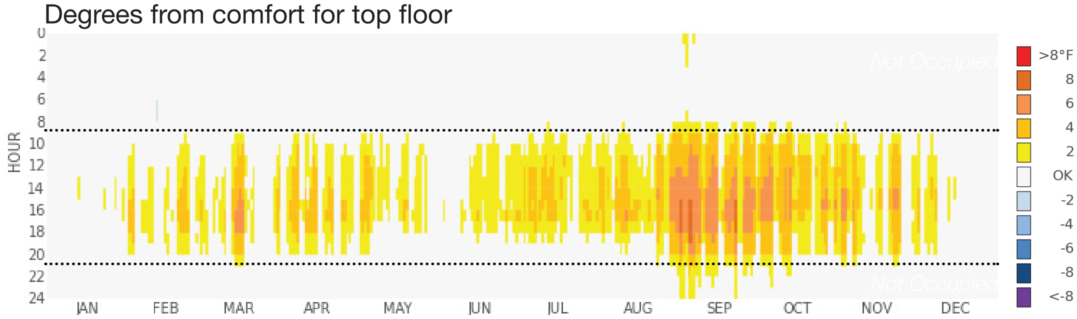




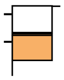
Operative temperature for top floor



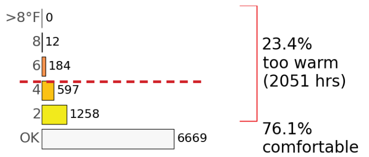
Degrees from comfort for top floor



Add/C.3.d.6 Classroom Analysis:: West Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2051	**23%**	**76%**
		w/ celing fans	196	2%	7%

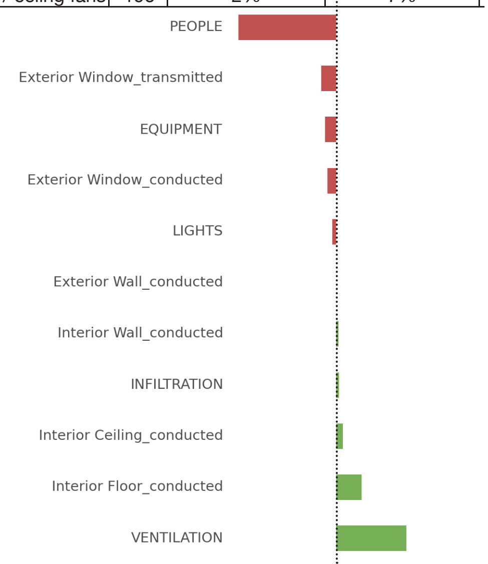


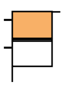
** Including all 8760 hrs of the year, not only occupied hours*

- - - - - Ceiling Fans Effective

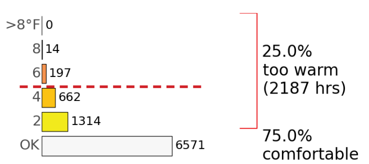
*** If considering only occupied hours (M-F 8am-8pm):: 76% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 7% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2187	**25%**	**81%**
		w/ celing fans	211	2%	8%

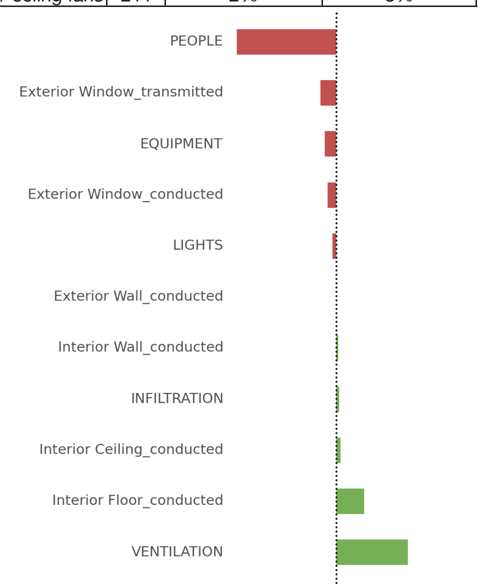


** Including all 8760 hrs of the year, not only occupied hours*

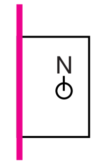
- - - - - - - - - - Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 81% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 8% too warm.*



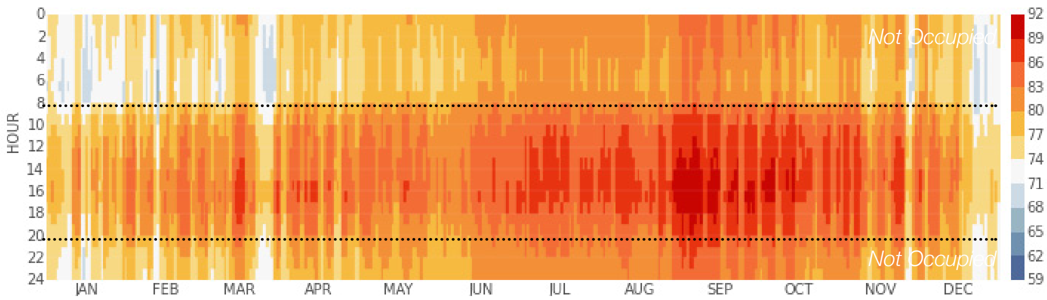
Add/C.3.d CLASSROOM ANALYSIS:: WEST FACING



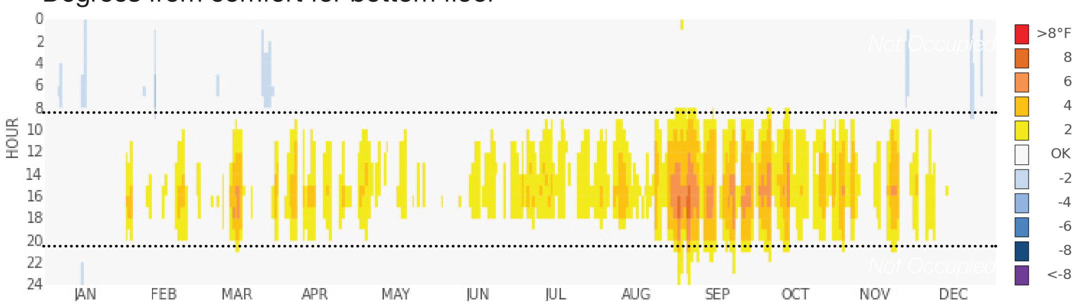
C.3.d.7. IDEAL SUITE WITH VENTILATION

Equal to IDEAL SUITE + 2ACH

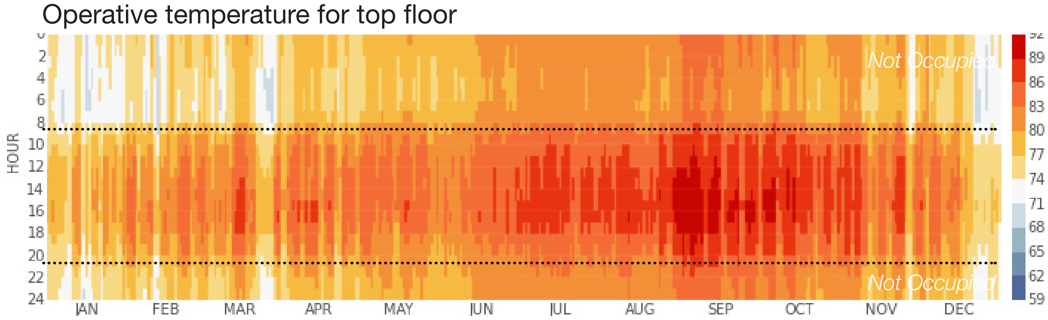
Operative temperature for bottom floor



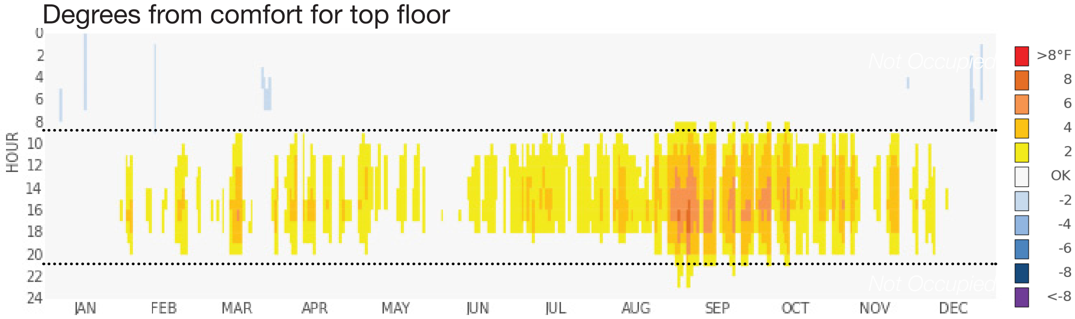
Degrees from comfort for bottom floor



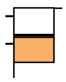
Operative temperature for top floor



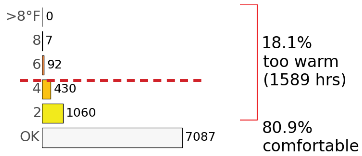
Degrees from comfort for top floor



Add/C.3.d.7 Classroom Analysis:: West Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL + 2 ACH	too warm	1589	**18%**	**59%**
		w/ celing fans	99	1%	4%

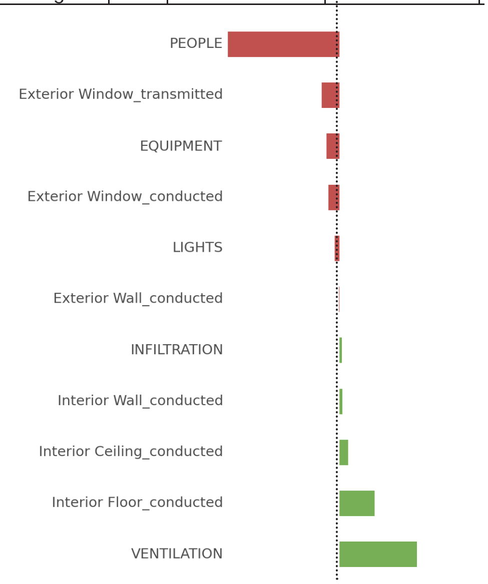


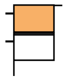
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

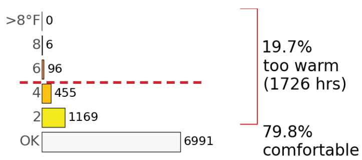
*** If considering only occupied hours (M-F 8am-8pm):: 59% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 4% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1726	**20%**	**64%**
		w/ celing fans	102	1%	4%

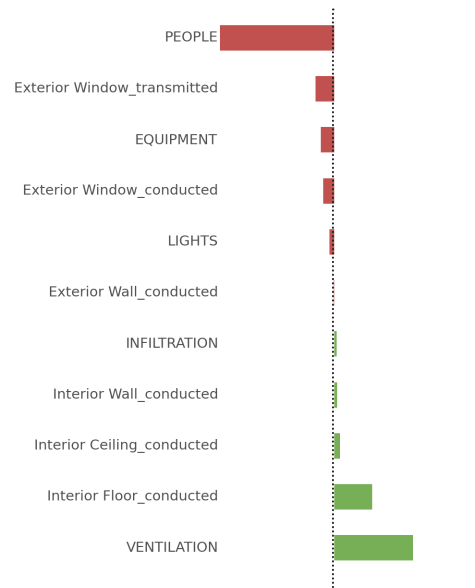


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 64% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 4% too warm.*



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Add/C. HVAC AUTONOMY AND THERMAL COMFORT STUDIES

4. OFFICE ANALYSIS

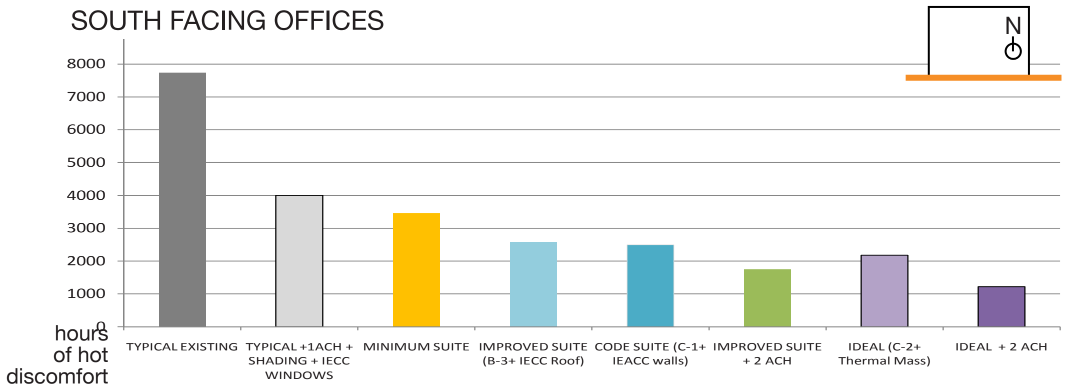
FOR EACH ORIENTATION (a. SOUTH, b. NORTH, c. WEST AND d. EAST)

OPEN OFFICE

0. ***TYPICAL EXISTING***:: No Insulation in Opaque Surfaces, Single Pane Glass Windows
1. TYPICAL + 1ACH + Shading + IECC Glazing
2. ***MINIMUM SUITE***:: TYPICAL + 1ACH + IECC Glazing + Shading + lower LPD + daylight controls
3. ***IMPROVED SUITE***:: Minimum Suite + IECC Roof
4. ***CODE SUITE***:: Improved Suite + IECC Walls
5. IMPROVED SUITE + 2ACH
6. ***IDEAL SUITE***:: Code Suite + Thermal Mass
7. IDEAL SUITE + 2ACH

Add/C.4 Office Analysis (Continued)

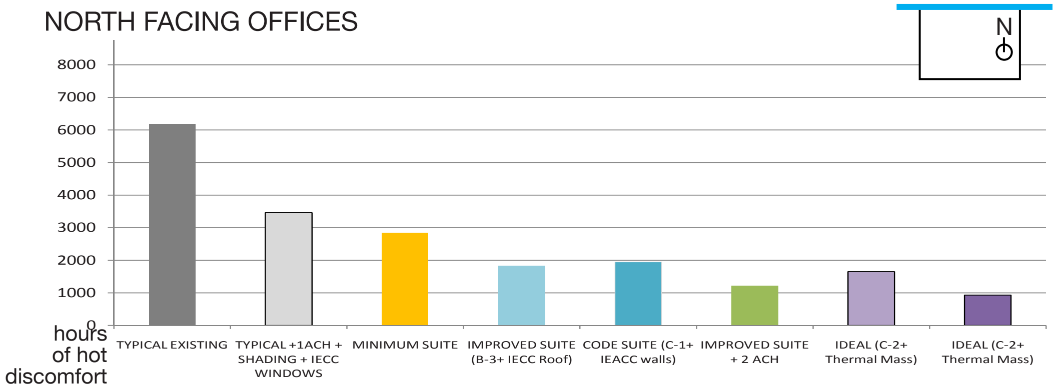
SOUTH FACING OFFICES



			Bottom Floor			Top Floor		
			hours	% of the whole year	% of occupied time	hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	8384	**96%**	**100%**	7736	**88%**	**100%**
		w/ celing fans	7209	82%	100%	6339	72%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3766	**43%**	**100%**	4003	**46%**	**100%**
		w/ celing fans	1665	19%	82%	2254	26%	100%
B-3	MINIMUM SUITE	too warm	2763	**32%**	**100%**	3452	**39%**	**100%**
		w/ celing fans	705	8%	35%	1623	19%	80%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2572	**29%**	**100%**	2593	**30%**	**100%**
		w/ celing fans	855	10%	42%	752	9%	37%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2506	**29%**	**100%**	2493	**28%**	**100%**
		w/ celing fans	501	6%	25%	393	4%	19%
D-2	IMPROVED SUITE + 2 ACH	too warm	1739	**20%**	**86%**	1746	**20%**	**86%**
		w/ celing fans	269	3%	13%	212	2%	10%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2028	**23%**	**100%**	2180	**25%**	**100%**
		w/ celing fans	203	2%	10%	197	2%	10%
E-2	IDEAL + 2 ACH	too warm	1060	**12%**	**52%**	1216	**14%**	**60%**
		w/ celing fans	32	0%	2%	33	0%	2%

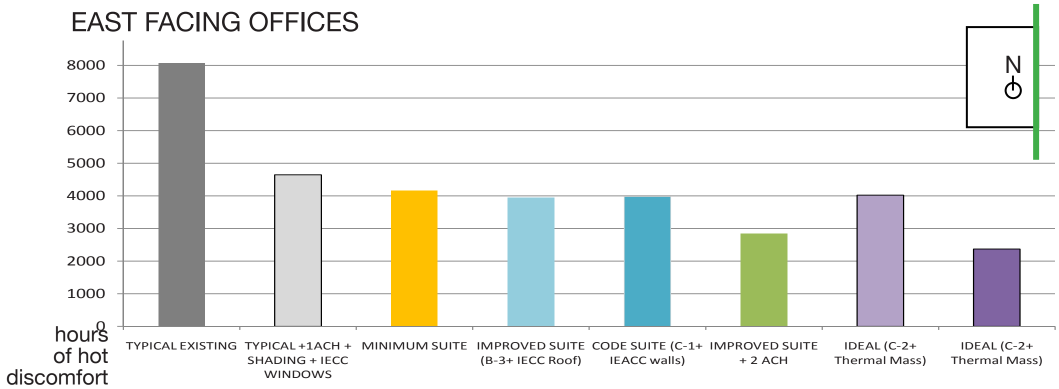
Add/C.4 Office Analysis (Continued)

NORTH FACING OFFICES



			Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time		Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
	TYPICAL EXISTING	too warm	6863	**78%**	**100%**	too warm	6181	**71%**	**100%**
		w/ celing fans	5001	57%	100%	w/ celing fans	4365	50%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3026	**35%**	**100%**	too warm	3458	**39%**	**100%**
		w/ celing fans	1077	12%	53%	w/ celing fans	1792	20%	88%
B-3	MINIMUM SUITE	too warm	2007	**23%**	**99%**	too warm	2850	**33%**	**100%**
		w/ celing fans	169	2%	8%	w/ celing fans	1162	13%	57%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	1814	**21%**	**90%**	too warm	1835	**21%**	**91%**
		w/ celing fans	122	1%	6%	w/ celing fans	172	2%	8%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	1881	**21%**	**93%**	too warm	1949	**22%**	**96%**
		w/ celing fans	149	2%	7%	w/ celing fans	120	1%	6%
D-2	IMPROVED SUITE + 2 ACH	too warm	1175	**13%**	**58%**	too warm	1217	**14%**	**60%**
		w/ celing fans	29	0%	1%	w/ celing fans	17	0%	1%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1462	**17%**	**72%**	too warm	1653	**19%**	**82%**
		w/ celing fans	32	0%	2%	w/ celing fans	40	0%	2%
E-1	IDEAL + 2 ACH	too warm	728	**8%**	**36%**	too warm	934	**11%**	**46%**
		w/ celing fans	0	0%	0%	w/ celing fans	0	0%	0%

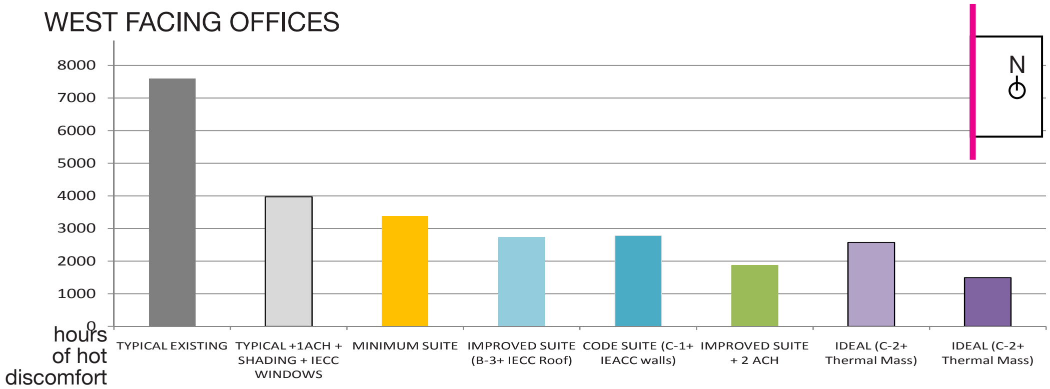
Add/C.4 Office Analysis (Continued)



			Bottom Floor			Top Floor			
			hours	% of the whole year	% of occupied time		hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	8497	**97%**	**100%**	too warm	8064	**92%**	**100%**
		w/ celing fans	7948	91%	100%	w/ celing fans	7175	82%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	4801	**55%**	**100%**	too warm	4647	**53%**	**100%**
		w/ celing fans	2582	29%	100%	w/ celing fans	2876	33%	100%
B-3	MINIMUM SUITE	too warm	4035	**46%**	**100%**	too warm	4158	**47%**	**100%**
		w/ celing fans	1795	20%	89%	w/ celing fans	2298	26%	100%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	3934	**45%**	**100%**	too warm	3951	**45%**	**100%**
		w/ celing fans	1700	19%	84%	w/ celing fans	1533	18%	76%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	3928	**45%**	**100%**	too warm	3975	**45%**	**100%**
		w/ celing fans	1561	18%	77%	w/ celing fans	1366	16%	67%
D-2	IMPROVED SUITE + 2 ACH	too warm	2870	**33%**	**100%**	too warm	2847	**33%**	**100%**
		w/ celing fans	830	9%	41%	w/ celing fans	680	8%	34%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	3964	**45%**	**100%**	too warm	4020	**46%**	**100%**
		w/ celing fans	932	11%	46%	w/ celing fans	945	11%	47%
E-1	IDEAL + 2 ACH	too warm	2339	**27%**	**100%**	too warm	2372	**27%**	**100%**
		w/ celing fans	184	2%	9%	w/ celing fans	194	2%	10%

Add/C.4 Office Analysis (Continued)

WEST FACING OFFICES



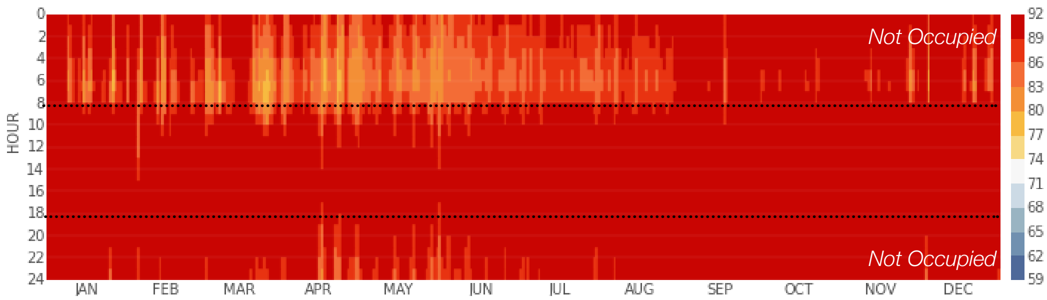
			Bottom Floor hours	Bottom Floor % of the whole year	Bottom Floor % of occupied time	Top Floor hours	Top Floor % of the whole year	Top Floor % of occupied time
	TYPICAL EXISTING	too warm	8202	**94%**	**100%**	7591	**87%**	**100%**
		w/ celing fans	7303	83%	100%	6271	72%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3857	**44%**		3972	**45%**	**100%**
		w/ celing fans	1677	19%	83%	2258	26%	100%
B-3	MINIMUM SUITE	too warm	2879	**33%**	**100%**	3380	**39%**	**100%**
		w/ celing fans	787	9%	39%	1641	19%	81%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2717	**31%**	**100%**	2742	**31%**	**100%**
		w/ celing fans	653	7%	32%	571	7%	28%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2723	**31%**	**100%**	2779	**32%**	**100%**
		w/ celing fans	575	7%	28%	498	6%	25%
D-2	IMPROVED SUITE + 2 ACH	too warm	1862	**21%**	**92%**	1879	**21%**	**93%**
		w/ celing fans	310	4%	15%	253	3%	12%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2449	**28%**	**100%**	2573	**29%**	**100%**
		w/ celing fans	282	3%	14%	304	3%	15%
E-1	IDEAL + 2 ACH	too warm	1332	**15%**	**66%**	1493	**17%**	**74%**
		w/ celing fans	74	1%	4%	84	1%	4%

Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

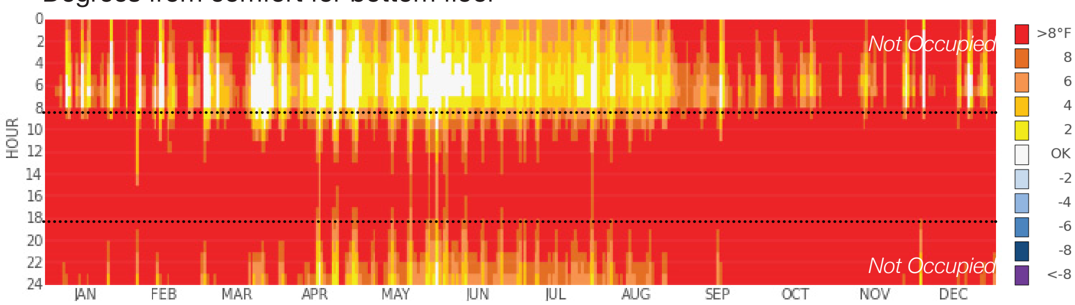
C.4.a.0. TYPICAL EXISTING

No Insulation in Opaque Surfaces and Single Pane Glass

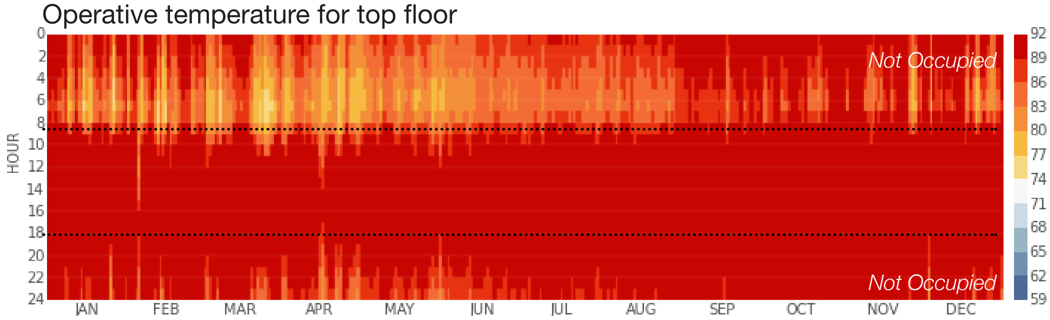
Operative temperature for bottom floor



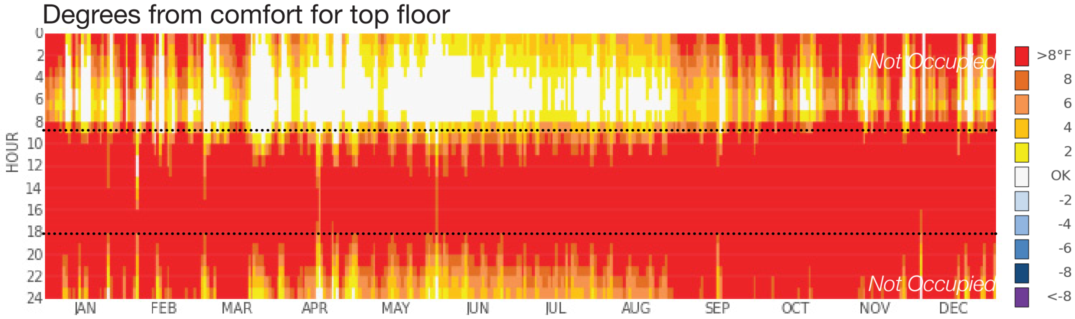
Degrees from comfort for bottom floor



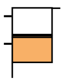
Operative temperature for top floor



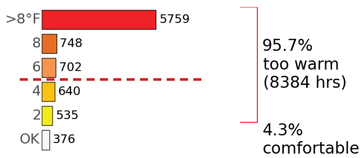
Degrees from comfort for top floor



Add/C.4.a.0 Office Analysis:: South Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	8384	**96%**	**100%**
	w/ celing fans	7209	82%	100%

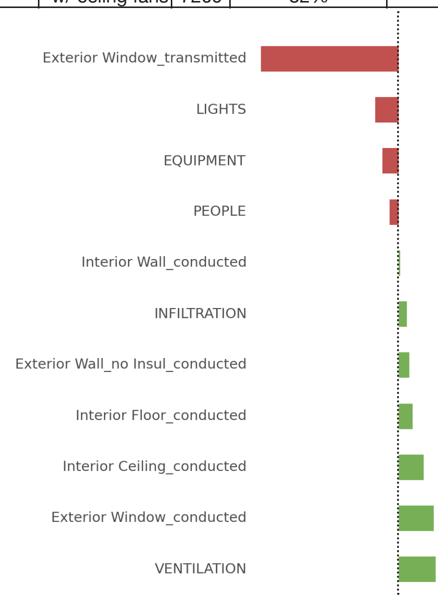


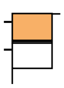
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

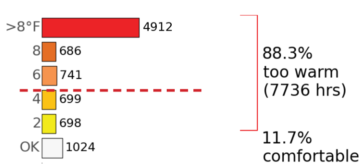
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*





		Top Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	7736	**88%**	**100%**
	w/ celing fans	6339	72%	100%

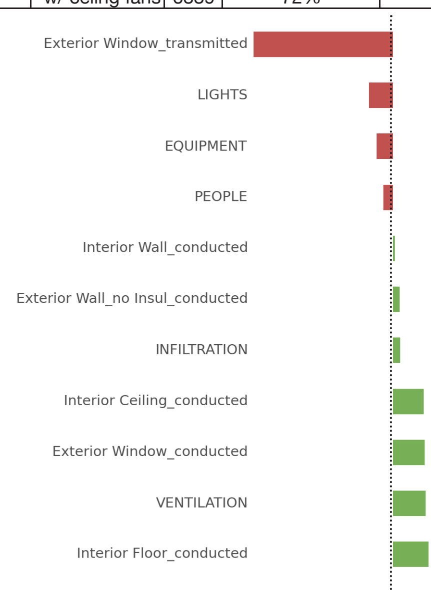


** Including all 8760 hrs of the year, not only occupied hours*

---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

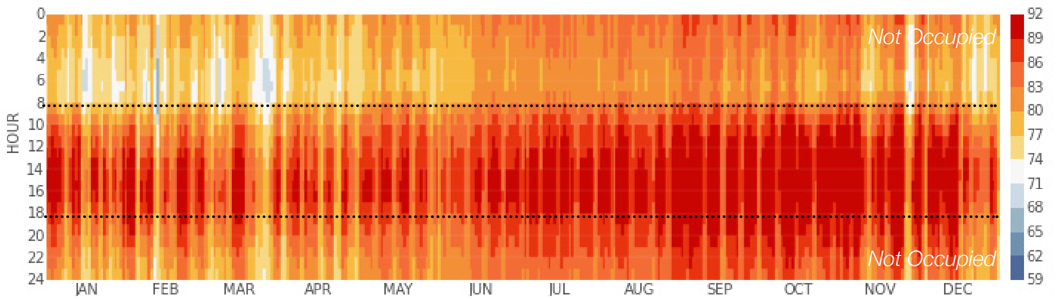


Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

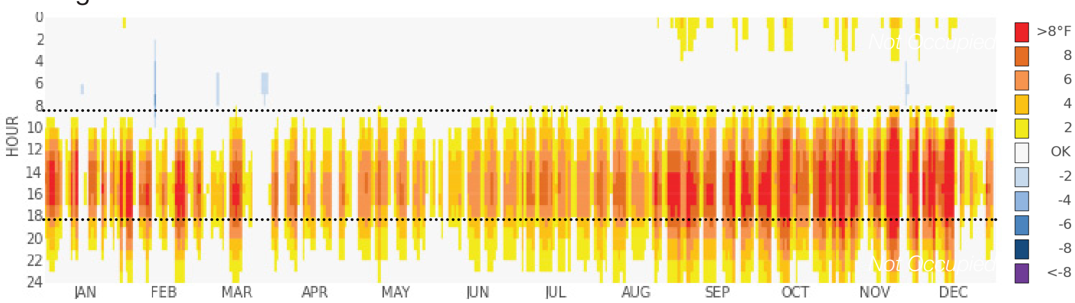
C.4.a.1.TYPICAL WITH WINDOW IMPROVEMENTS

Equal to TYPICAL + 1ACH + Shading + IECC 2015 Windows

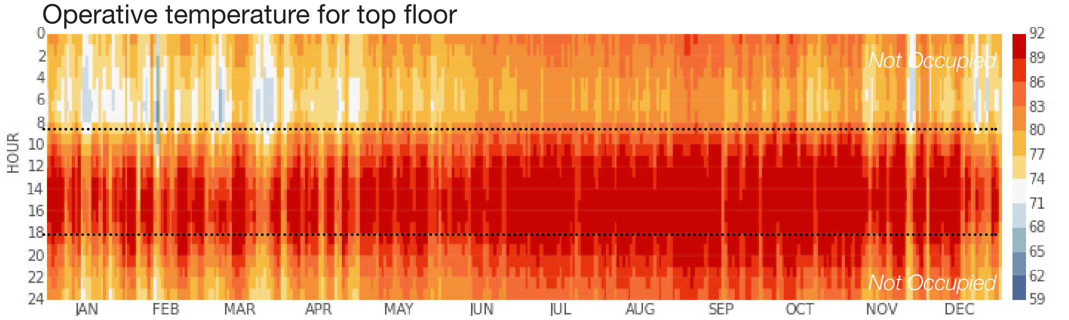
Operative temperature for bottom floor



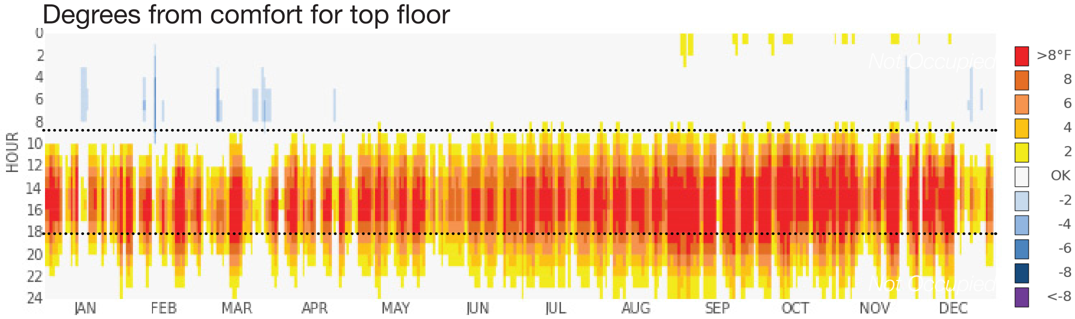
Degrees from comfort for bottom floor



Operative temperature for top floor



Degrees from comfort for top floor



Add/C.4.a.1 Office Analysis:: South Facing (Continued)

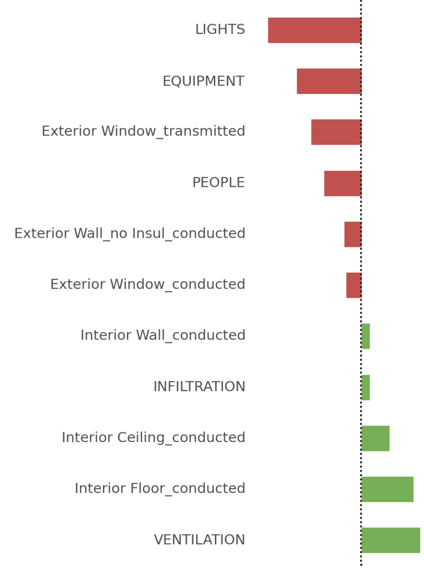
			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3766	**43%**	**100%**
		w/ celing fans	1665	19%	82%

** Including all 8760 hrs of the year, not only occupied hours*

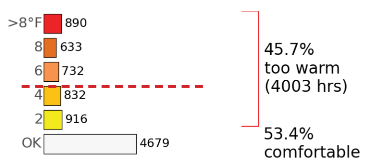
----- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 82% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	4003	**46%**	**100%**
		w/ celing fans	2254	26%	100%

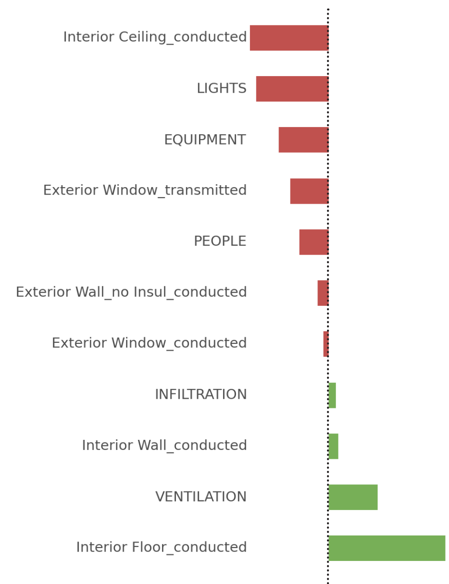


** Including all 8760 hrs of the year, not only occupied hours*

---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

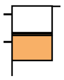
**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*



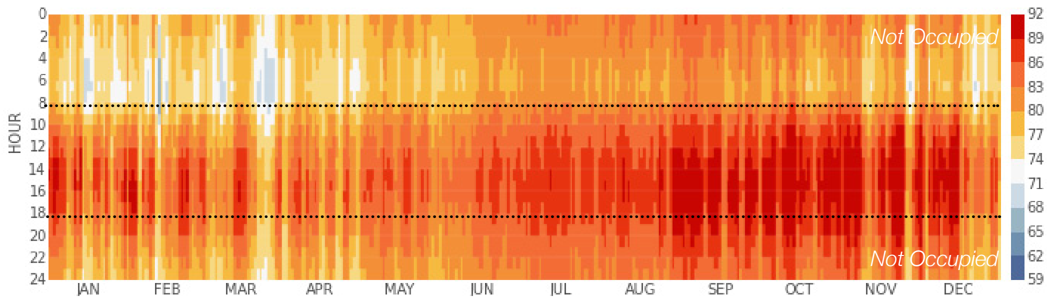
Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

C.4.a.2. MINIMUM SUITE

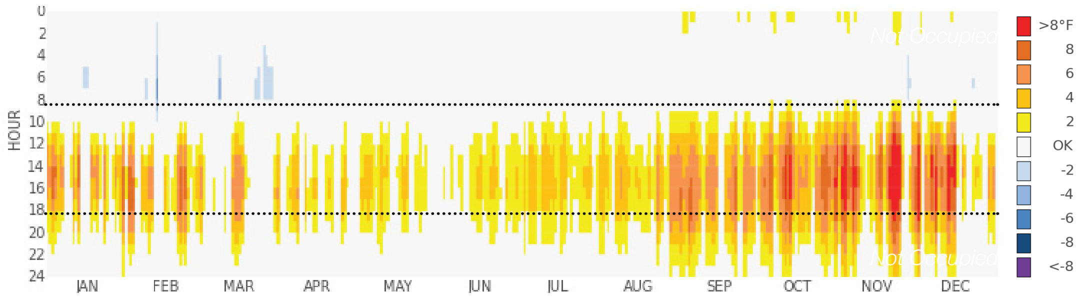
Equal to TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

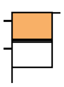


Operative temperature for bottom floor

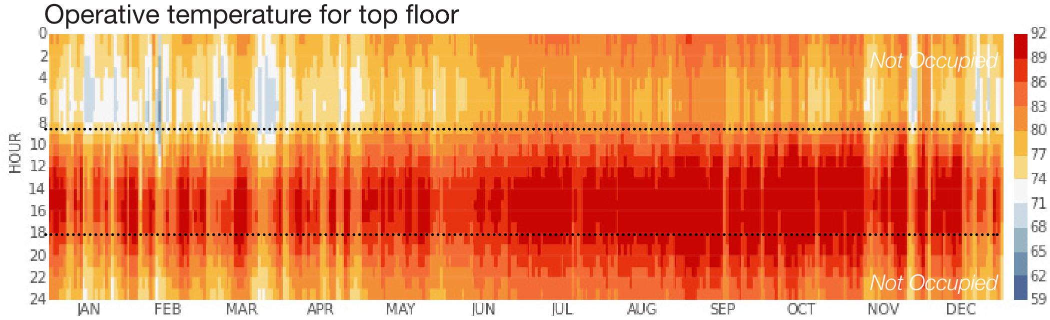


Degrees from comfort for bottom floor

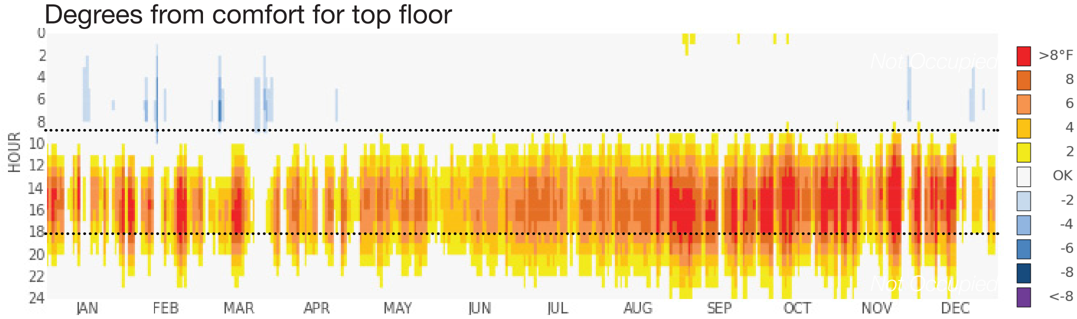




Operative temperature for top floor

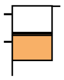


Degrees from comfort for top floor

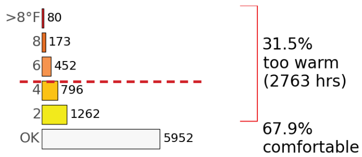


LOISOS + UBBELOHDE

Add/C.4.a.2 Office Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	2763	**32%**	**100%**
		w/ celing fans	705	8%	35%

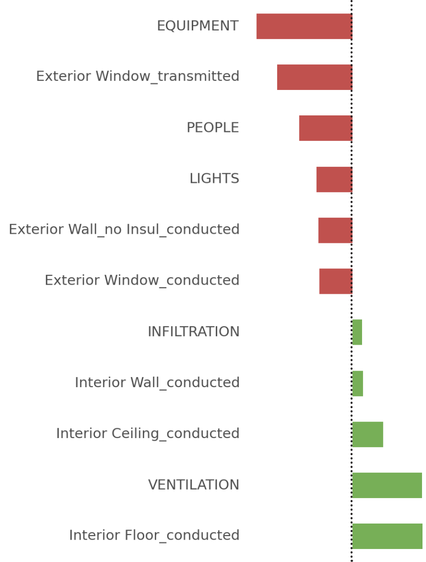


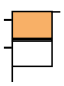
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 35% too warm.*





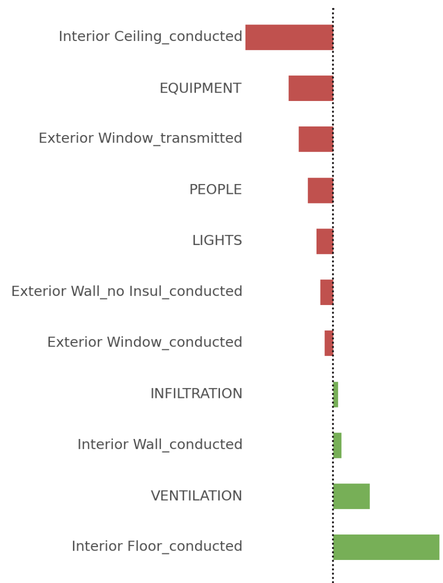
			Top Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	3452	**39%**	**100%**
		w/ celing fans	1623	19%	80%

** Including all 8760 hrs of the year, not only occupied hours*

---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

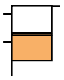
**** With ceiling fans (M-F 8am-8pm):: 80% too warm.*



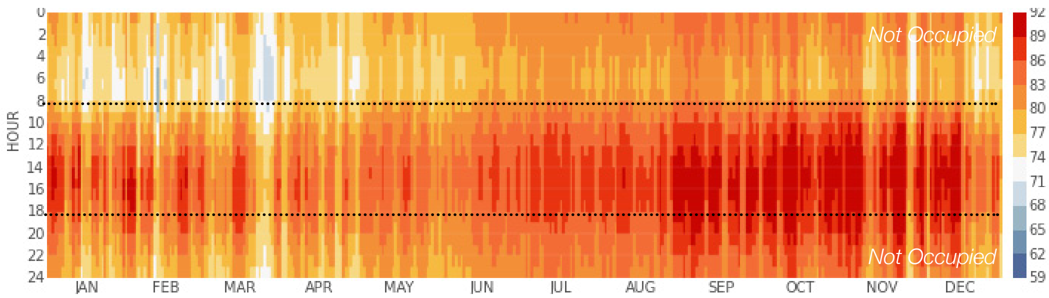
Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

C.4.a.3. IMPROVED SUITE

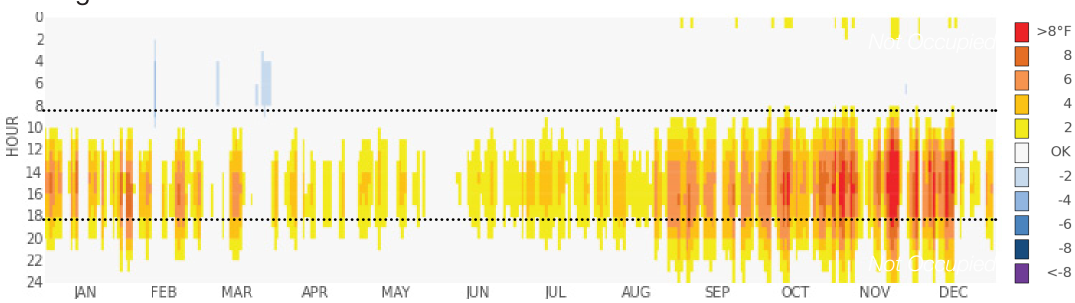
Equal to MINIMUM SUITE + IECC Roof

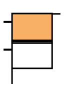


Operative temperature for bottom floor

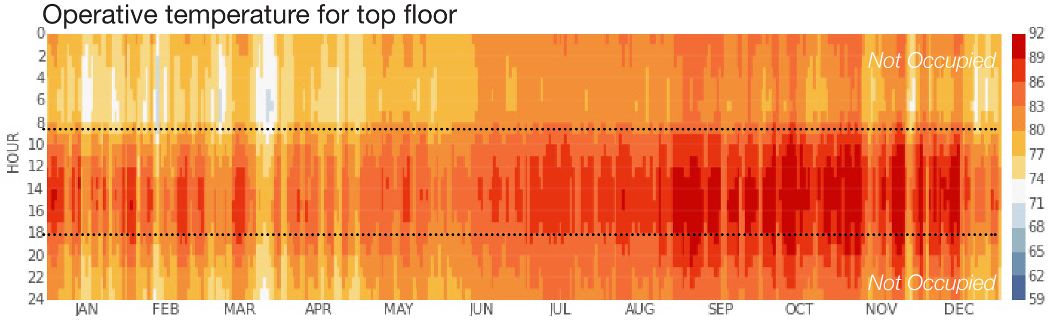


Degrees from comfort for bottom floor

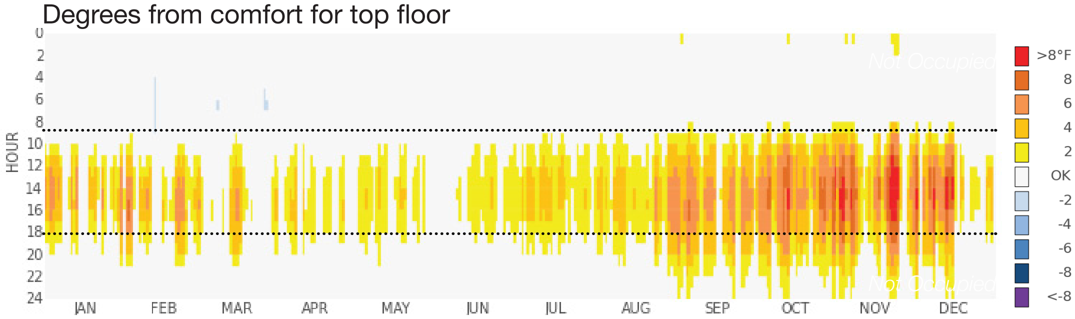




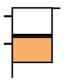
Operative temperature for top floor



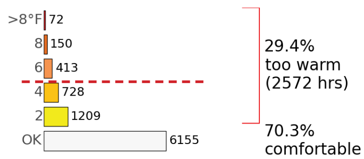
Degrees from comfort for top floor



Add/C.4.a.3 Office Analysis:: South Facing (Continued)

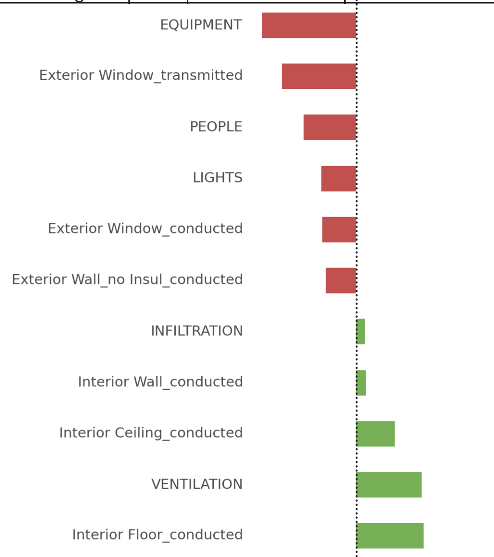


			Bottom Floor		
		hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2572	**29%**	**100%**
		w/ celing fans	855	10%	42%



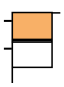
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

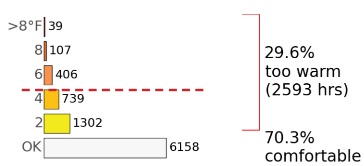


*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 42% too warm.*



			Top Floor		
		hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2593	**30%**	**100%**
		w/ celing fans	752	9%	37%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

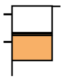
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 37% too warm.*

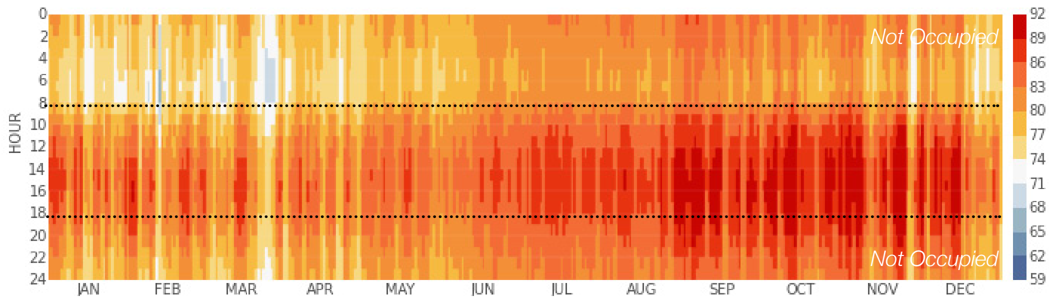
Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

C.4.a.4. CODE SUITE

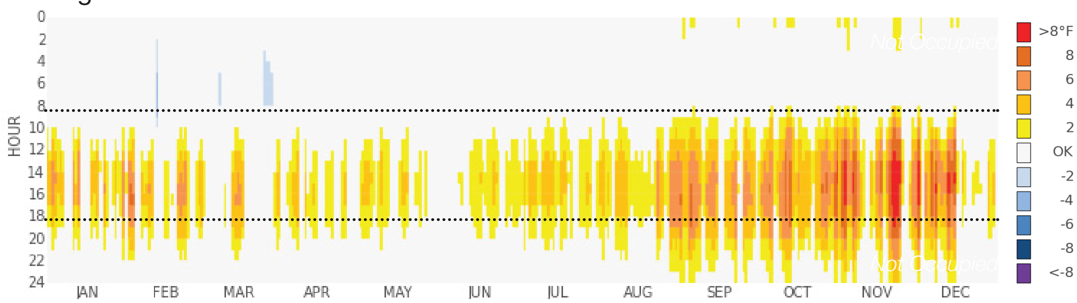
Equal to IMPROVED SUITE + IECC Walls

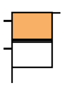


Operative temperature for bottom floor

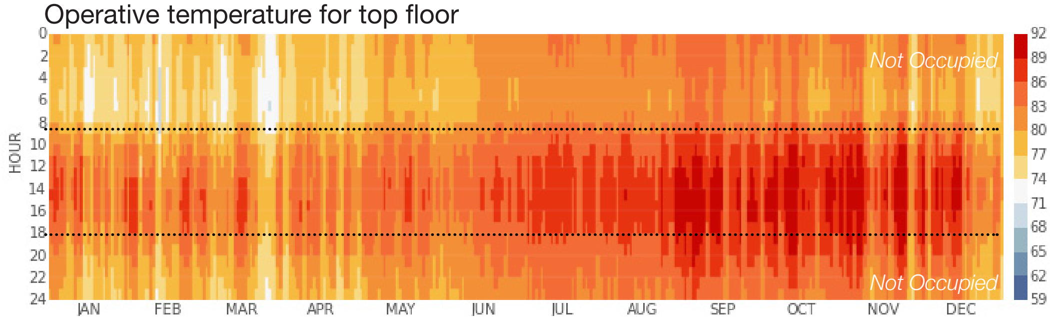


Degrees from comfort for bottom floor

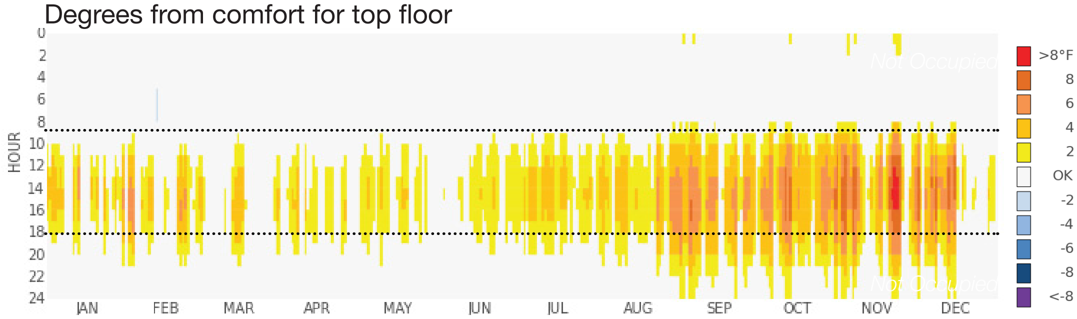




Operative temperature for top floor

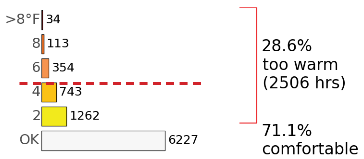


Degrees from comfort for top floor



Add/C.4.a.4 Office Analysis:: South Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2506	**29%**	**100%**
		w/ celing fans	501	6%	25%

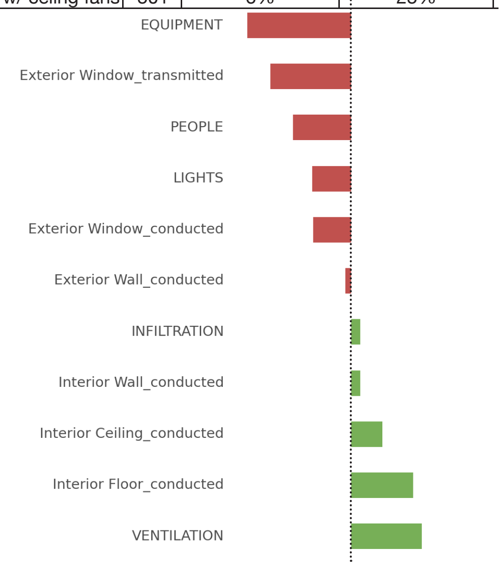


** Including all 8760 hrs of the year, not only occupied hours*

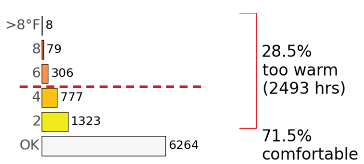
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 25% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2493	**28%**	**100%**
		w/ celing fans	393	4%	19%

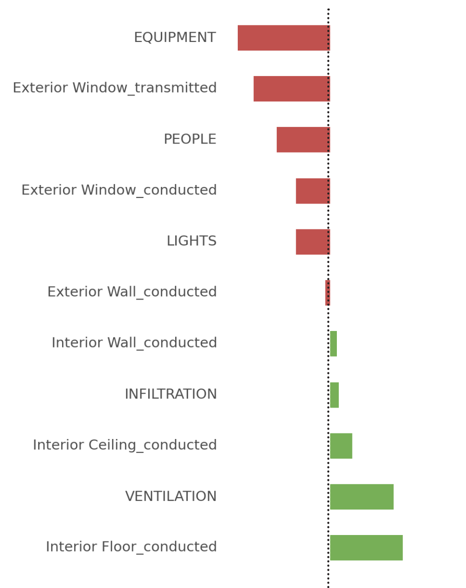


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

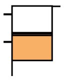
**** With ceiling fans (M-F 8am-8pm):: 19% too warm.*



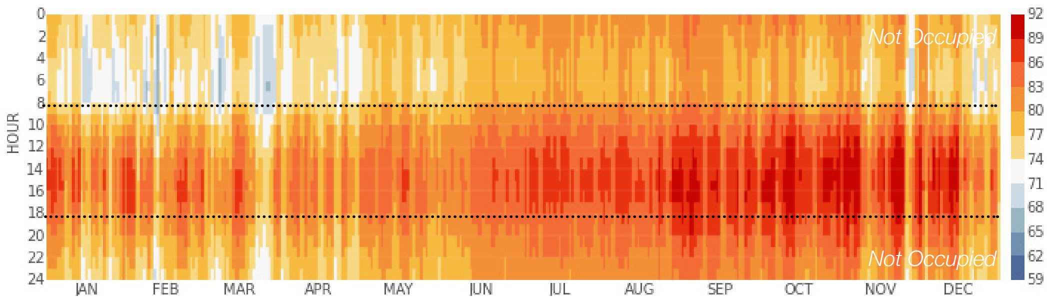
Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

C.4.a.5. IMPROVED SUITE WITH VENTILATION

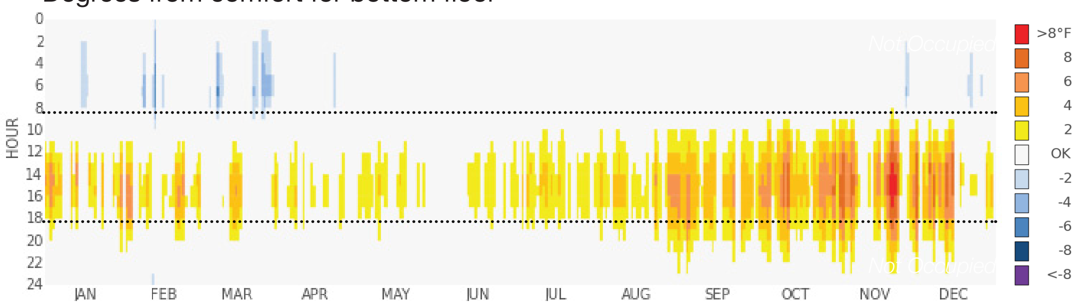
Equal to IMPROVED SUITE +2ACH

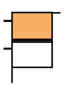


Operative temperature for bottom floor

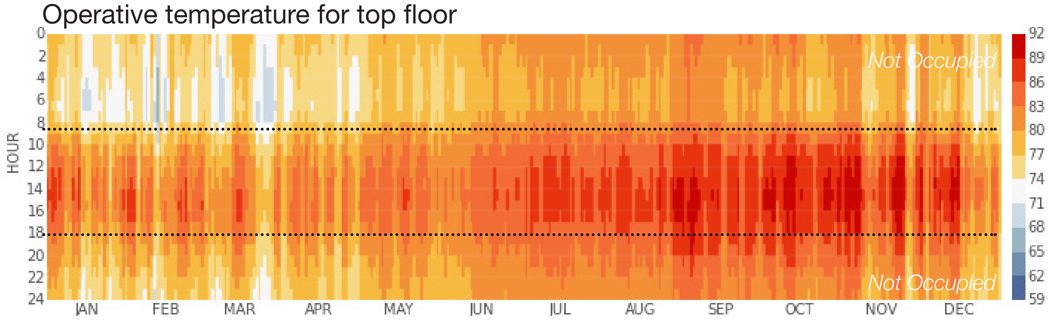


Degrees from comfort for bottom floor

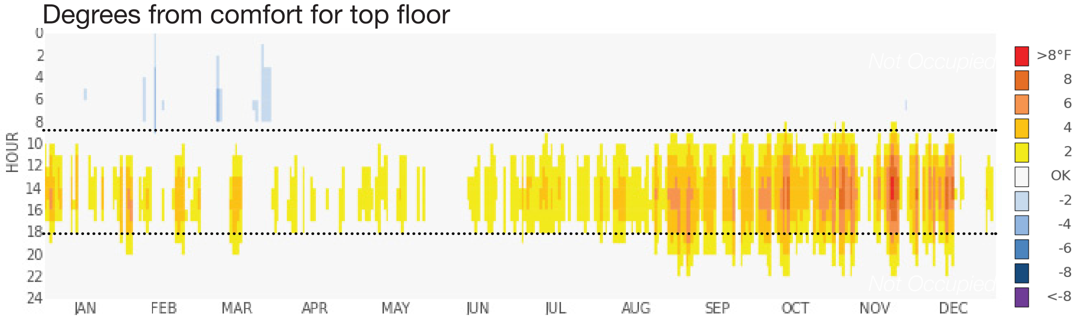




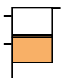
Operative temperature for top floor



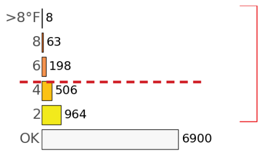
Degrees from comfort for top floor

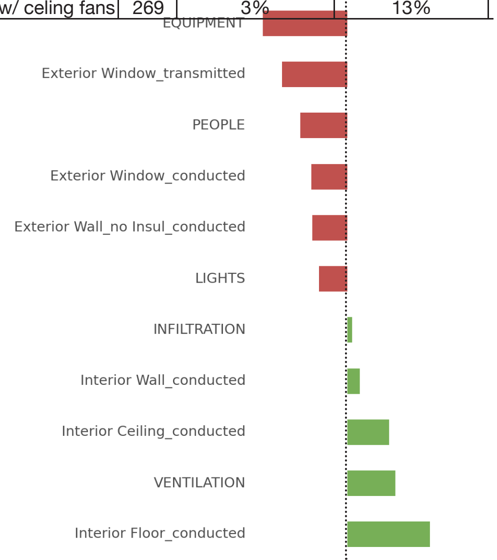


Add/C.4.a.5 Office Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1739	**20%**	**86%**
		w/ celing fans	269	3%	13%



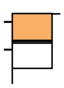


** Including all 8760 hrs of the year, not only occupied hours*

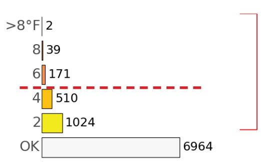
----- *Ceiling Fans Effective*

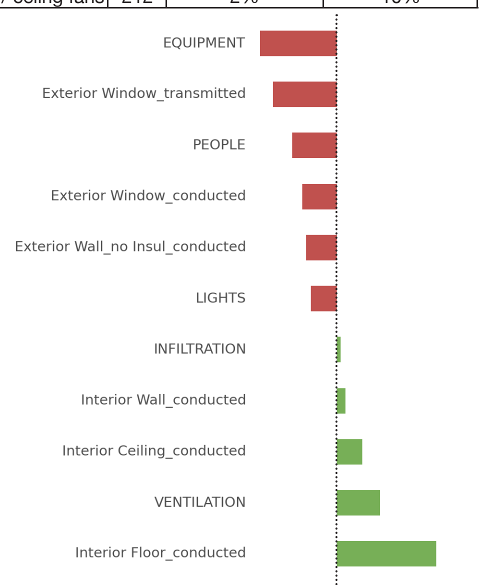
*** If considering only occupied hours (M-F 8am-5pm):: 86% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 13% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1746	**20%**	**86%**
		w/ celing fans	212	2%	10%





** Including all 8760 hrs of the year, not only occupied hours*

---------- *Ceiling Fans Effective*

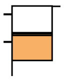
*** If considering only occupied hours (M-F 8am-5pm):: 86% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 10% too warm.*

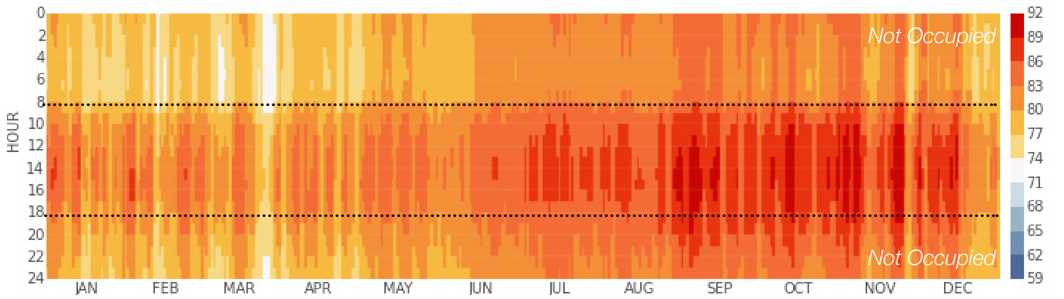
Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

C.4.a.6. IDEAL SUITE

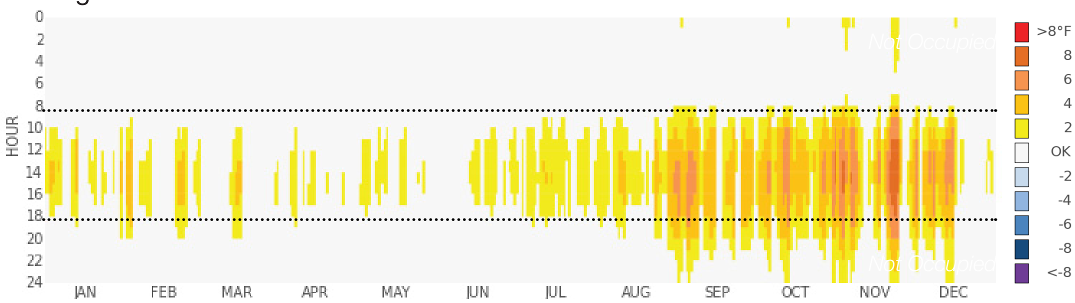
Equal to CODE SUITE + Thermal Mass

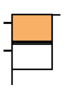


Operative temperature for bottom floor

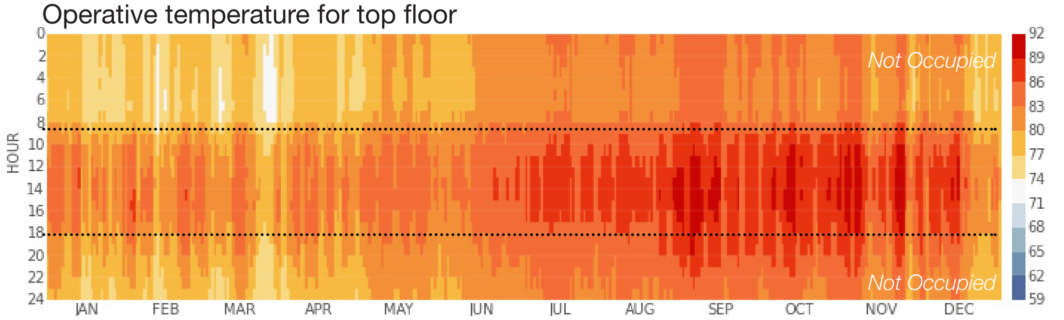


Degrees from comfort for bottom floor

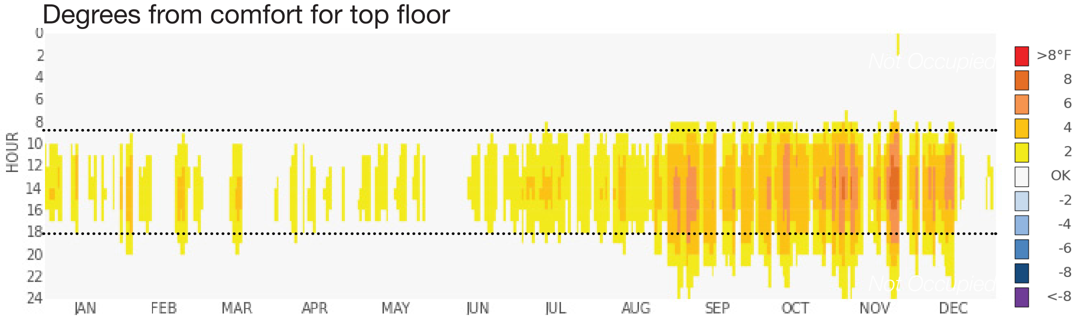




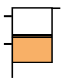
Operative temperature for top floor



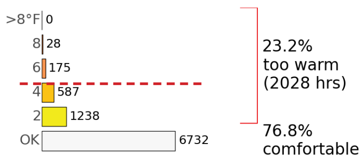
Degrees from comfort for top floor



Add/C.4.a.6 Office Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2028	**23%**	**100%**
		w/ celing fans	203	2%	10%

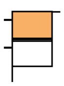


** Including all 8760 hrs of the year, not only occupied hours*

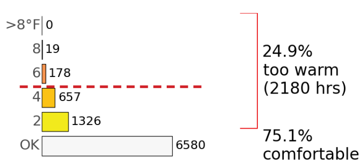
- - - - - Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 10% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2180	**25%**	**100%**
		w/ celing fans	197	2%	10%

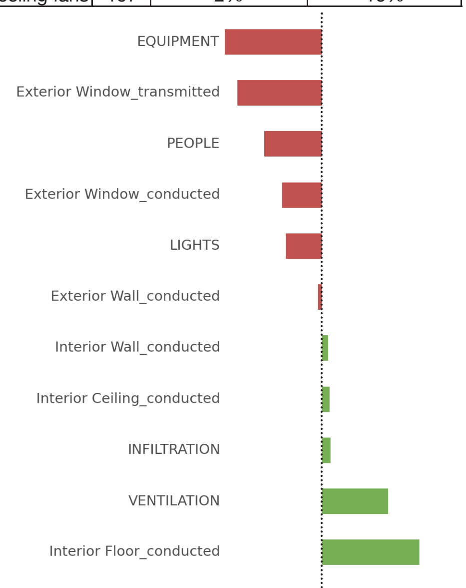


** Including all 8760 hrs of the year, not only occupied hours*

- - - - - - - - - - Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 10% too warm.*

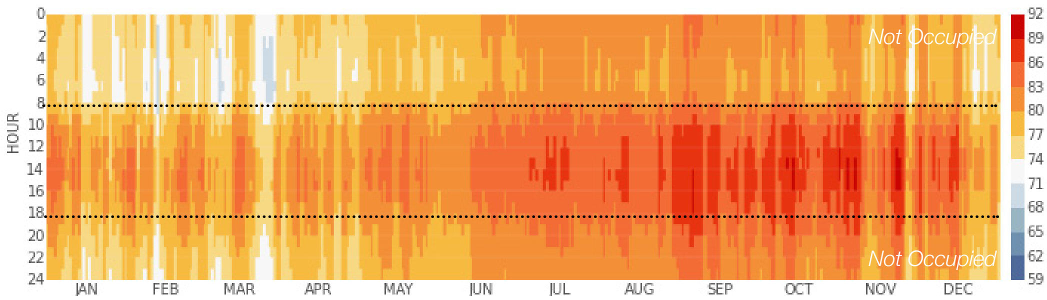


Add/C.4.a. OFFICE ANALYSIS:: SOUTH FACING

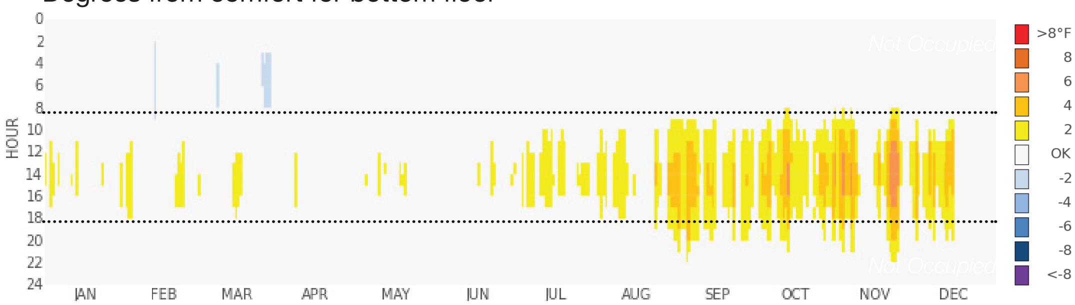
C.4.a.7. IDEAL SUITE WITH VENTILATION

Equal to IDEAL SUITE + 2ACH

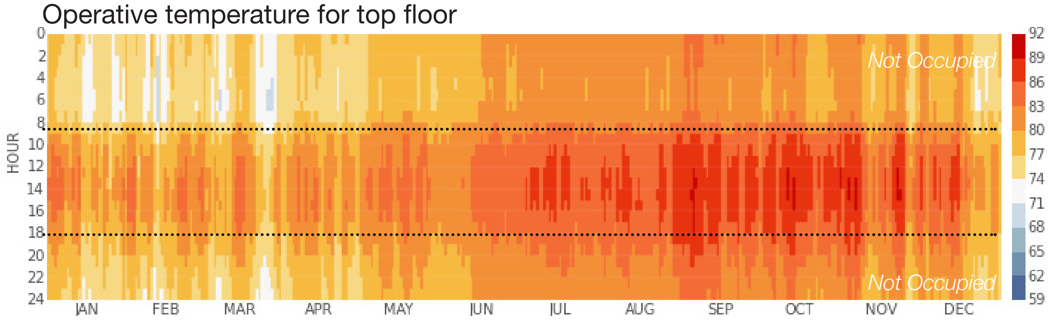
Operative temperature for bottom floor



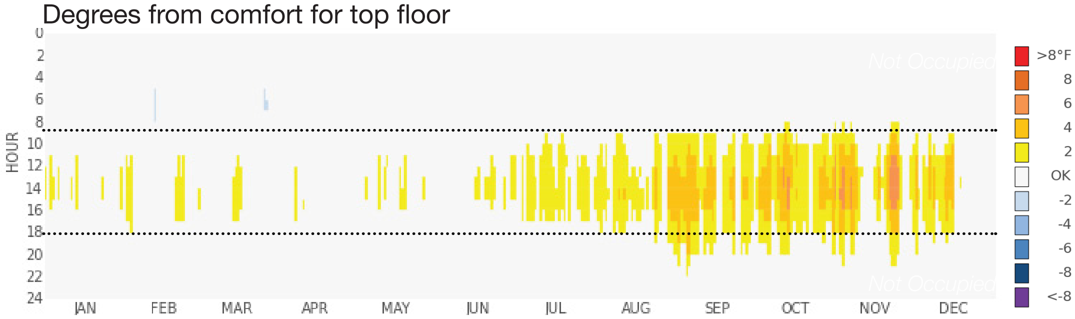
Degrees from comfort for bottom floor



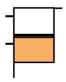
Operative temperature for top floor



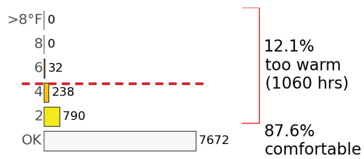
Degrees from comfort for top floor



Add/C.4.a.7 Office Analysis:: South Facing (Continued)

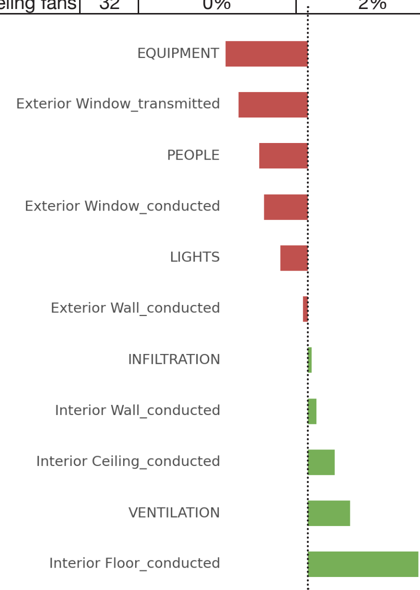


			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + 2 ACH	too warm	1060	**12%**	**52%**
		w/ celing fans	32	0%	2%



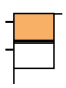
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

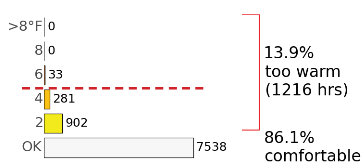


*** If considering only occupied hours (M-F 8am-5pm):: 52% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 2% too warm.*

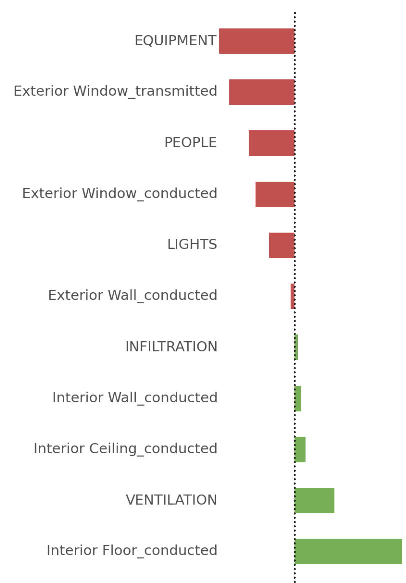


			Top Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + 2 ACH	too warm	1216	**14%**	**60%**
		w/ celing fans	33	0%	2%



** Including all 8760 hrs of the year, not only occupied hours*

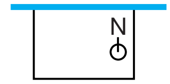
---------- Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-5pm):: 60% too warm.*

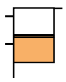
**** With ceiling fans (M-F 8am-8pm):: 2% too warm.*

Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

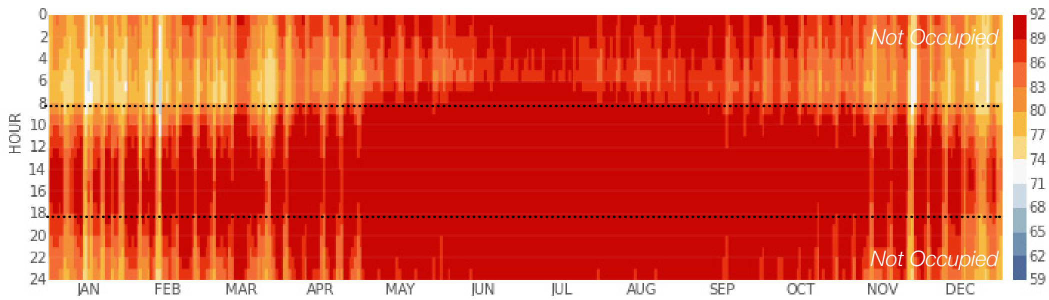


C.4.b.0. TYPICAL EXISTING

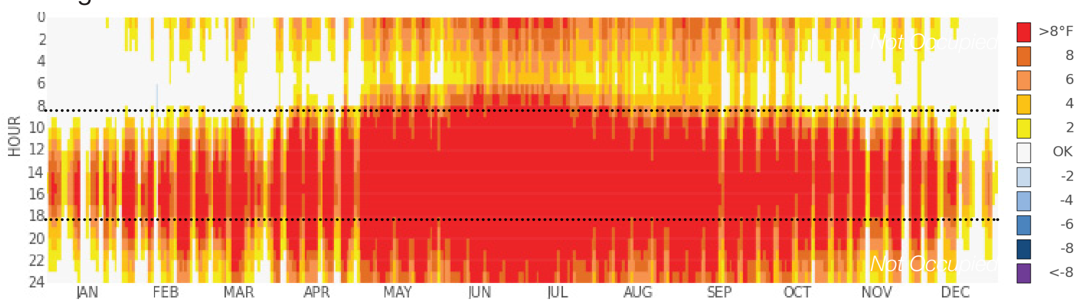
No Insulation in Opaque Surfaces and Single Pane Glass

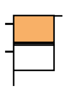


Operative temperature for bottom floor

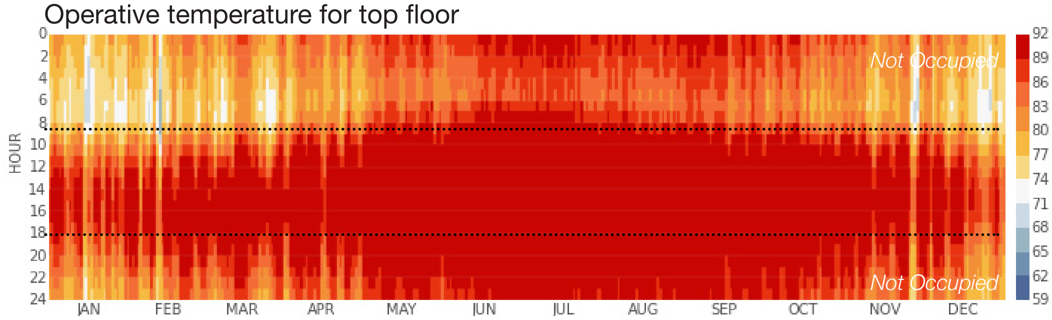


Degrees from comfort for bottom floor

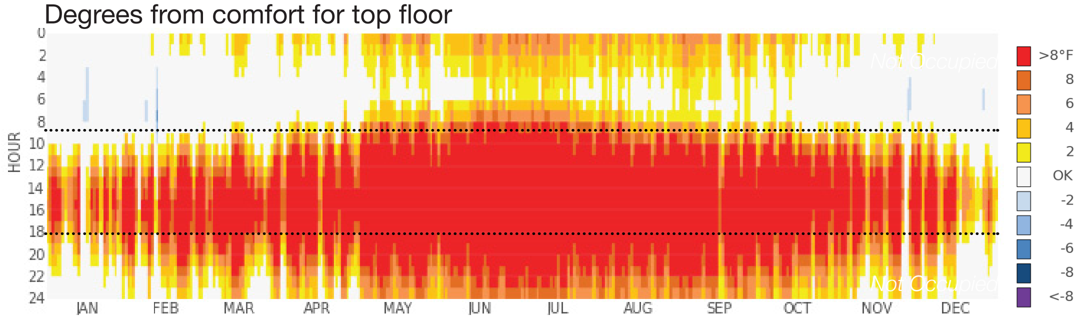




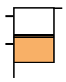
Operative temperature for top floor



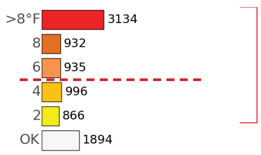
Degrees from comfort for top floor



Add/C.4.b.0 Office Analysis:: North Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	6863	**78%**	**100%**
	w/ celing fans	5001	57%	100%

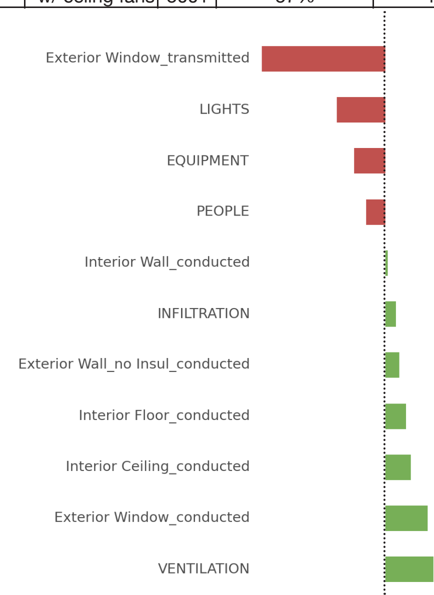


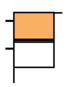
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

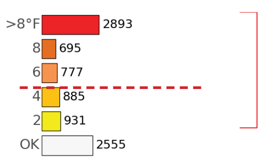
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*





		Top Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	6181	**71%**	**100%**
	w/ celing fans	4365	50%	100%

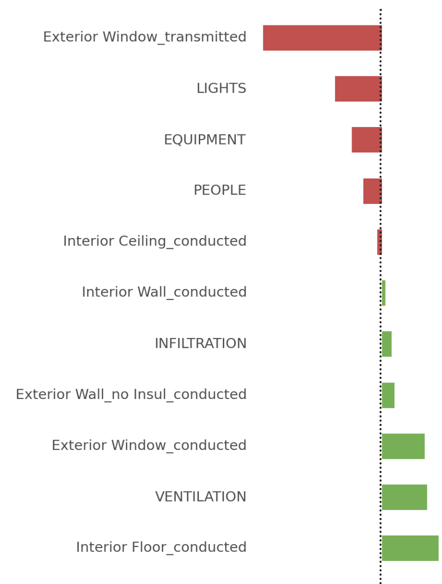


** Including all 8760 hrs of the year, not only occupied hours*

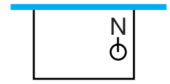
---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

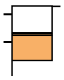


Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

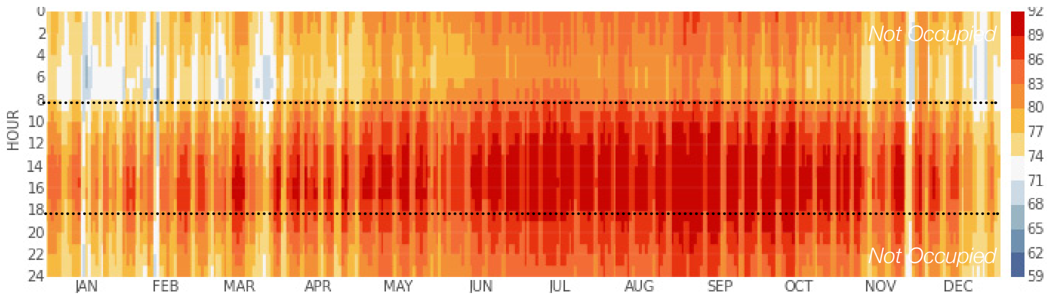


C.4.b.1. TYPICAL WITH WINDOW IMPROVEMENTS

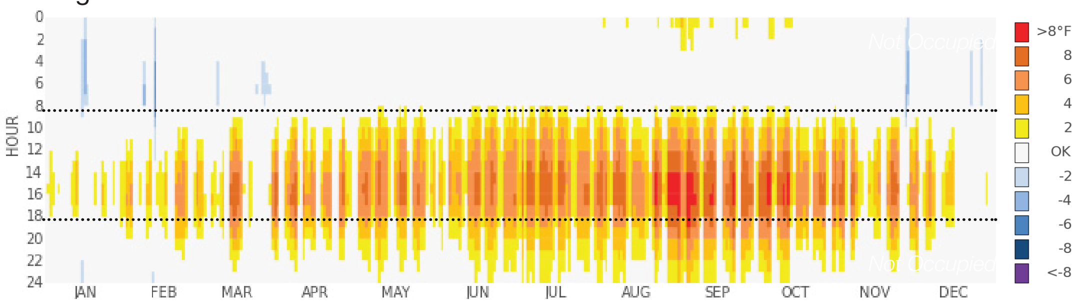
Equal to TYPICAL + 1ACH + Shading + IECC 2015 Windows

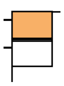


Operative temperature for bottom floor

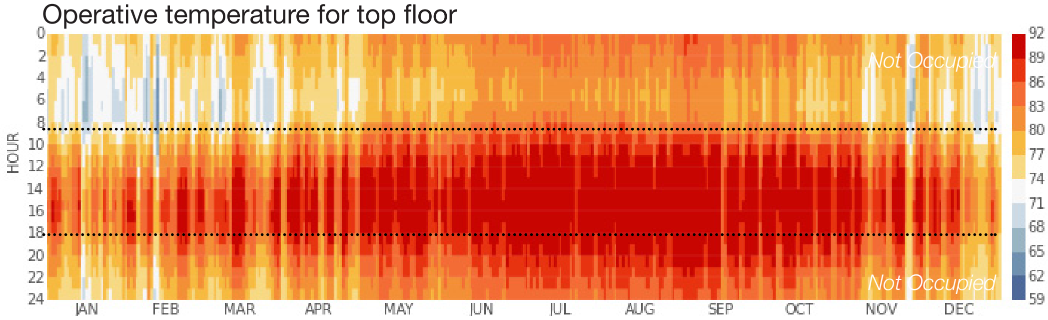


Degrees from comfort for bottom floor

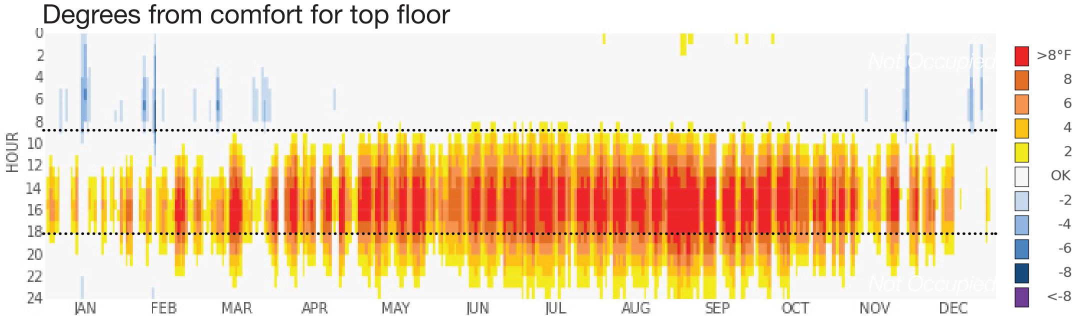




Operative temperature for top floor



Degrees from comfort for top floor



LOISOS + UBBELOHDE

Add/C.4.b.1 Office Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3026	**35%**	**100%**
		w/ celing fans	1077	12%	53%

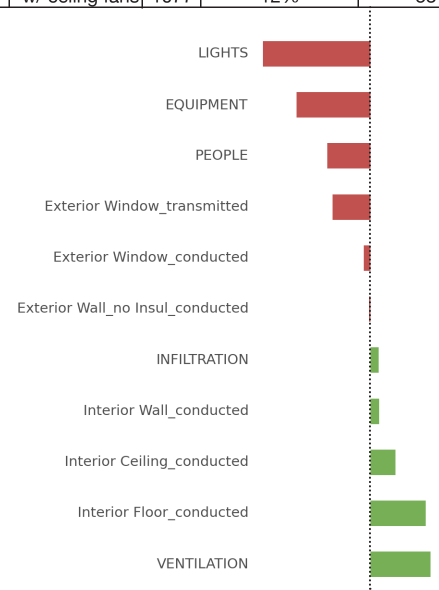
A-3 TYPICAL +1ACH +

** Including all 8760 hrs of the year, not only occupied hours*

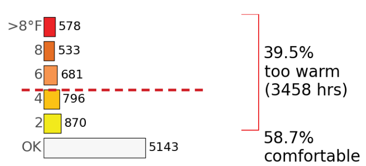
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 53% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3458	**39%**	**100%**
		w/ celing fans	1792	20%	88%

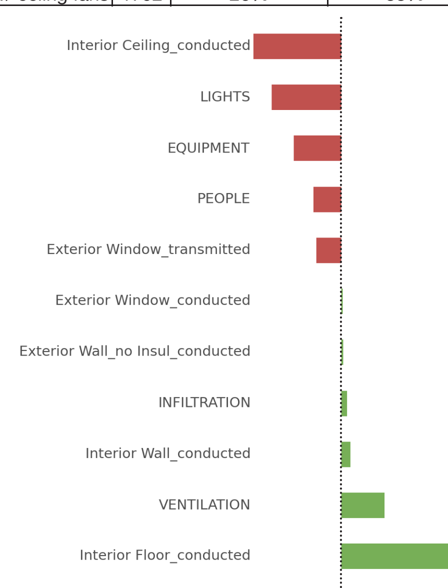


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 88% too warm.*

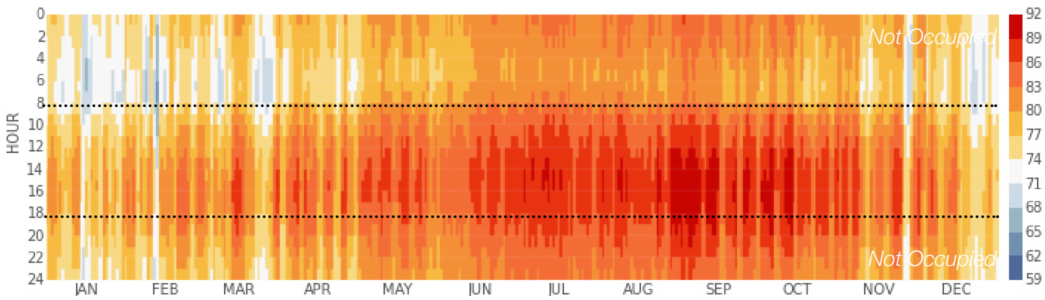


Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

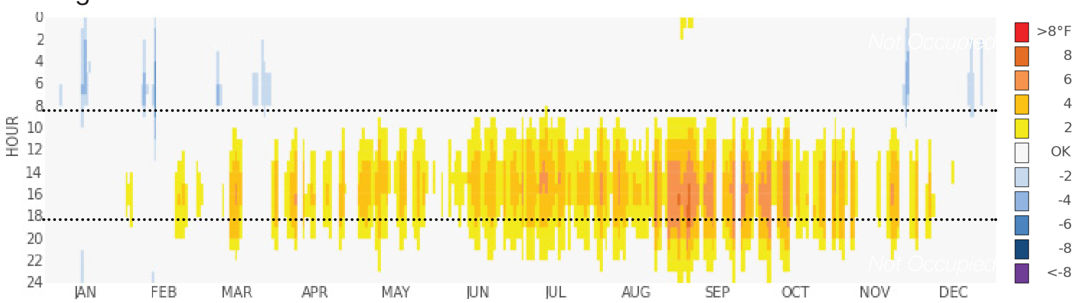
C.4.b.2. MINIMUM SUITE

Equal to TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

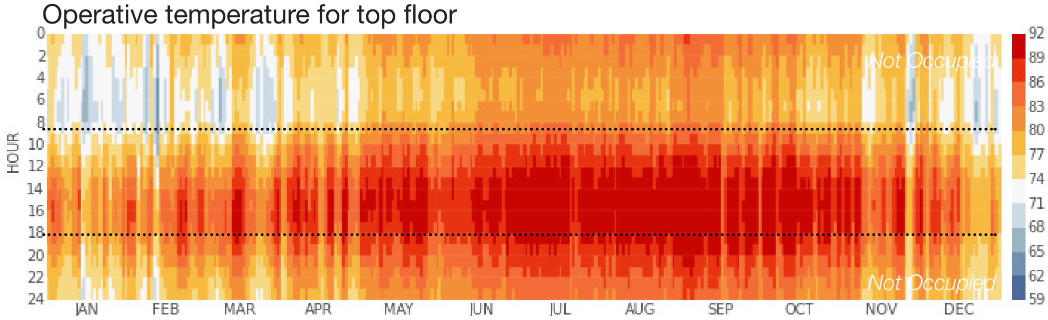
Operative temperature for bottom floor



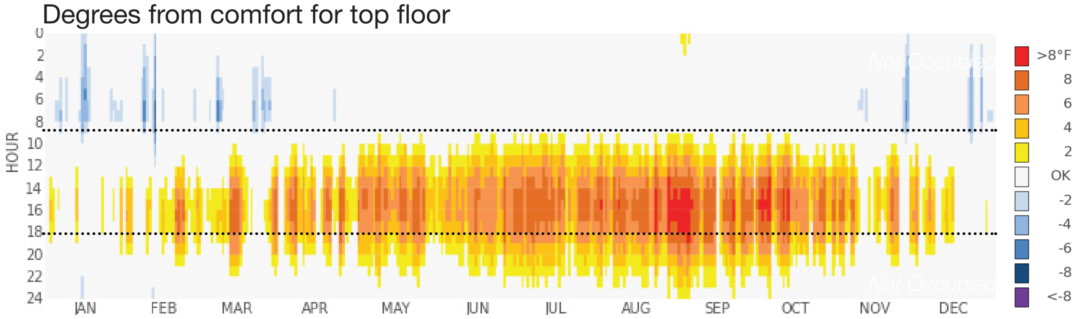
Degrees from comfort for bottom floor



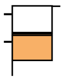
Operative temperature for top floor



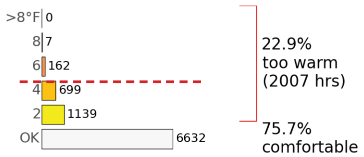
Degrees from comfort for top floor



Add/C.4.b.2 Office Analysis:: North Facing (Continued)



B-3	MINIMUM SUITE		Bottom Floor		
			hours	% of the whole year	% of occupied time
		too warm	2007	**23%**	**99%**
		w/ celing fans	169	2%	8%

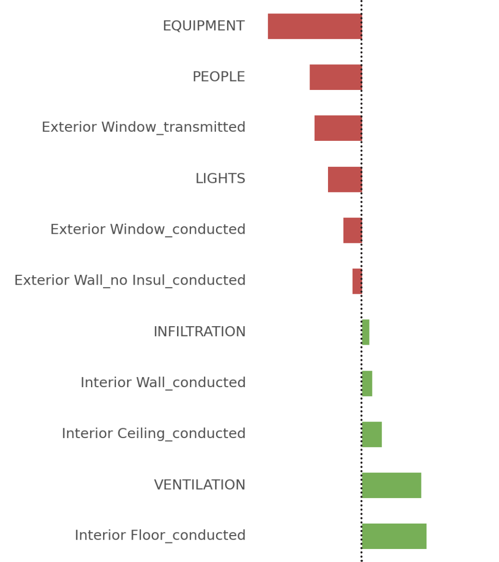


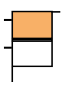
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

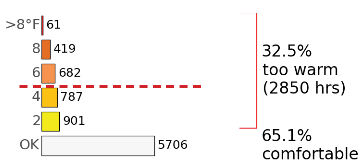
*** If considering only occupied hours (M-F 8am-5pm):: 99% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 8% too warm.*





B-3	MINIMUM SUITE		Top Floor		
			hours	% of the whole year	% of occupied time
		too warm	2850	**33%**	**100%**
		w/ celing fans	1162	13%	57%

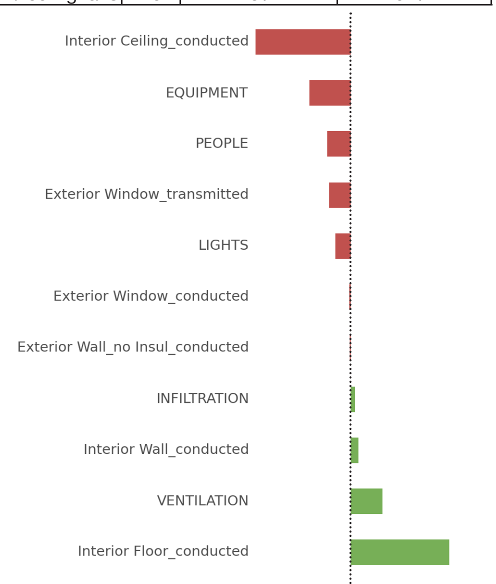


** Including all 8760 hrs of the year, not only occupied hours*

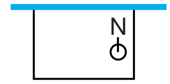
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 57% too warm.*

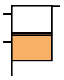


Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

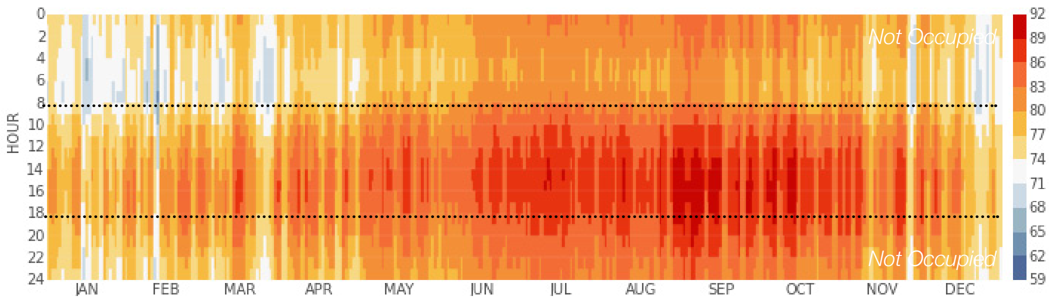


C.4.b.3. IMPROVED SUITE

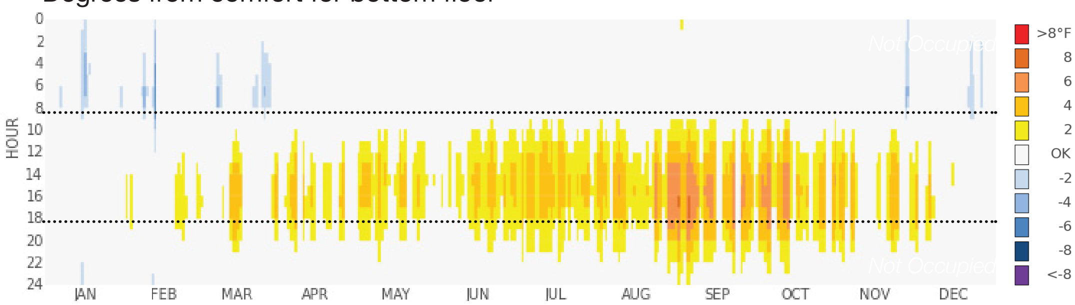
Equal to MINIMUM SUITE + IECC Roof

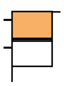


Operative temperature for bottom floor

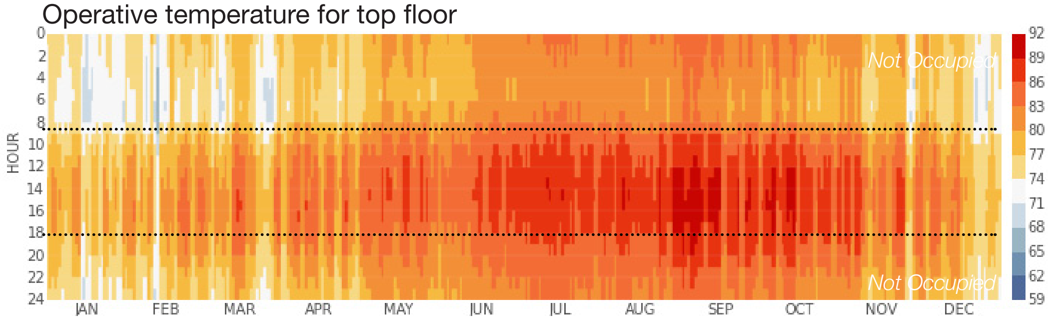


Degrees from comfort for bottom floor

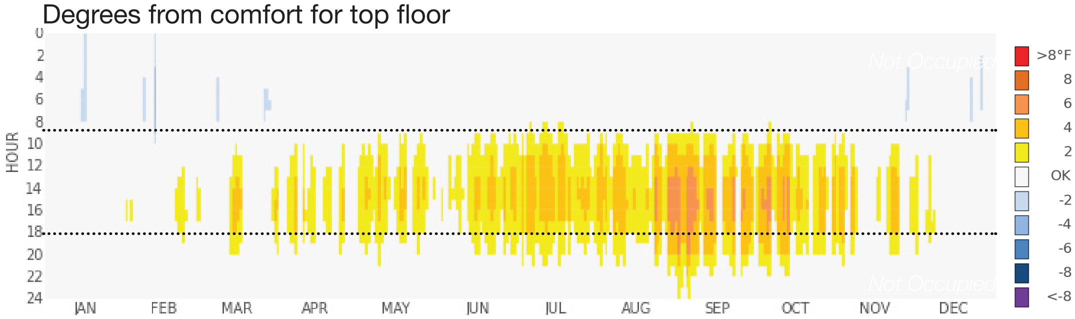




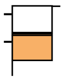
Operative temperature for top floor



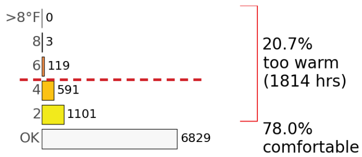
Degrees from comfort for top floor



Add/C.4.b.3 Office Analysis:: North Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
C-1 IMPROVED SUITE (B-3+ IECC Roof)	too warm	1814	**21%**	**90%**
	w/ celing fans	122	1%	6%

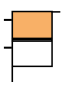


** Including all 8760 hrs of the year, not only occupied hours*

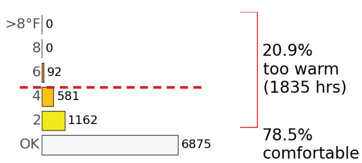
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 90% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 6% too warm.*



		Top Floor		
		hours	% of the whole year	% of occupied time
C-1 IMPROVED SUITE (B-3+ IECC Roof)	too warm	1835	**21%**	**91%**
	w/ celing fans	172	2%	8%

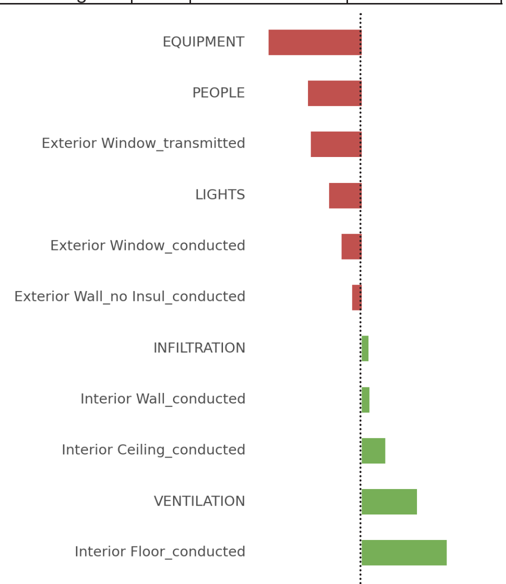


** Including all 8760 hrs of the year, not only occupied hours*

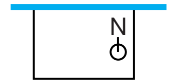
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 91% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 8% too warm.*

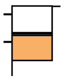


Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

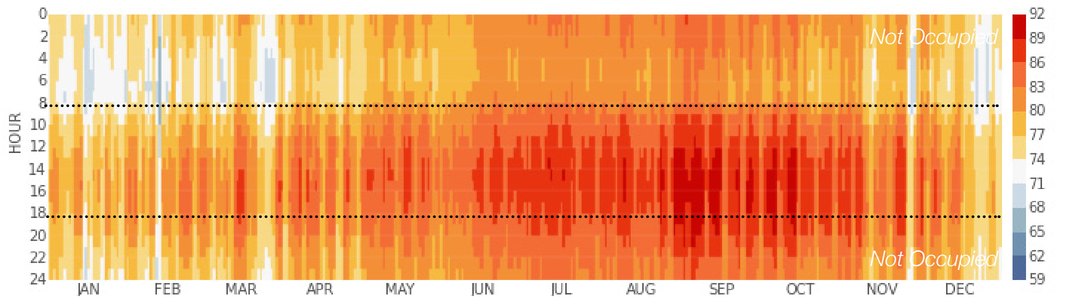


C.4.b.4. CODE SUITE

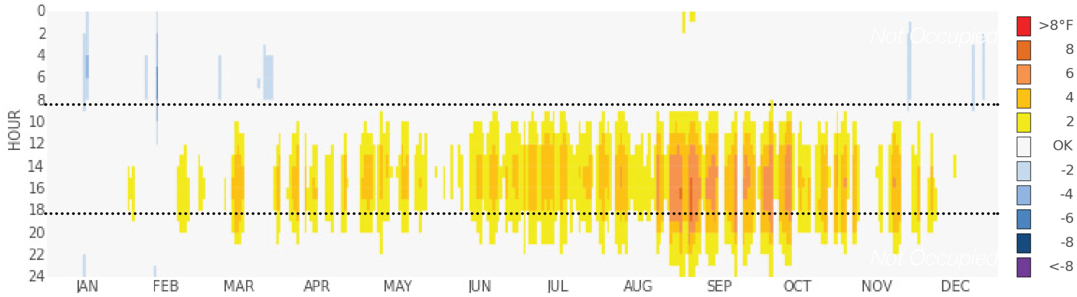
Equal to IMPROVED SUITE + IECC Walls

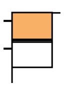


Operative temperature for bottom floor

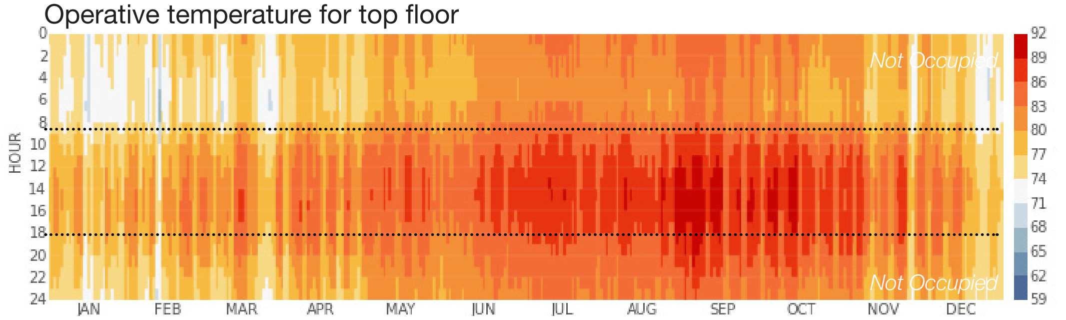


Degrees from comfort for bottom floor

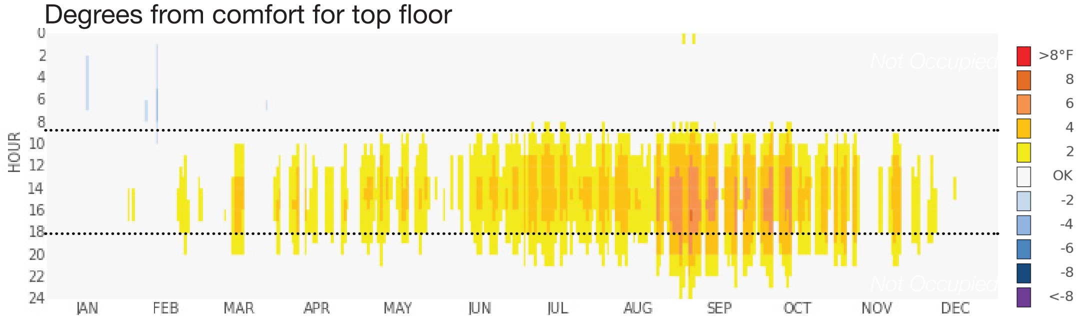




Operative temperature for top floor

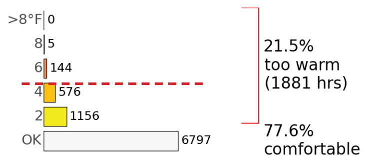


Degrees from comfort for top floor



Add/C.4.b.4 Office Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	1881	**21%**	**93%**
		w/ celing fans	149	2%	7%



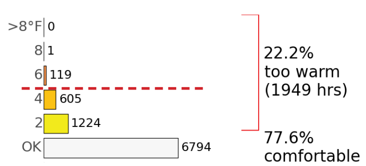
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 93% too warm.*

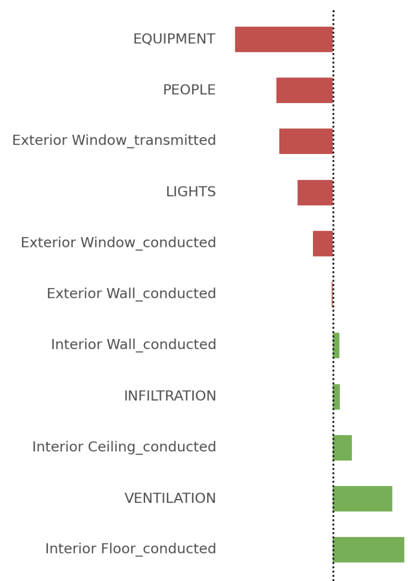
**** With ceiling fans (M-F 8am-8pm):: 7% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	1949	**22%**	**96%**
		w/ celing fans	120	1%	6%



** Including all 8760 hrs of the year, not only occupied hours*

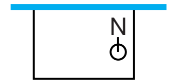
Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-5pm):: 96% too warm.*

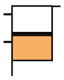
**** With ceiling fans (M-F 8am-8pm):: 6% too warm.*

Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

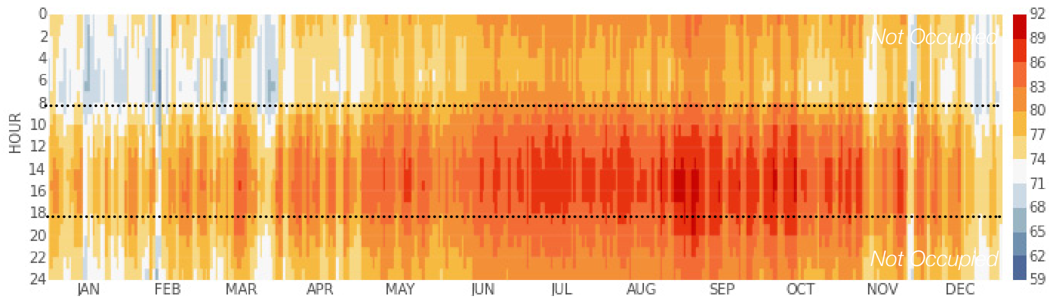


C.4.b.5. IMPROVED SUITE WITH VENTILATION

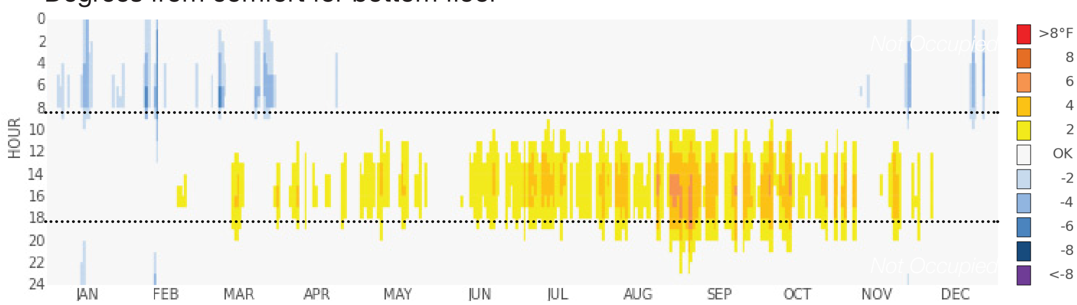
Equal to IMPROVED SUITE +2ACH

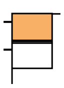


Operative temperature for bottom floor

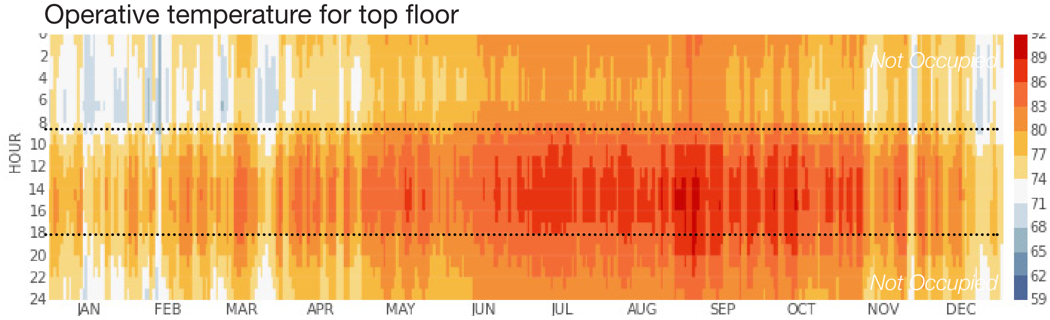


Degrees from comfort for bottom floor

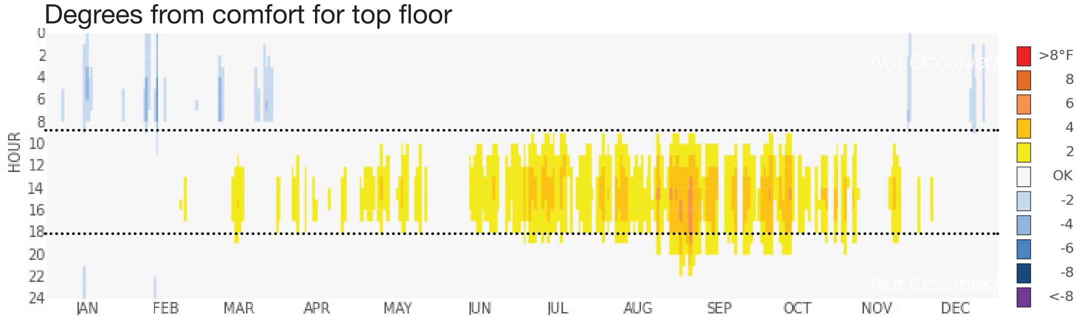




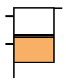
Operative temperature for top floor



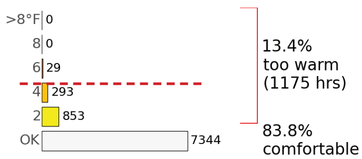
Degrees from comfort for top floor



Add/C.4.b.5 Office Analysis:: North Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1175	**13%**	**58%**
		w/ celing fans	29	0%	1%

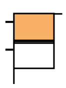


** Including all 8760 hrs of the year, not only occupied hours*

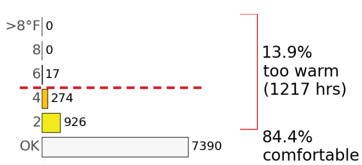
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 58% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 1% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1217	**14%**	**60%**
		w/ celing fans	17	0%	1%



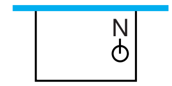
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 60% too warm.*

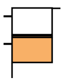
**** With ceiling fans (M-F 8am-8pm):: 1% too warm.*

Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

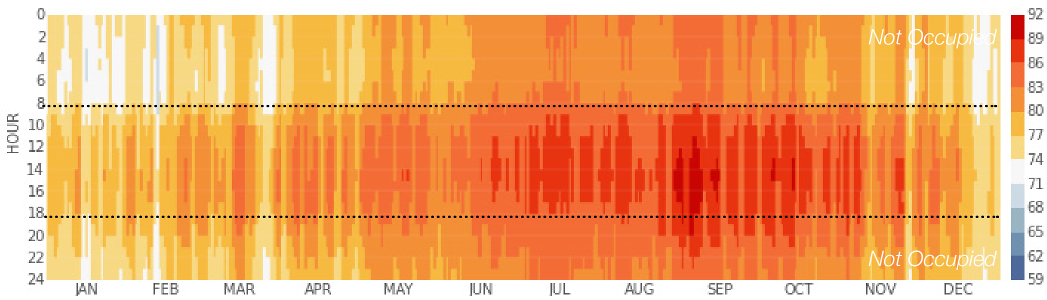


C.4.b.6. IDEAL SUITE

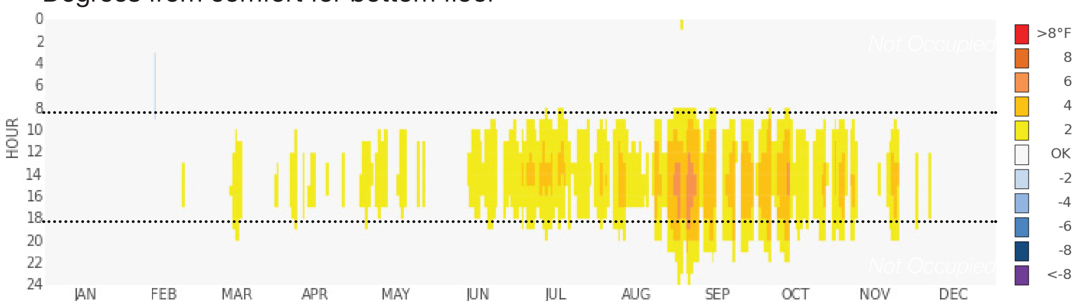
Equal to CODE SUITE + Thermal Mass

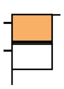


Operative temperature for bottom floor

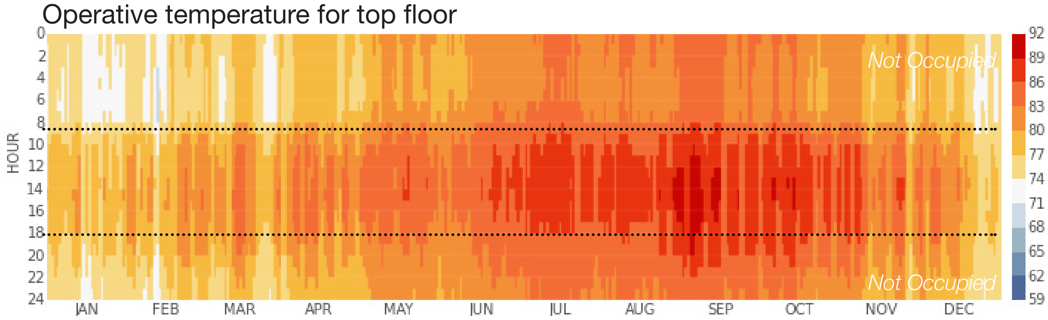


Degrees from comfort for bottom floor

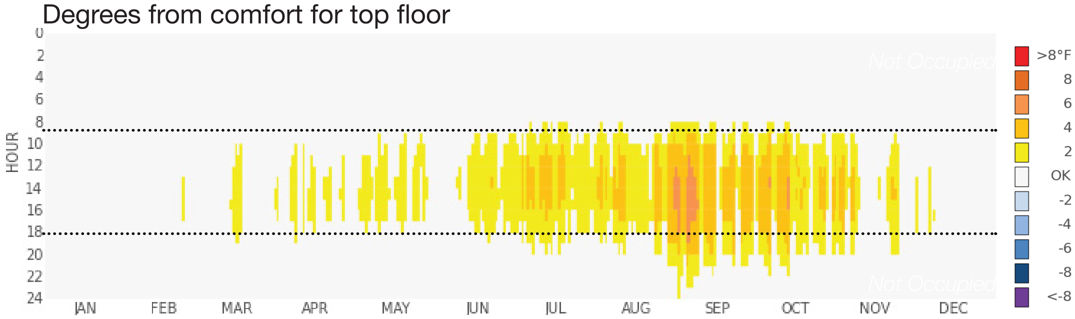




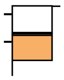
Operative temperature for top floor



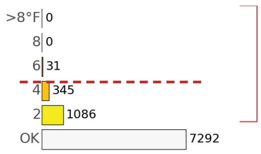
Degrees from comfort for top floor



Add/C.4.b.6 Office Analysis:: North Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1462	**17%**	**72%**
		w/ celing fans	32	0%	2%



16.7% too warm (1462 hrs)

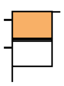
83.2% comfortable

** Including all 8760 hrs of the year, not only occupied hours*

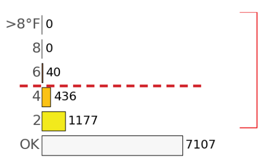
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 72% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 2% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1653	**19%**	**82%**
		w/ celing fans	40	0%	2%



18.9% too warm (1653 hrs)

81.1% comfortable

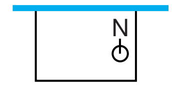
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 82% too warm.*

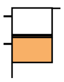
**** With ceiling fans (M-F 8am-8pm):: 2% too warm.*

Add/C.4.b. OFFICE ANALYSIS:: NORTH FACING

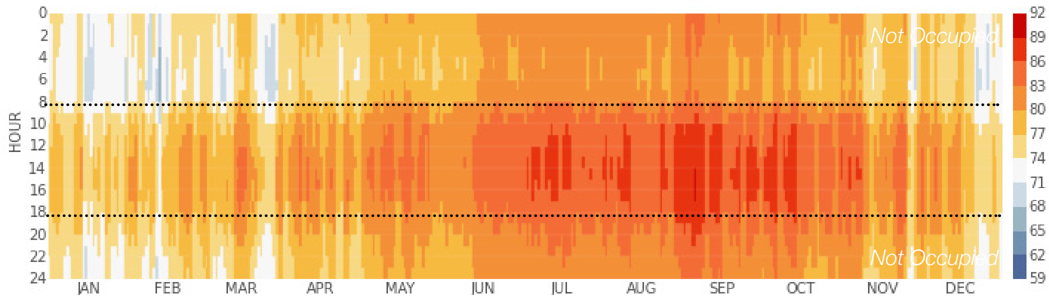


C.4.b.7. IDEAL SUITE WITH VENTILATION

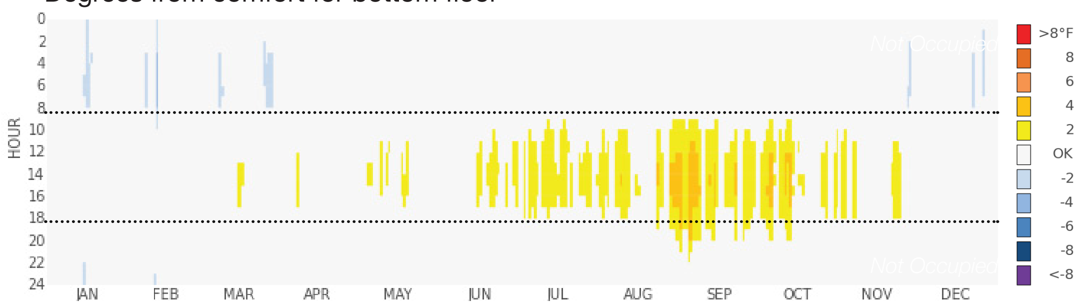
Equal to IDEAL SUITE + 2ACH

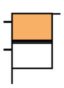


Operative temperature for bottom floor

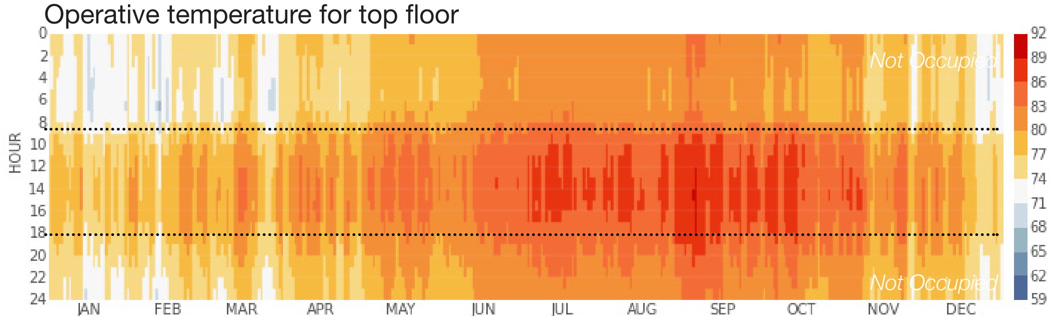


Degrees from comfort for bottom floor

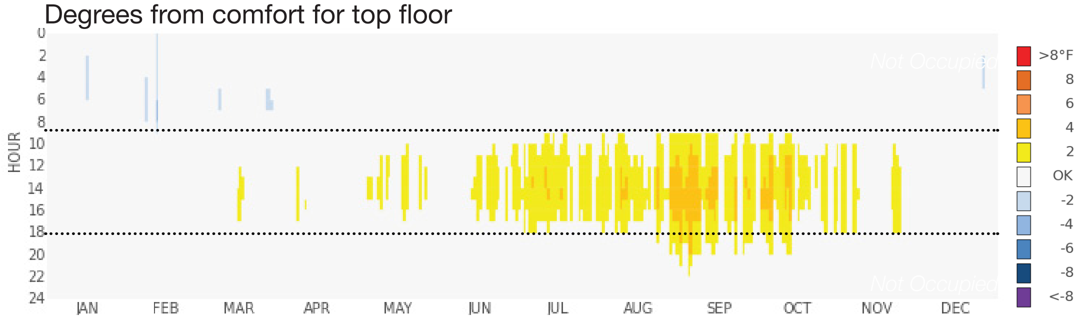




Operative temperature for top floor

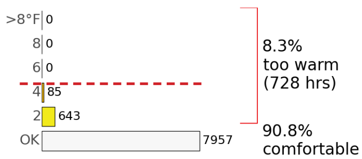


Degrees from comfort for top floor



Add/C.4.b.7 Office Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL + 2 ACH	too warm	728	**8%**	**36%**
		w/ celing fans	0	0%	0%



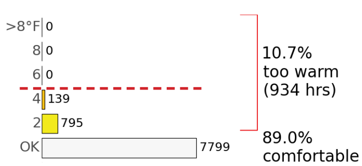
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 36% too warm.*

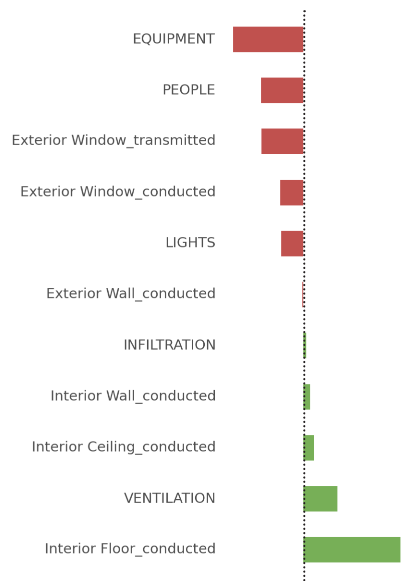
**** With ceiling fans (M-F 8am-8pm):: 0% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	934	**11%**	**46%**
		w/ celing fans	0	0%	0%



** Including all 8760 hrs of the year, not only occupied hours*

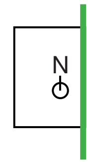
---------- Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-5pm):: 46% too warm.*

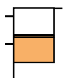
**** With ceiling fans (M-F 8am-8pm):: 0% too warm.*

Add/C.4.c. OFFICE ANALYSIS:: EAST FACING



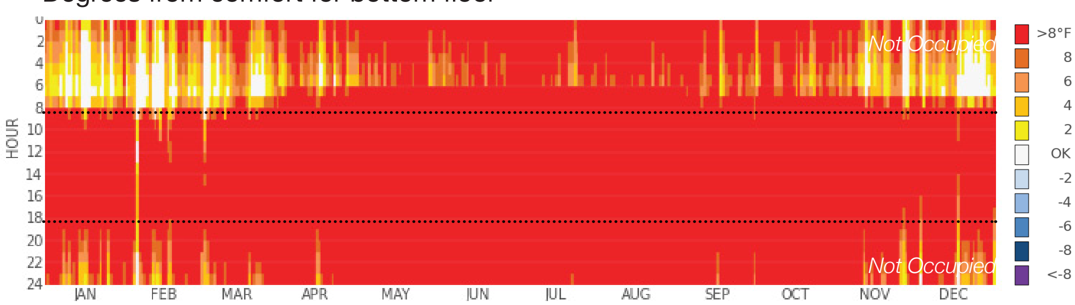
C.4.c.0. TYPICAL EXISTING

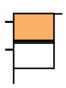
No Insulation in Opaque Surfaces and Single Pane Glass



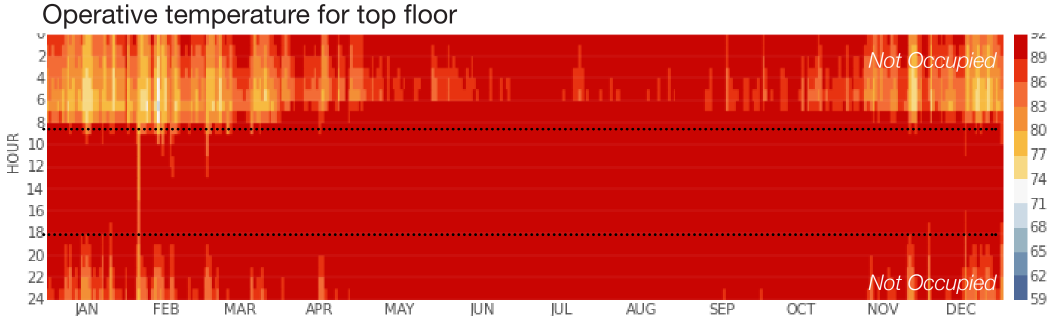
Operative temperature for bottom floor

Degrees from comfort for bottom floor

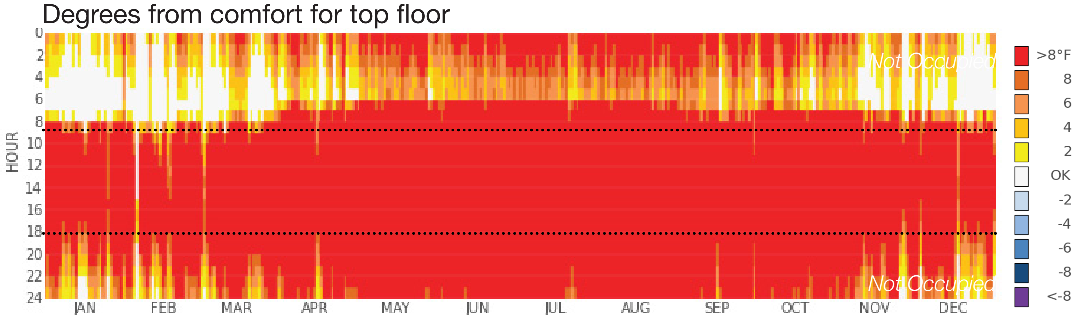




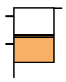
Operative temperature for top floor



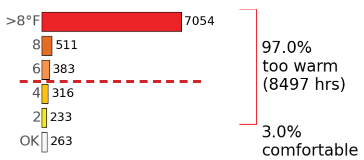
Degrees from comfort for top floor



Add/C.4.c.0 Office Analysis:: East Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	8497	**97%**	**100%**
	w/ celing fans	7948	91%	100%

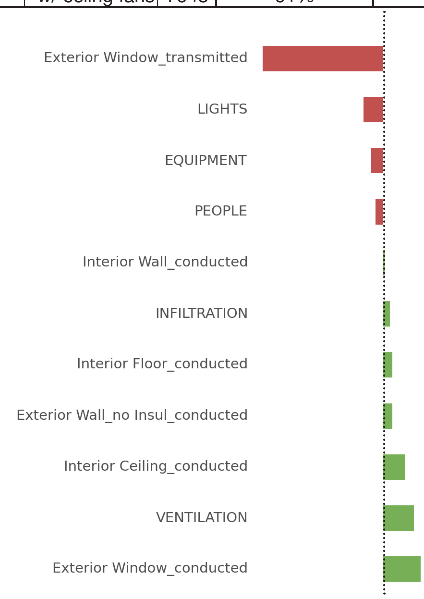


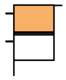
** Including all 8760 hrs of the year, not only occupied hours*

----- Ceiling Fans Effective

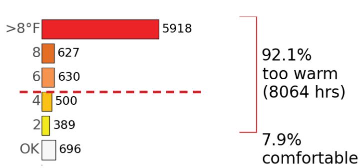
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*





		Top Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	8064	**92%**	**100%**
	w/ celing fans	7175	82%	100%

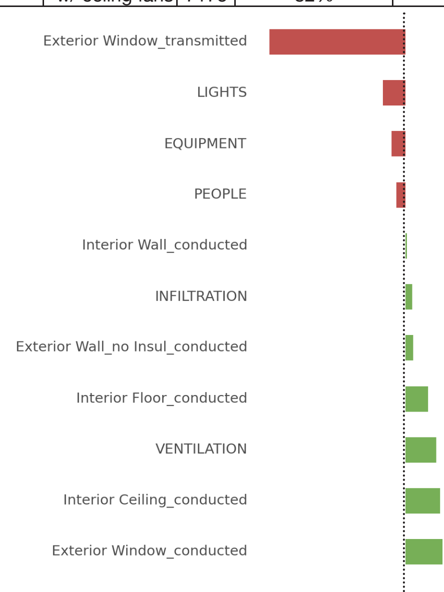


** Including all 8760 hrs of the year, not only occupied hours*

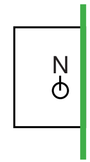
---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

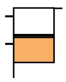


Add/C.4.c. OFFICE ANALYSIS:: EAST FACING

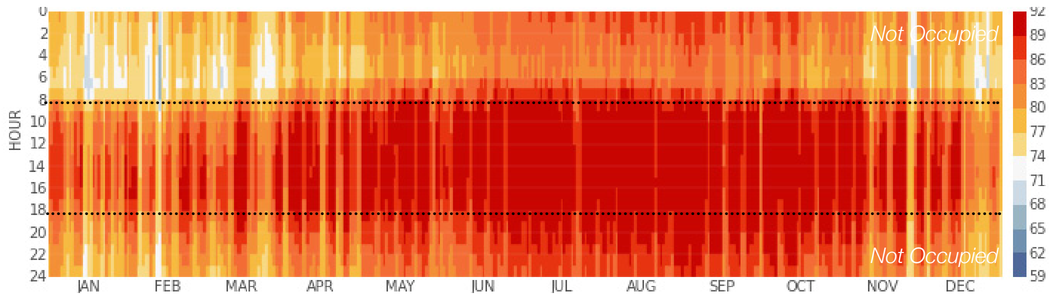


C.4.c.1. TYPICAL WITH WINDOW IMPROVEMENTS

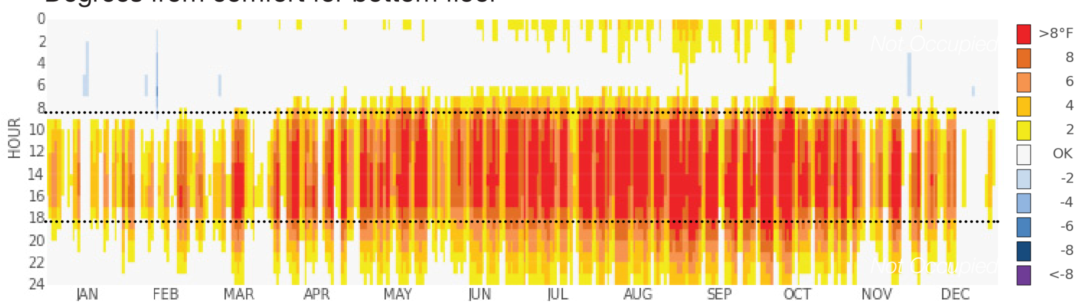
Equal to TYPICAL + 1ACH + Shading + IECC 2015 Windows

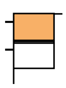


Operative temperature for bottom floor

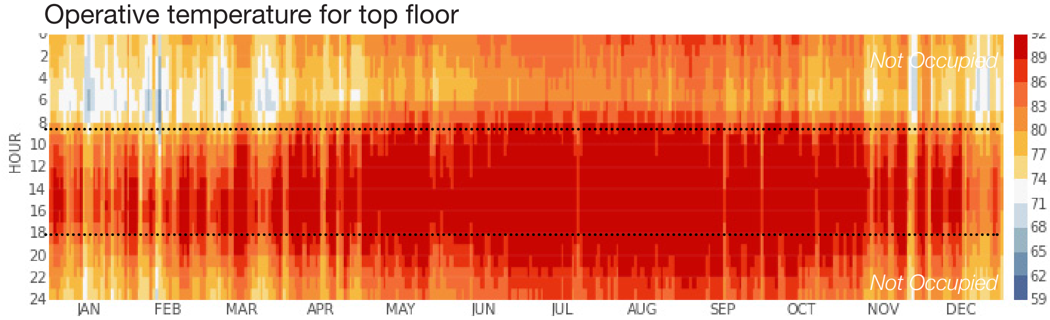


Degrees from comfort for bottom floor

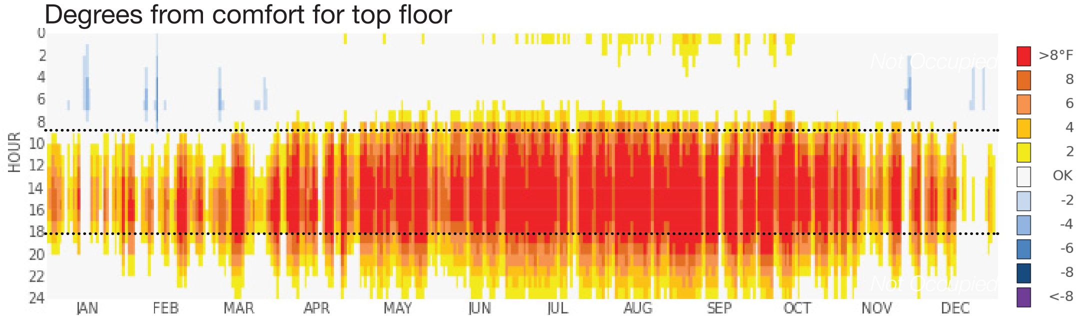




Operative temperature for top floor



Degrees from comfort for top floor



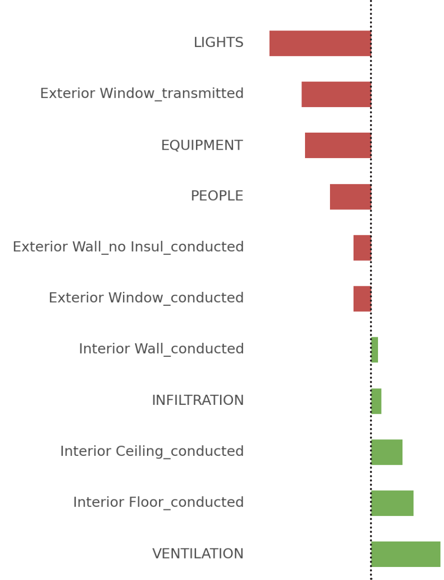
Add/C.4.c.1 Office Analysis:: East Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	4801	**55%**	**100%**
		w/ celing fans	2582	29%	100%

A-3 TYPICAL +1ACH +

** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



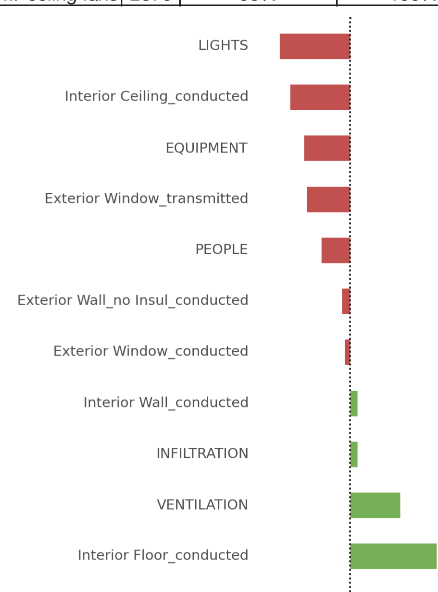
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	4647	**53%**	**100%**
		w/ celing fans	2876	33%	100%

** Including all 8760 hrs of the year, not only occupied hours*

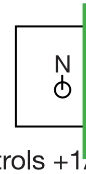
Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

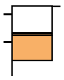
**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

Add/C.4.c. OFFICE ANALYSIS:: EAST FACING

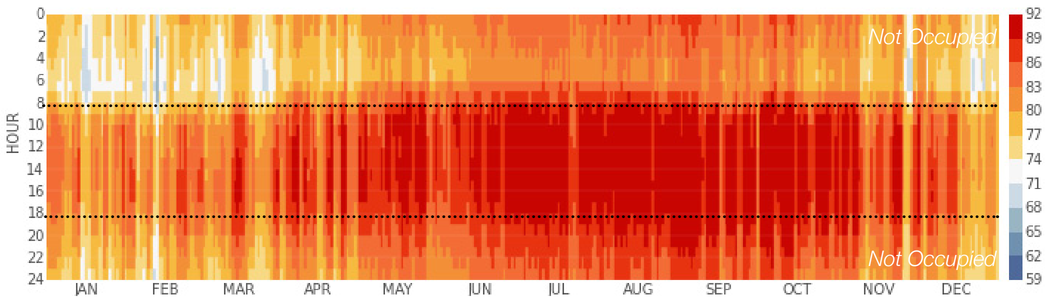


C.4.c.2. MINIMUM SUITE

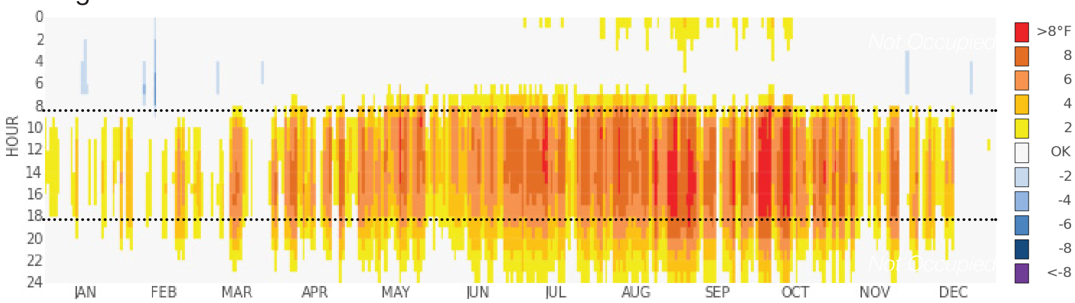
Equal to TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

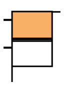


Operative temperature for bottom floor

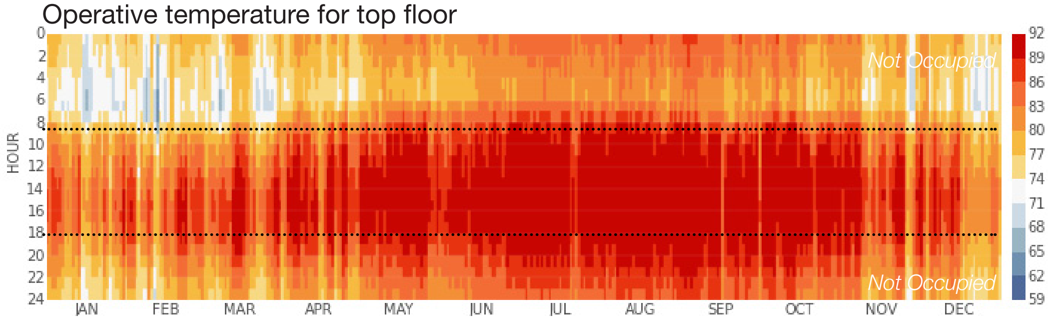


Degrees from comfort for bottom floor

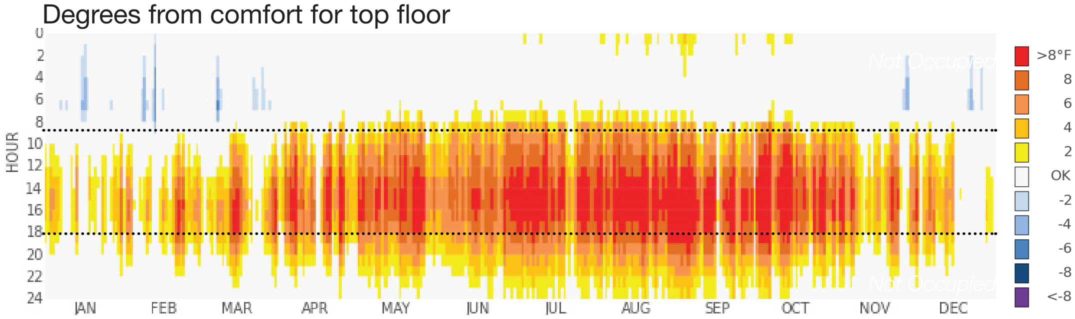




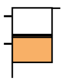
Operative temperature for top floor



Degrees from comfort for top floor



Add/C.4.c.2 Office Analysis:: East Facing (Continued)



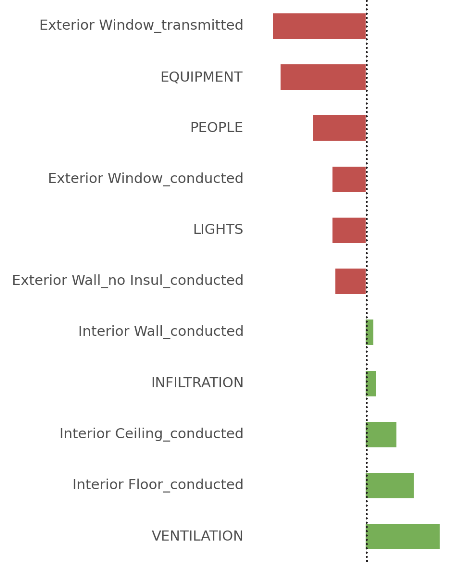
B-3	MINIMUM SUITE		Bottom Floor		
			hours	% of the whole year	% of occupied time
		too warm	4035	**46%**	**100%**
		w/ celing fans	1795	20%	89%

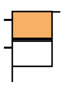
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

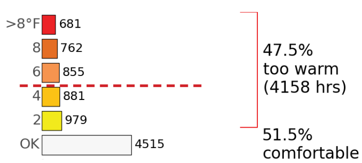
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 89% too warm.*





B-3	MINIMUM SUITE		Top Floor		
			hours	% of the whole year	% of occupied time
		too warm	4158	**47%**	**100%**
		w/ celing fans	2298	26%	100%

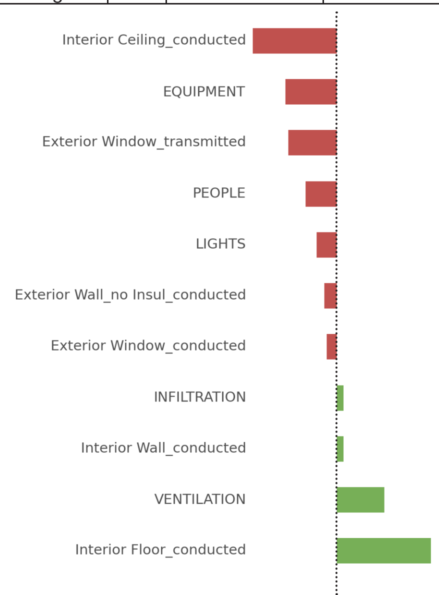


** Including all 8760 hrs of the year, not only occupied hours*

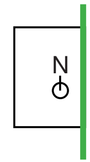
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

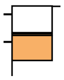


Add/C.4.c. OFFICE ANALYSIS:: EAST FACING

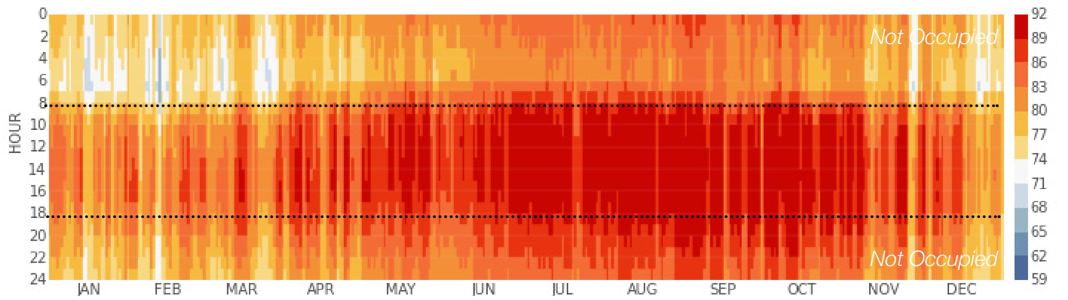


C.4.c.3. IMPROVED SUITE

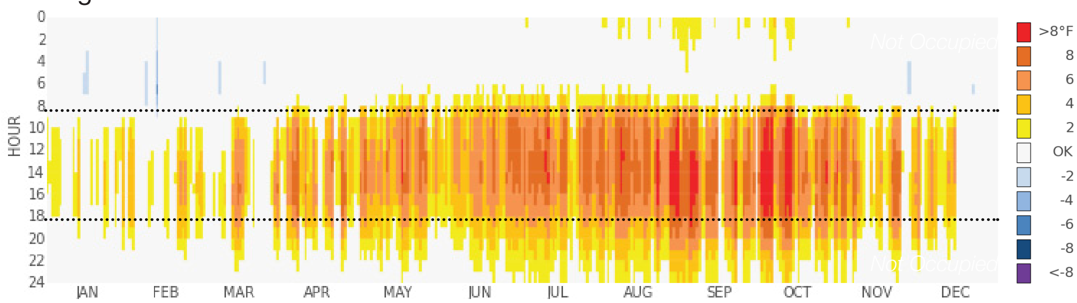
Equal to MINIMUM SUITE + IECC Roof

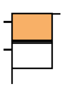


Operative temperature for bottom floor

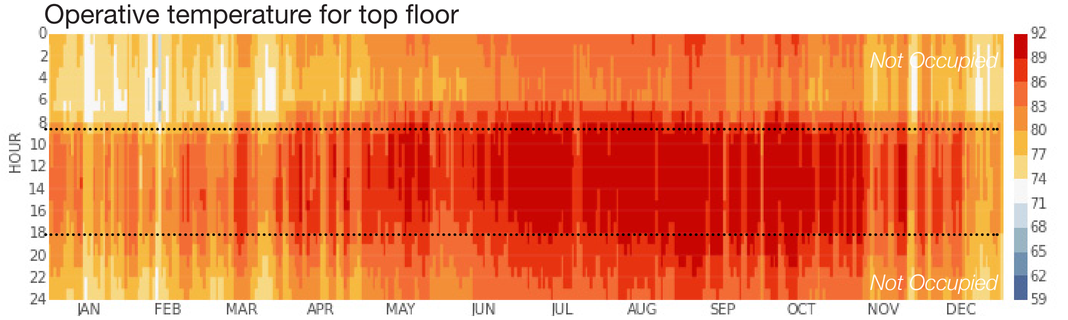


Degrees from comfort for bottom floor

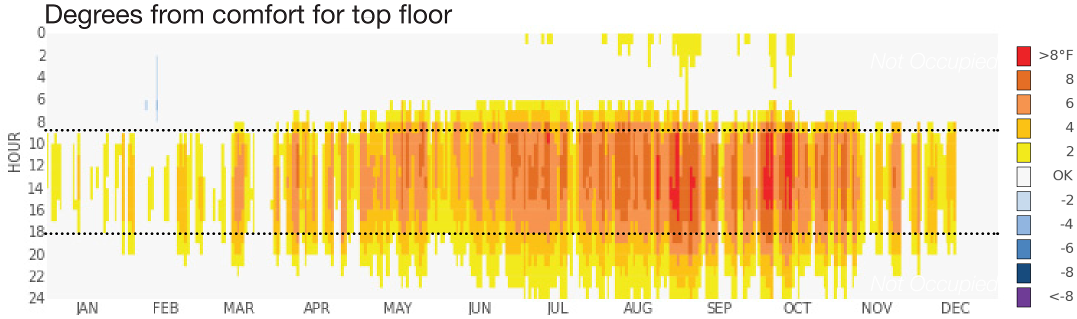




Operative temperature for top floor

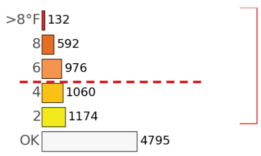


Degrees from comfort for top floor



Add/C.4.c.3 Office Analysis:: East Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	3934	**45%**	**100%**
		w/ celing fans	1700	19%	84%

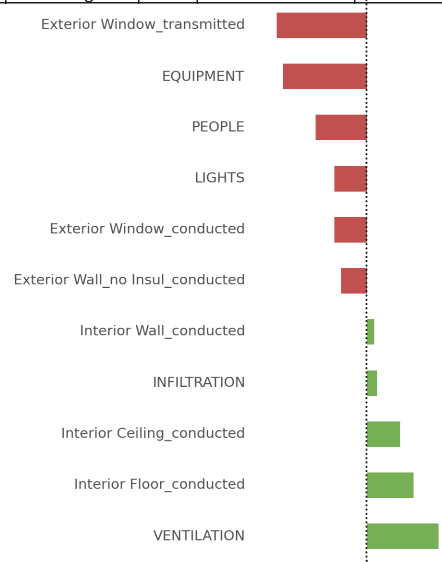


** Including all 8760 hrs of the year, not only occupied hours*

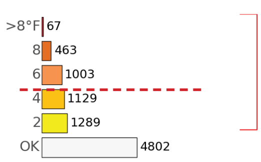
----- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 84% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	3951	**45%**	**100%**
		w/ celing fans	1533	18%	76%

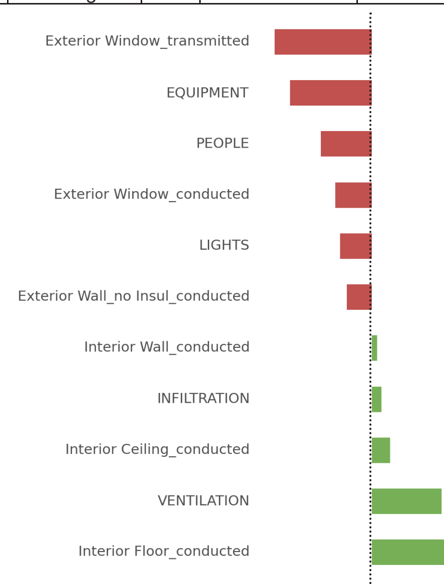


** Including all 8760 hrs of the year, not only occupied hours*

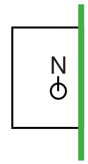
---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 76% too warm.*

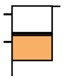


Add/C.4.c. OFFICE ANALYSIS:: EAST FACING

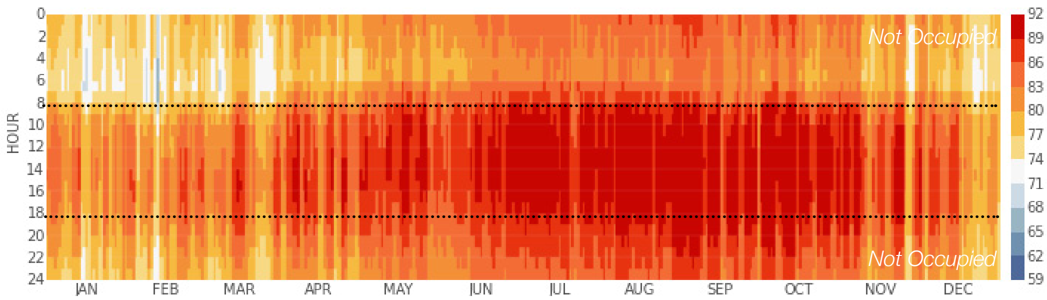


C.4.c.4. CODE SUITE

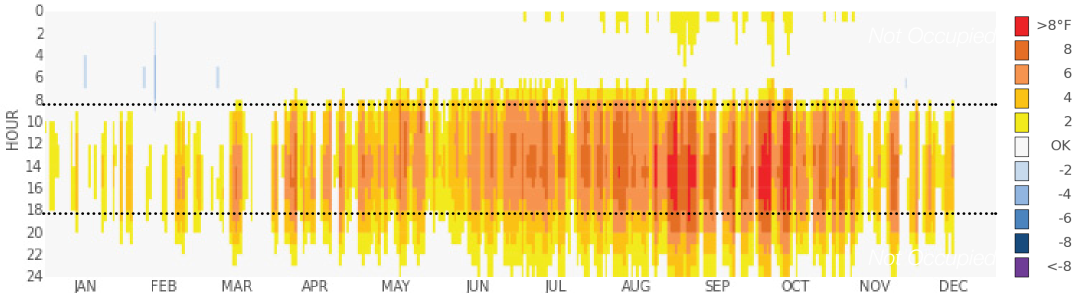
Equal to IMPROVED SUITE + IECC Walls

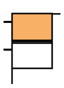


Operative temperature for bottom floor

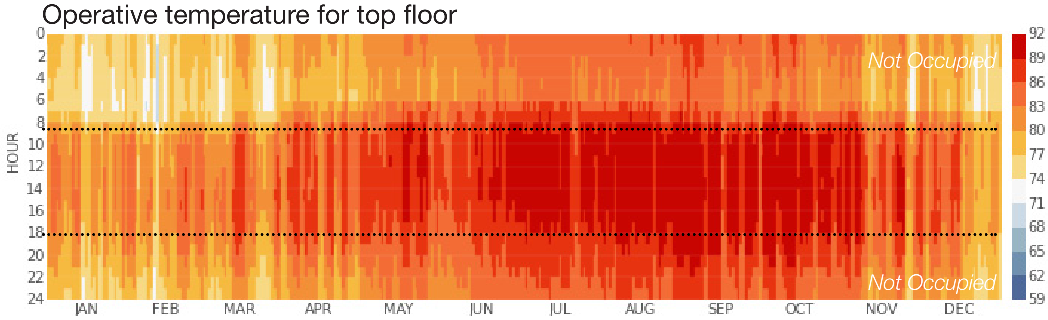


Degrees from comfort for bottom floor

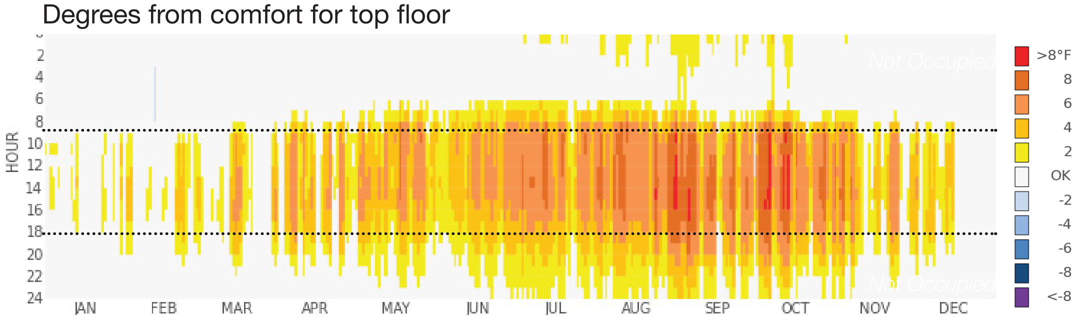




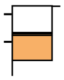
Operative temperature for top floor



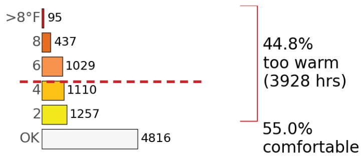
Degrees from comfort for top floor



Add/C.4.c.4 Office Analysis:: East Facing (Continued)



			Bottom Floor	
		hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls) too warm	3928	**45%**	**100%**
	w/ celing fans	1561	18%	77%

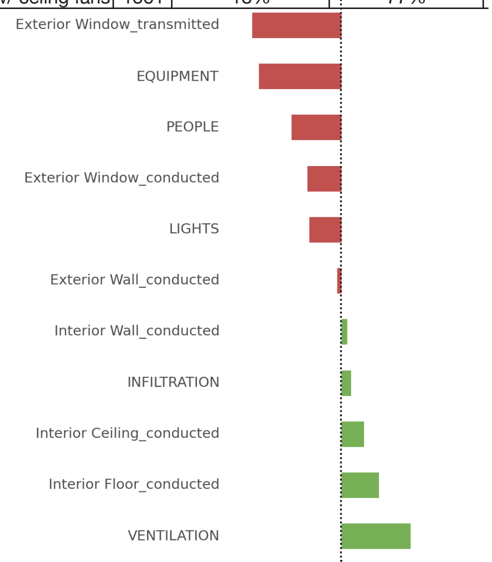


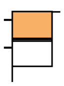
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

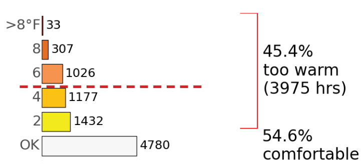
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 77% too warm.*





			Top Floor	
		hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls) too warm	3975	**45%**	**100%**
	w/ celing fans	1366	16%	67%

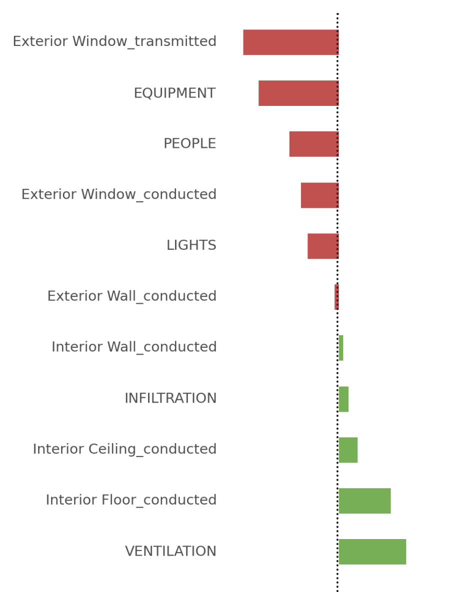


** Including all 8760 hrs of the year, not only occupied hours*

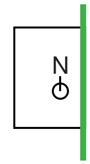
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 67% too warm.*

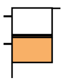


Add/C.4.c. OFFICE ANALYSIS:: EAST FACING

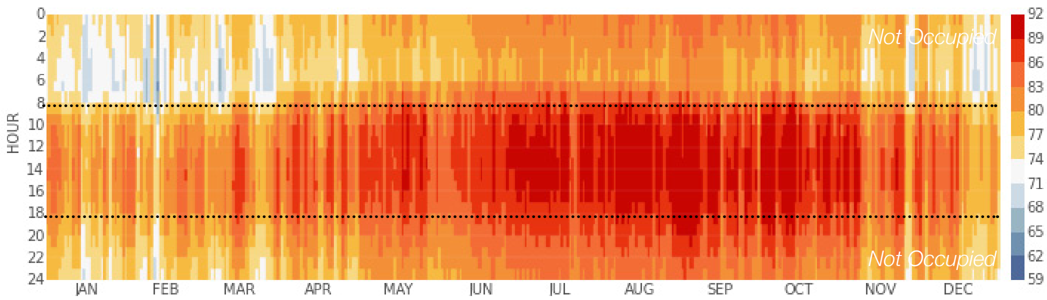


C.4.c.5. IMPROVED SUITE WITH VENTILATION

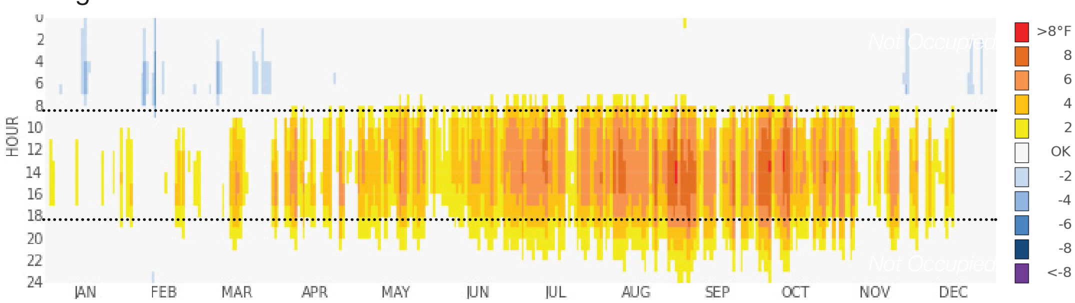
Equal to IMPROVED SUITE +2ACH

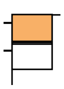


Operative temperature for bottom floor

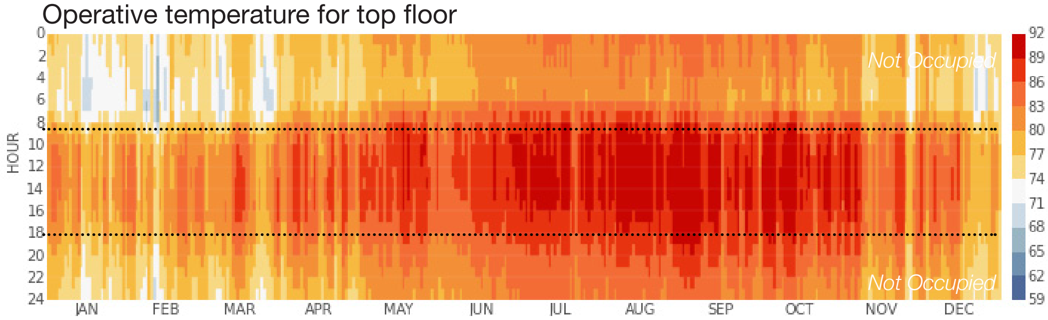


Degrees from comfort for bottom floor

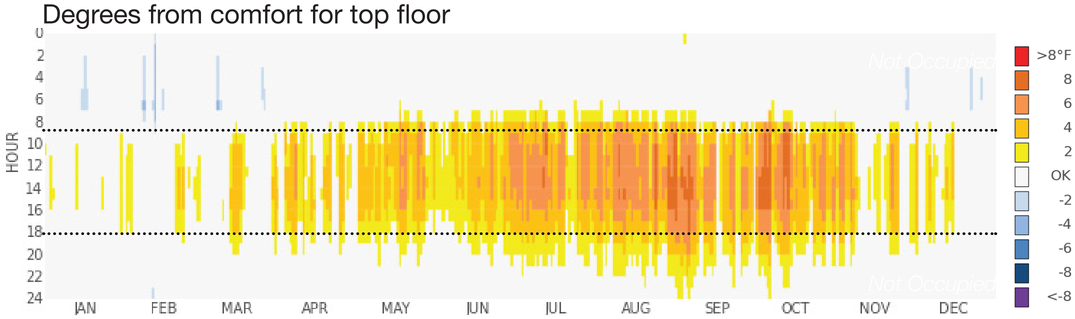




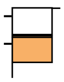
Operative temperature for top floor



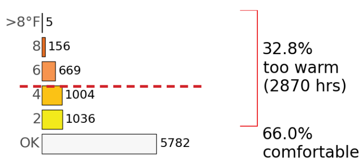
Degrees from comfort for top floor



Add/C.4.c.5 Office Analysis:: East Facing (Continued)

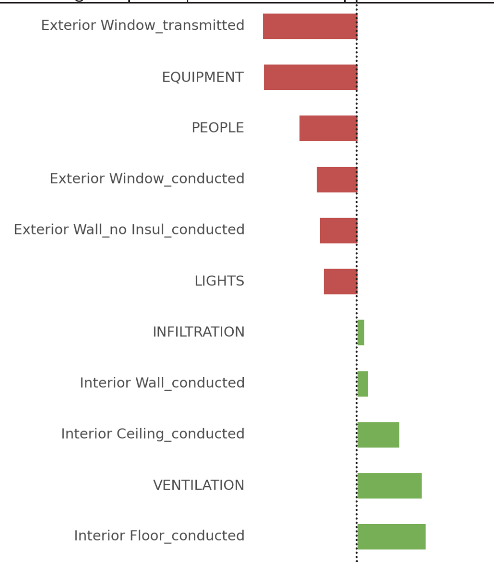


			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2870	**33%**	**100%**
		w/ celing fans	830	9%	41%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

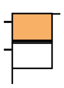


*** If considering only occupied hours*

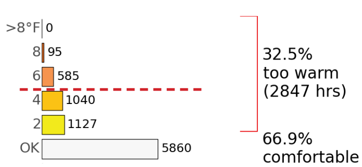
(M-F 8am-5pm):: 100% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

41% too warm.

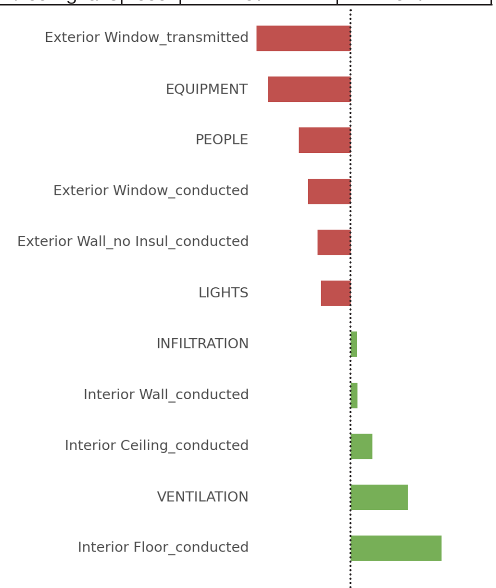


			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	2847	**33%**	**100%**
		w/ celing fans	680	8%	34%



** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective



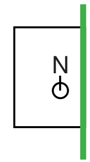
*** If considering only occupied hours*

(M-F 8am-5pm):: 100% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

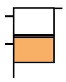
34% too warm.

Add/C.4.c. OFFICE ANALYSIS:: EAST FACING

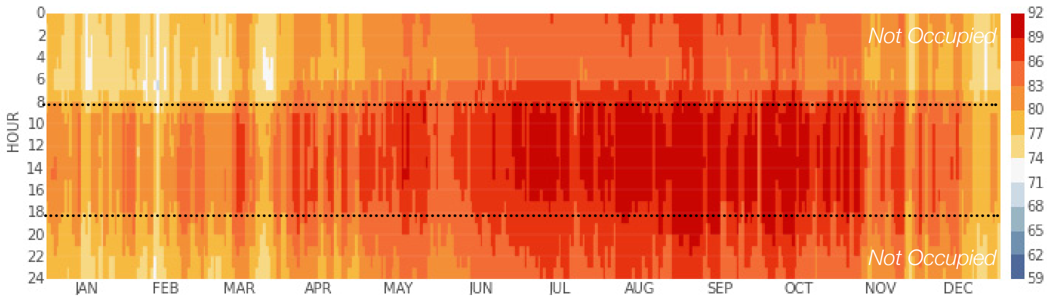


C.4.c.6. IDEAL SUITE

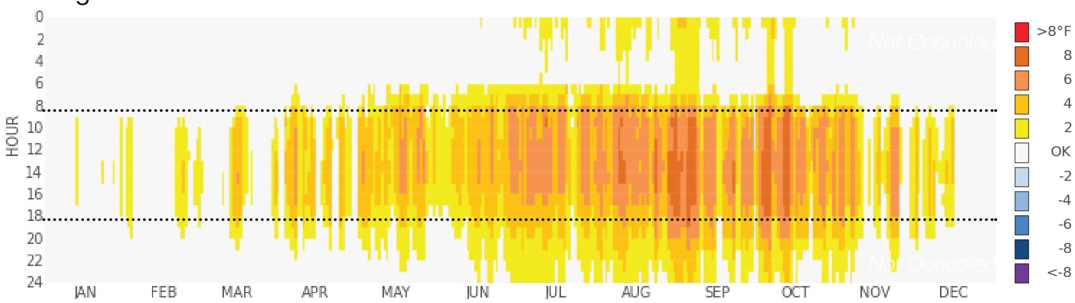
Equal to CODE SUITE + Thermal Mass

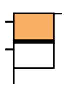


Operative temperature for bottom floor

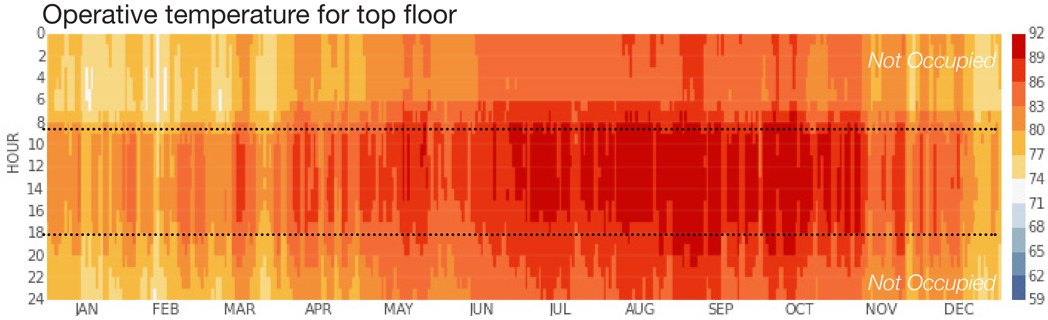


Degrees from comfort for bottom floor

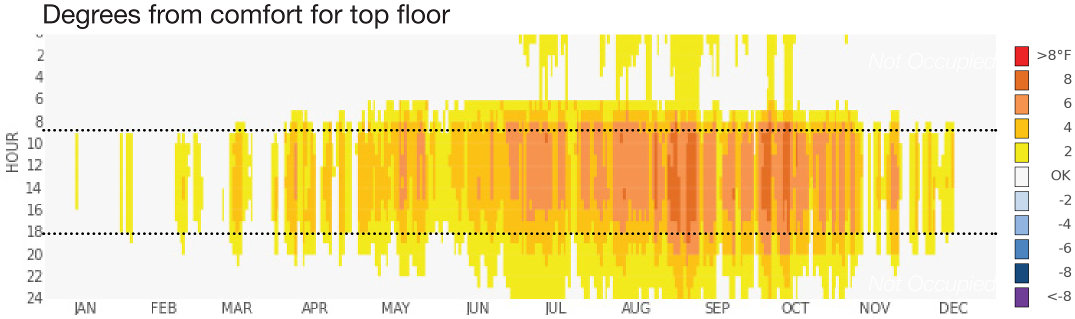




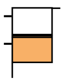
Operative temperature for top floor



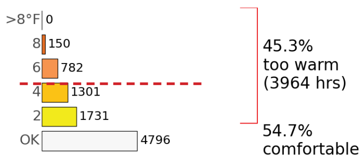
Degrees from comfort for top floor



Add/C.4.c.6 Office Analysis:: East Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	3964	**45%**	**100%**
		w/ celing fans	932	11%	46%



** Including all 8760 hrs of the year, not only occupied hours*

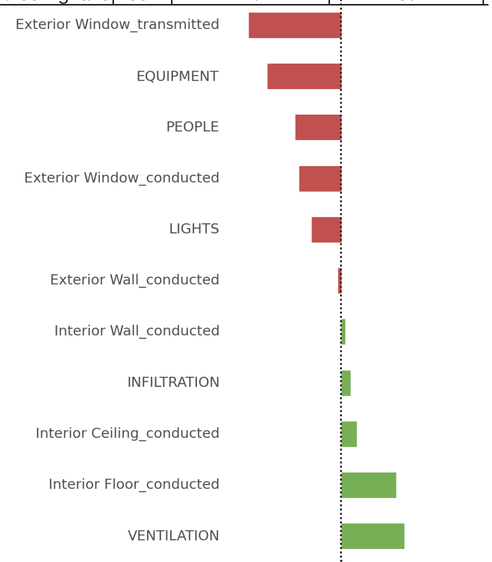
- - - - - *Ceiling Fans Effective*

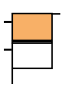
*** If considering only occupied hours*

(M-F 8am-5pm):: 100% too warm.

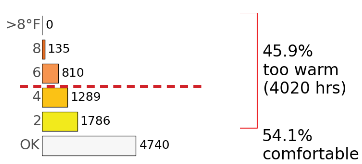
**** With ceiling fans (M-F 8am-8pm)::*

46% too warm.





			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	4020	**46%**	**100%**
		w/ celing fans	945	11%	47%



** Including all 8760 hrs of the year, not only occupied hours*

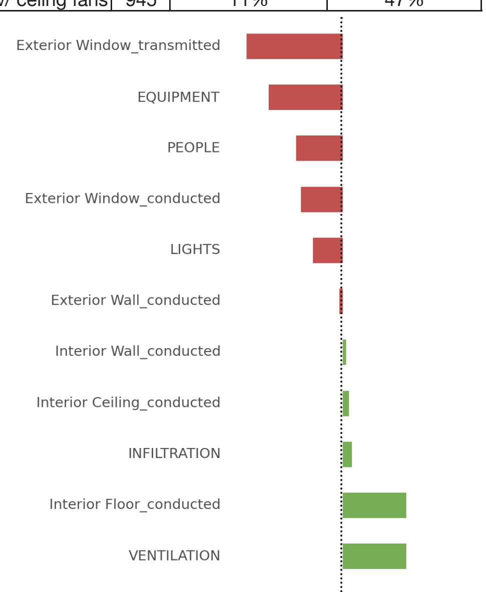
- - - - - - - - - *Ceiling Fans Effective*

*** If considering only occupied hours*

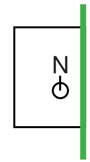
(M-F 8am-5pm):: 100% too warm.

**** With ceiling fans (M-F 8am-8pm)::*

47% too warm.



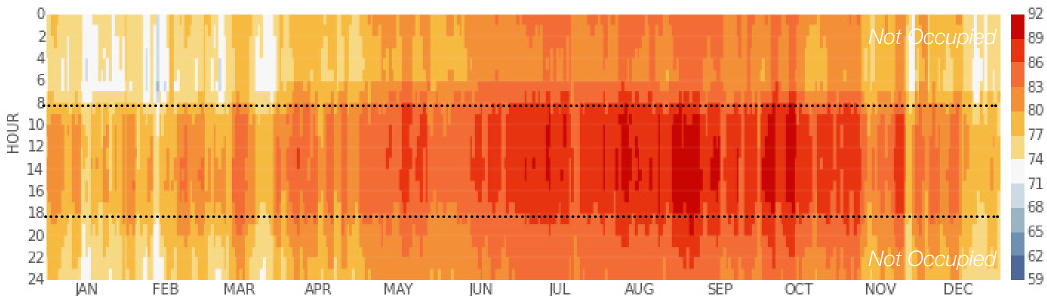
Add/C.4.c. OFFICE ANALYSIS:: EAST FACING



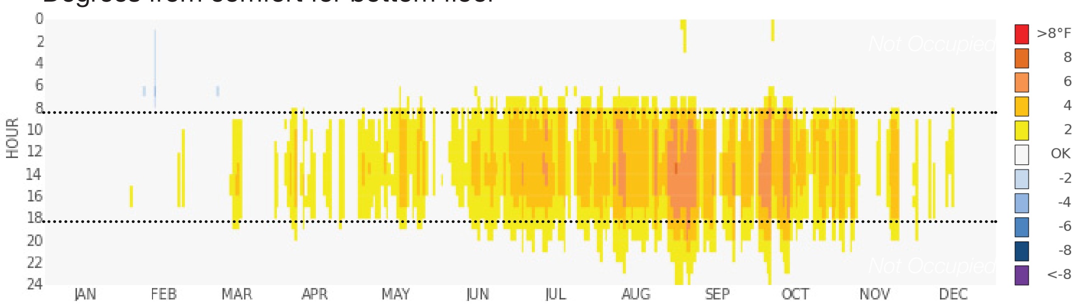
C.4.c.7. IDEAL SUITE WITH VENTILATION

Equal to IDEAL SUITE + 2ACH

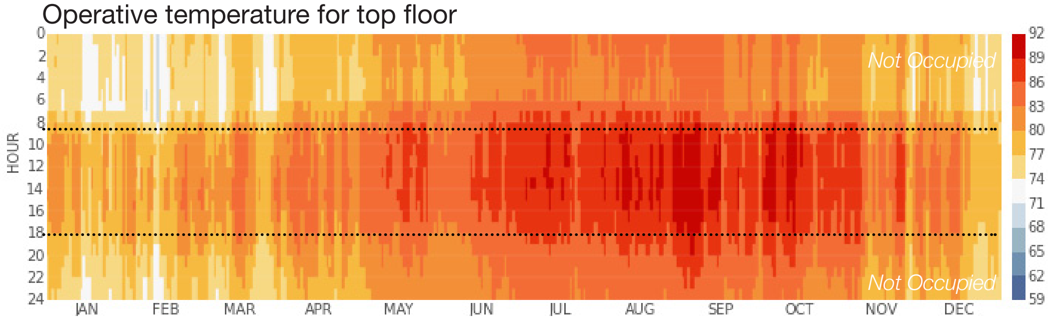
Operative temperature for bottom floor



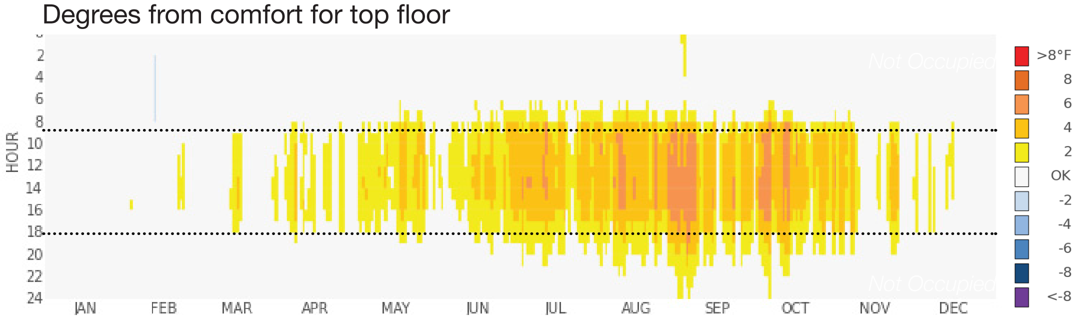
Degrees from comfort for bottom floor



Operative temperature for top floor

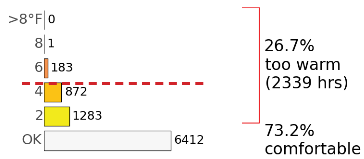


Degrees from comfort for top floor



Add/C.4.c.7 Office Analysis:: East Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL + 2 ACH	too warm	2339	**27%**	**100%**
		w/ celing fans	184	2%	9%

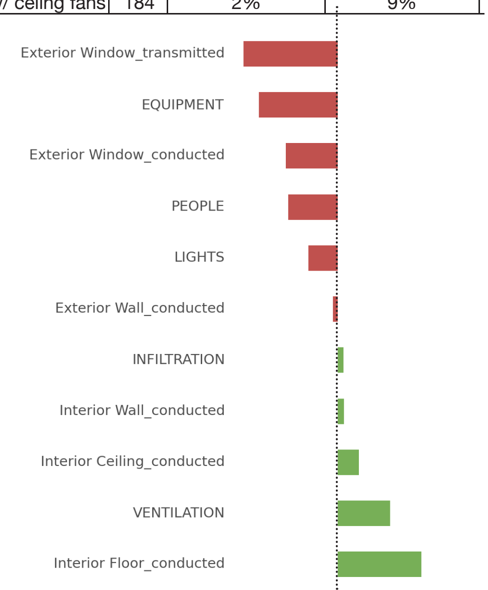


** Including all 8760 hrs of the year, not only occupied hours*

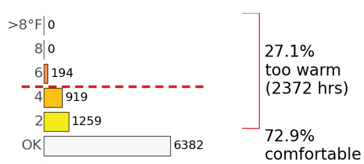
----- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 9% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2372	**27%**	**100%**
		w/ celing fans	194	2%	10%

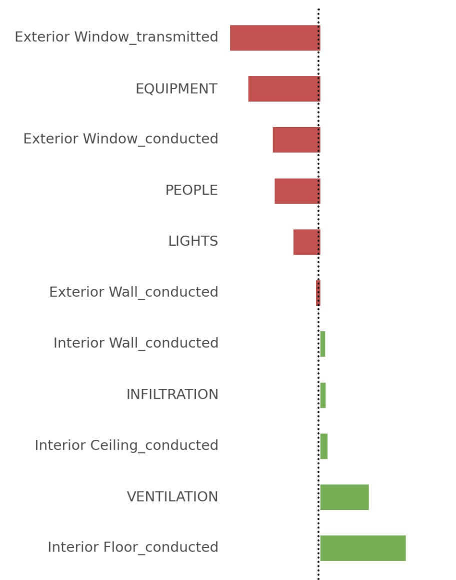


** Including all 8760 hrs of the year, not only occupied hours*

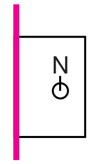
---------- Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

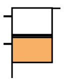


Add/C.4.d OFFICE ANALYSIS:: WEST FACING



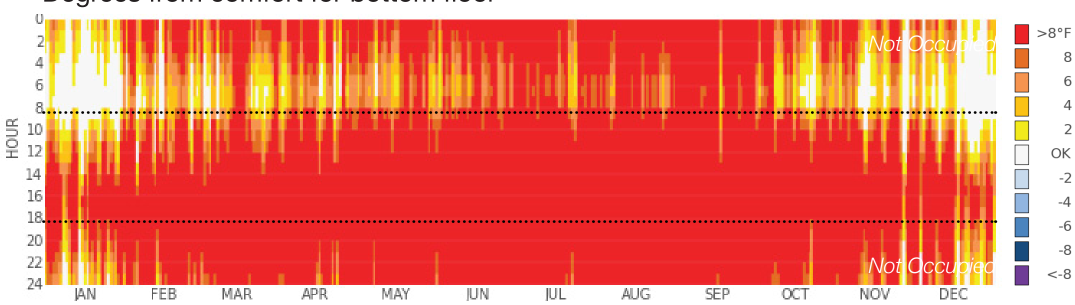
C.4.d.0. TYPICAL EXISTING CONDITIONS

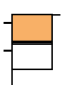
No Insulation in Opaque Surfaces and Single Pane Glass



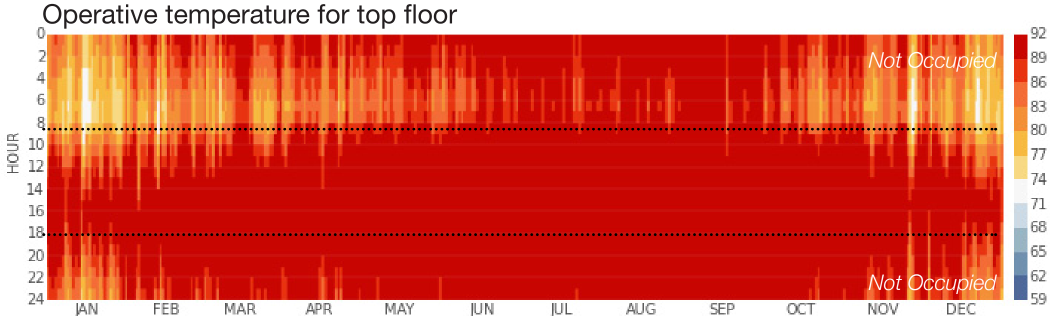
Operative temperature for bottom floor

Degrees from comfort for bottom floor

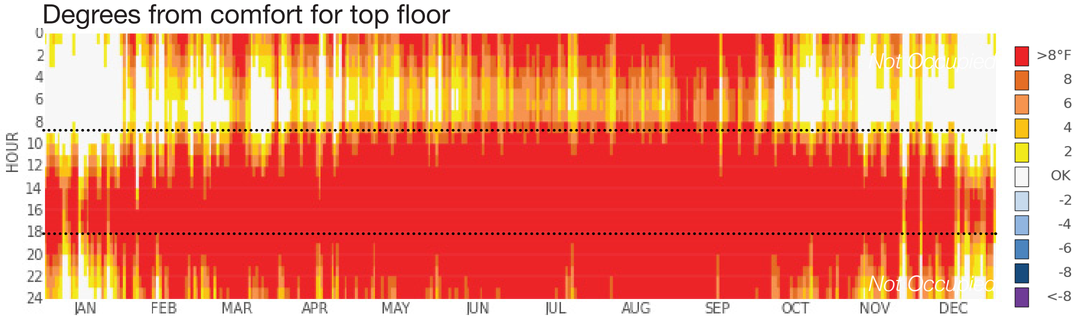




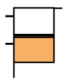
Operative temperature for top floor



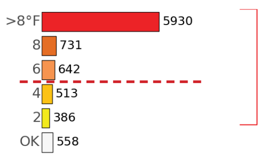
Degrees from comfort for top floor



Add/C.4.d.0 Office Analysis:: West Facing (Continued)

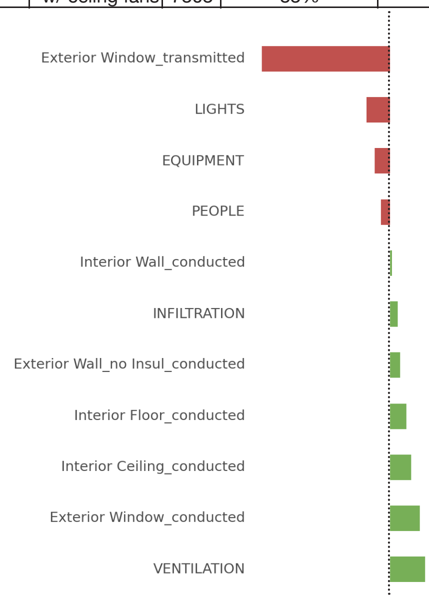


		Bottom Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	8202	**94%**	**100%**
	w/ celing fans	7303	83%	100%



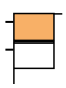
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

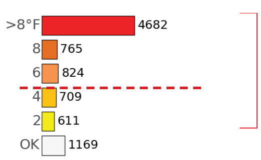


*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

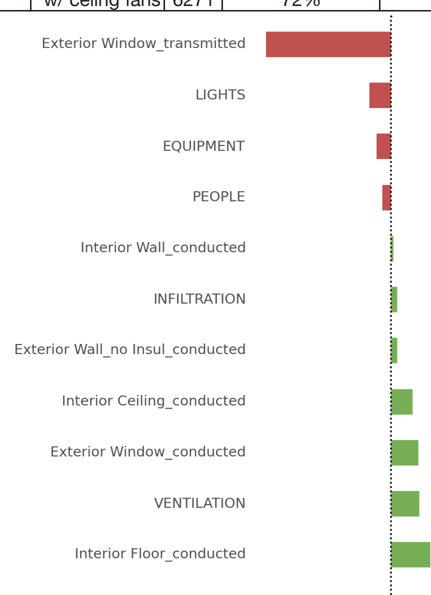


		Top Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	7591	**87%**	**100%**
	w/ celing fans	6271	72%	100%



** Including all 8760 hrs of the year, not only occupied hours*

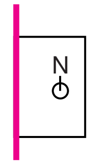
Ceiling Fans Effective



*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

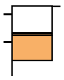
**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

Add/C.4.d OFFICE ANALYSIS:: WEST FACING

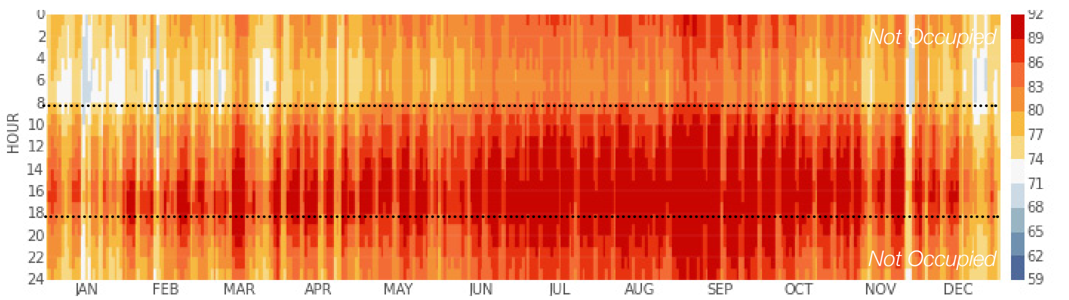


C.4.d.1. TYPICAL WITH WINDOW IMPROVEMENTS

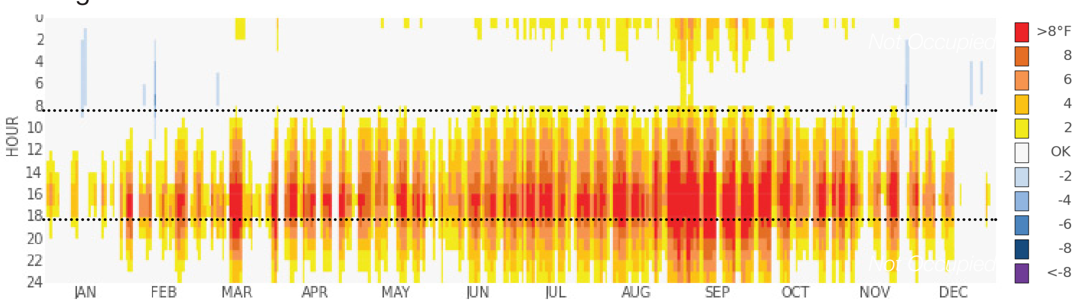
Equal to TYPICAL + 1ACH + Shading + IECC 2015 Windows

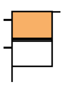


Operative temperature for bottom floor

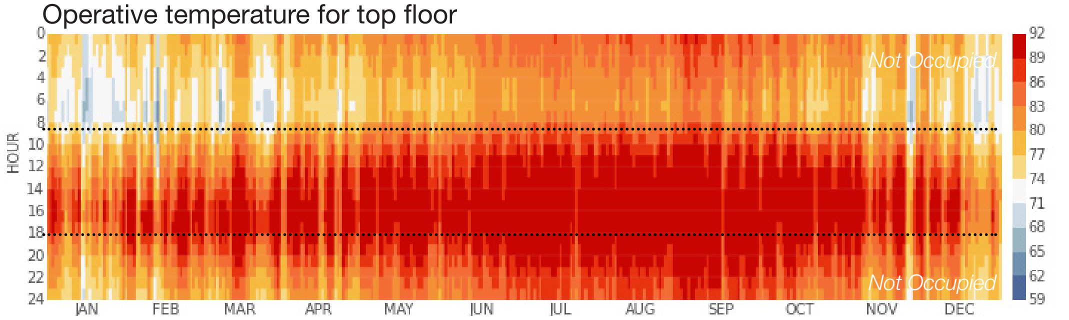


Degrees from comfort for bottom floor

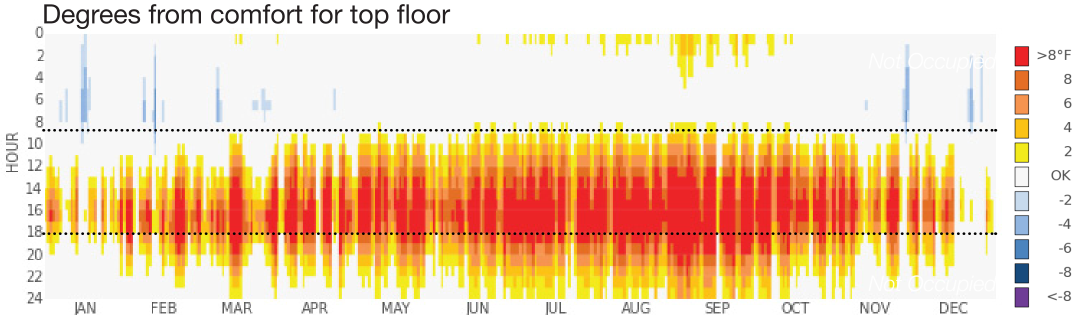




Operative temperature for top floor



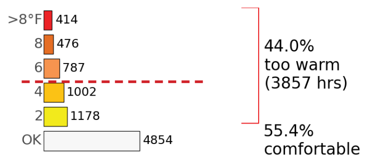
Degrees from comfort for top floor



Add/C.4.d.1 Office Analysis:: West Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3857	**44%**	**100%**
		w/ celing fans	1677	19%	83%

A-3 TYPICAL +1ACH +



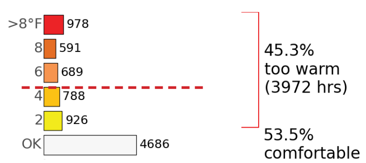
** Including all 8760 hrs of the year, not only occupied hours*

----- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 83% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3972	**45%**	**100%**
		w/ celing fans	2258	26%	100%

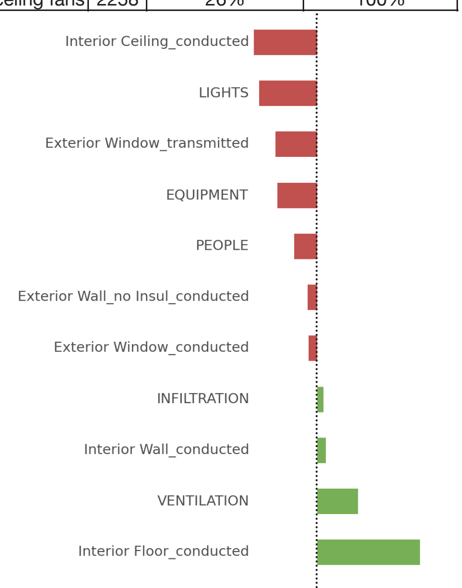


** Including all 8760 hrs of the year, not only occupied hours*

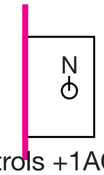
---------- *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 100% too warm.*

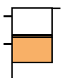


Add/C.4.d OFFICE ANALYSIS:: WEST FACING

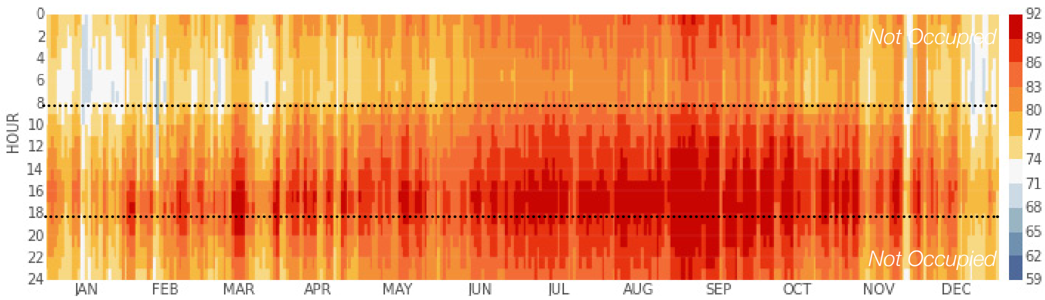


C.4.d.2. MINIMUM SUITE

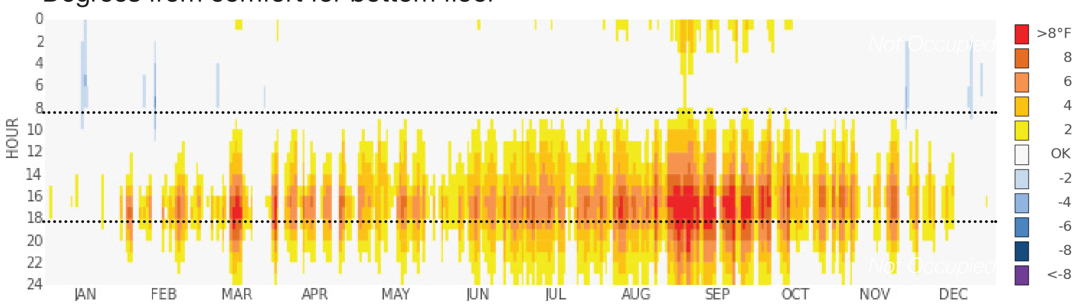
Equal to TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

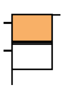


Operative temperature for bottom floor

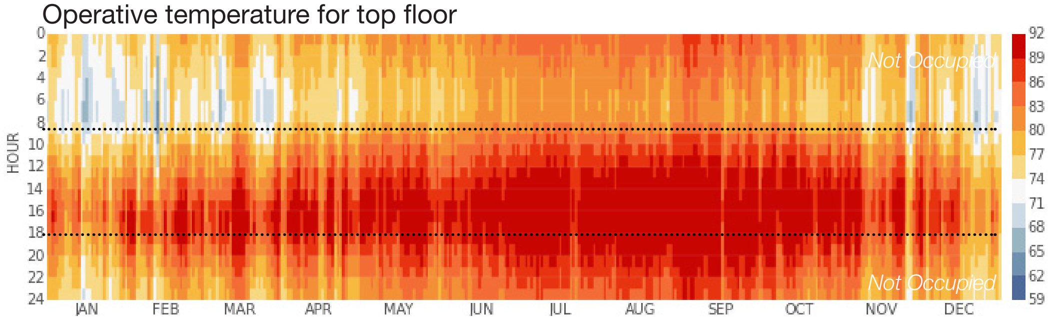


Degrees from comfort for bottom floor

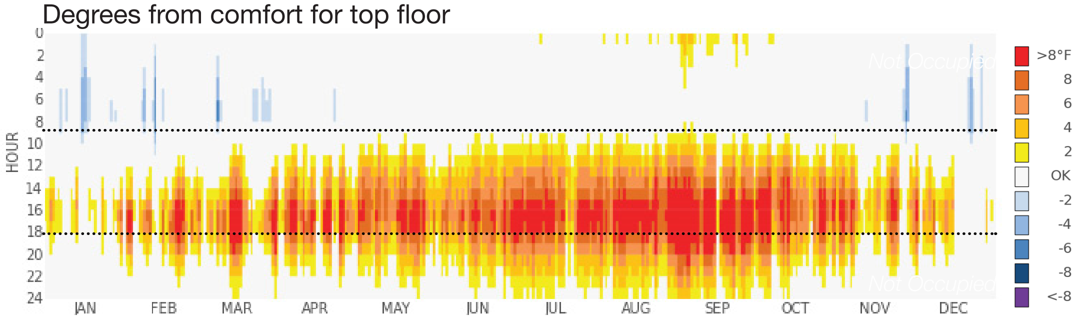




Operative temperature for top floor

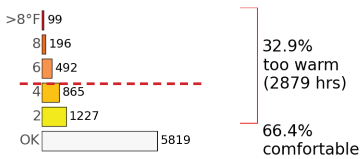


Degrees from comfort for top floor



Add/C.4.d.2 Office Analysis:: West Facing (Continued)

		Bottom Floor		
		hours	% of the whole year	% of occupied time
B-3 MINIMUM SUITE	too warm	2879	**33%**	**100%**
	w/ celing fans	787	9%	39%

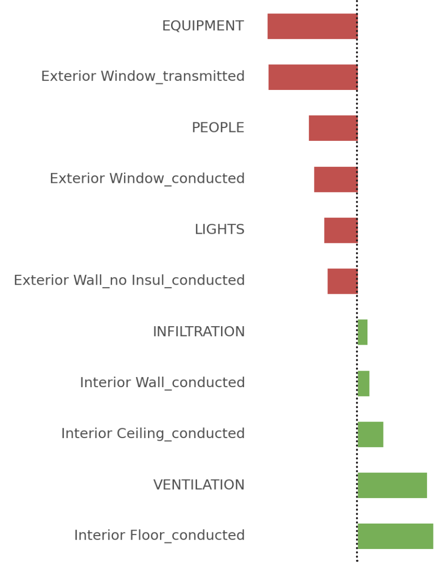


** Including all 8760 hrs of the year, not only occupied hours*

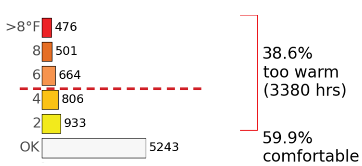
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 39% too warm.*



		Top Floor		
		hours	% of the whole year	% of occupied time
B-3 MINIMUM SUITE	too warm	3380	**39%**	**100%**
	w/ celing fans	1641	19%	81%

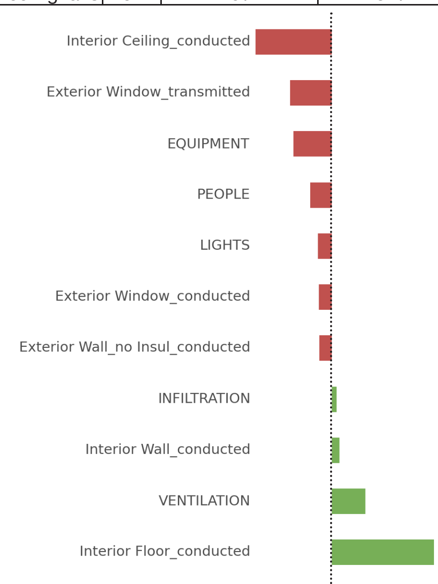


** Including all 8760 hrs of the year, not only occupied hours*

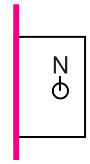
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 81% too warm.*

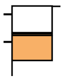


Add/C.4.d OFFICE ANALYSIS:: WEST FACING

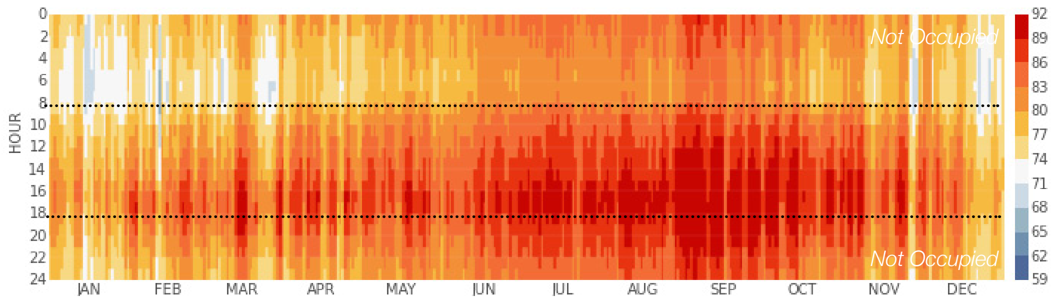


C.4.d.3. IMPROVED SUITE

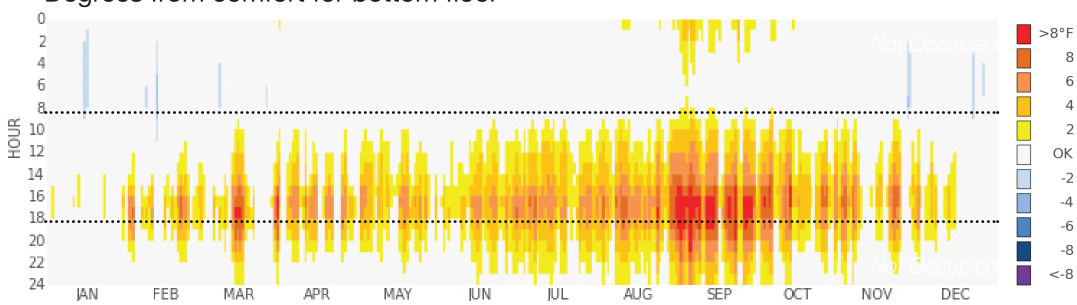
Equal to MINIMUM SUITE + IECC Roof

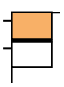


Operative temperature for bottom floor

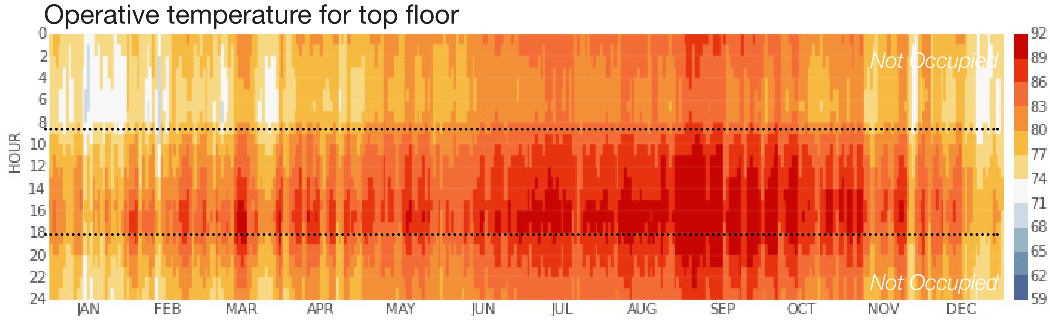


Degrees from comfort for bottom floor

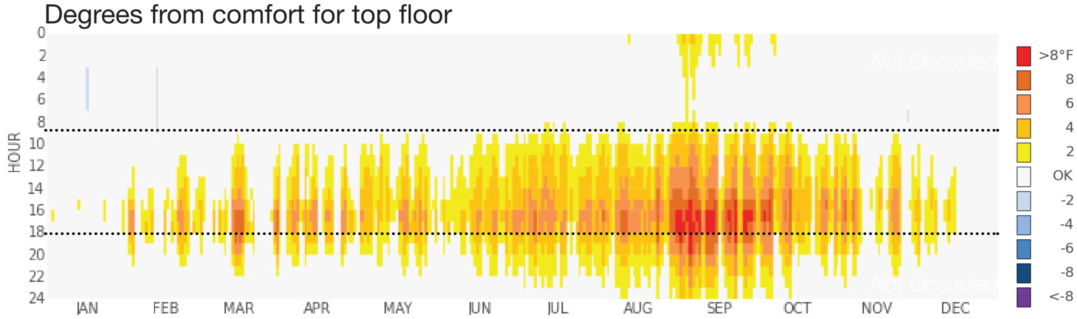




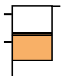
Operative temperature for top floor



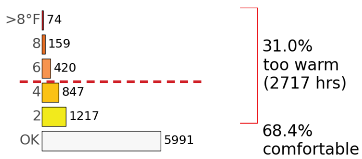
Degrees from comfort for top floor



Add/C.4.d.3 Office Analysis:: West Facing (Continued)



			Bottom Floor	
		hours	% of the whole year	% of occupied time
C-1 IMPROVED SUITE (B-3+ IECC Roof)	too warm	2717	**31%**	**100%**
	w/ celing fans	653	7%	32%

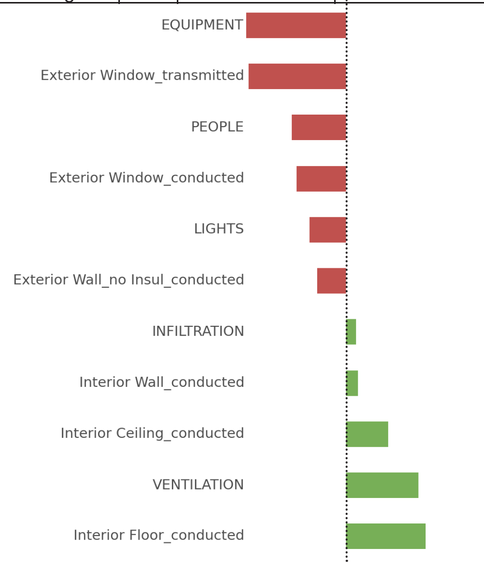


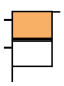
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

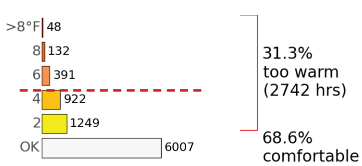
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 32% too warm.*





			Top Floor	
		hours	% of the whole year	% of occupied time
C-1 IMPROVED SUITE (B-3+ IECC Roof)	too warm	2742	**31%**	**100%**
	w/ celing fans	571	7%	28%

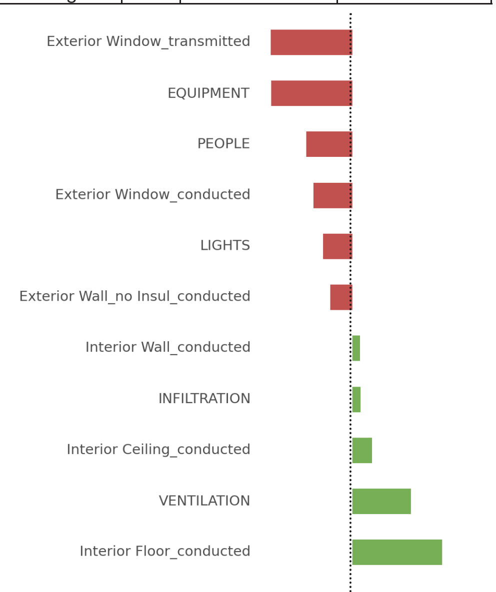


** Including all 8760 hrs of the year, not only occupied hours*

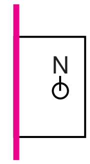
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 28% too warm.*

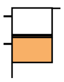


Add/C.4.d OFFICE ANALYSIS:: WEST FACING

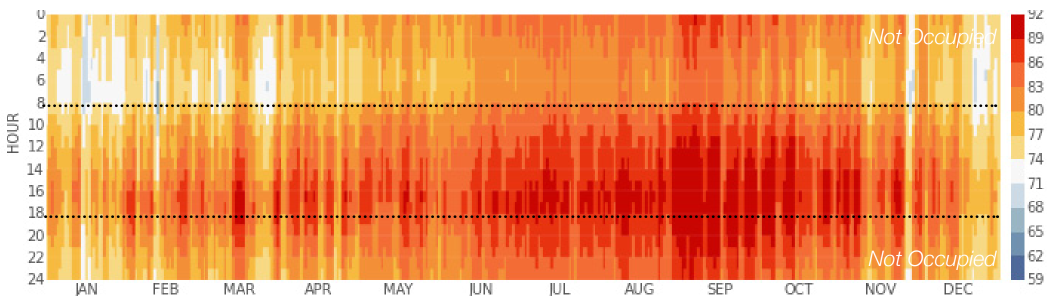


C.4.d.4. CODE SUITE

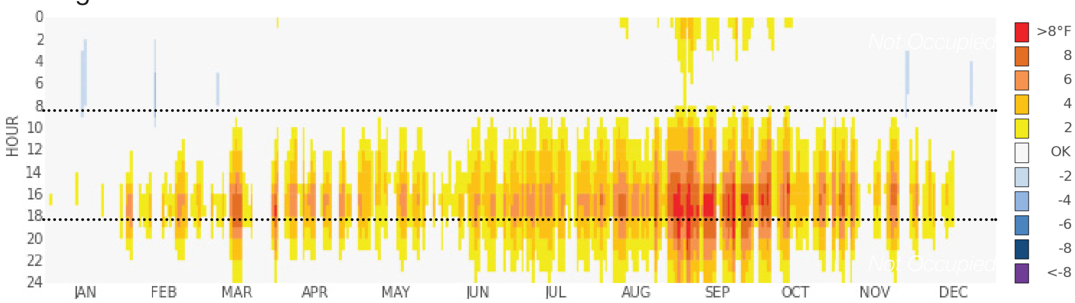
Equal to IMPROVED SUITE + IECC Walls

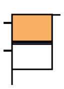


Operative temperature for bottom floor

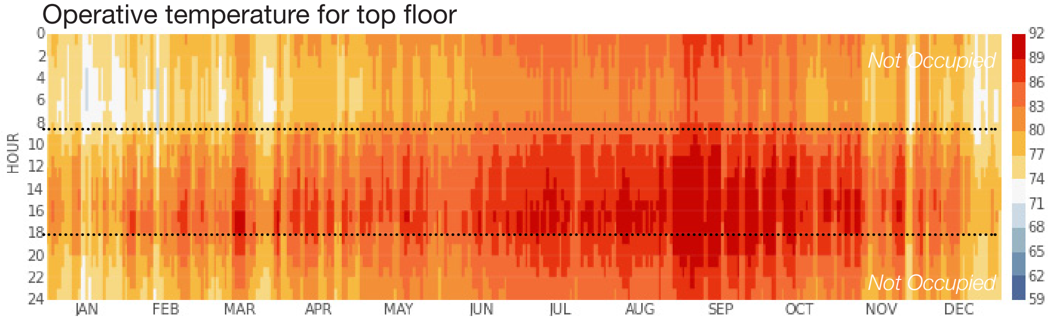


Degrees from comfort for bottom floor

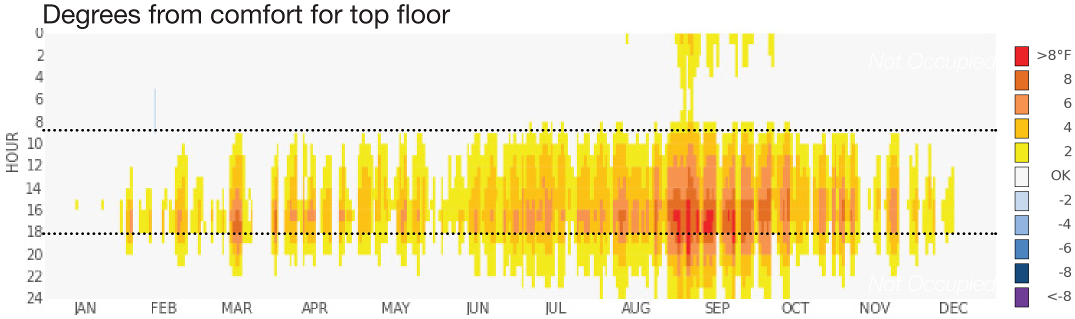




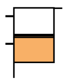
Operative temperature for top floor



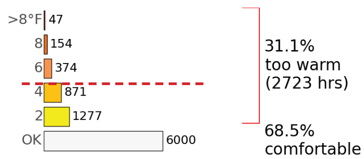
Degrees from comfort for top floor



Add/C.4.d.4 Office Analysis:: West Facing (Continued)



		Bottom Floor		
		hours	% of the whole year	% of occupied time
C-2 CODE SUITE (C-1+ IEACC walls)	too warm	2723	**31%**	**100%**
	w/ celing fans	575	7%	28%

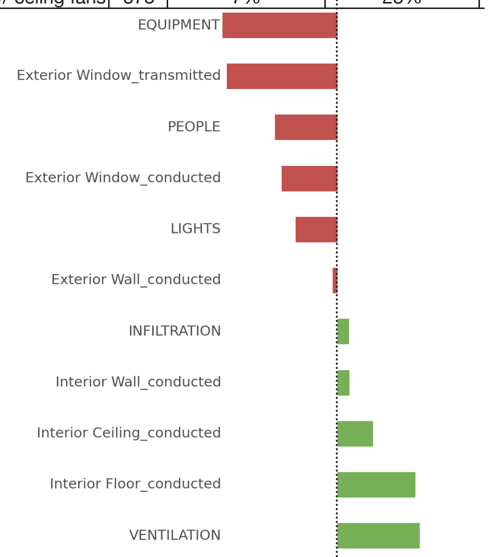


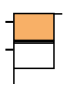
** Including all 8760 hrs of the year, not only occupied hours*

- - - - - *Ceiling Fans Effective*

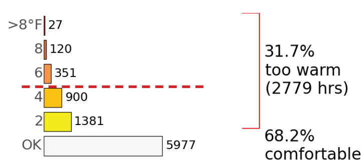
*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 28% too warm.*





		Top Floor		
		hours	% of the whole year	% of occupied time
C-2 CODE SUITE (C-1+ IEACC walls)	too warm	2779	**32%**	**100%**
	w/ celing fans	498	6%	25%



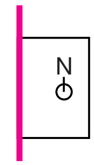
** Including all 8760 hrs of the year, not only occupied hours*

- - - - - - - - - - *Ceiling Fans Effective*

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

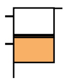
**** With ceiling fans (M-F 8am-8pm):: 25% too warm.*

Add/C.4.d OFFICE ANALYSIS:: WEST FACING

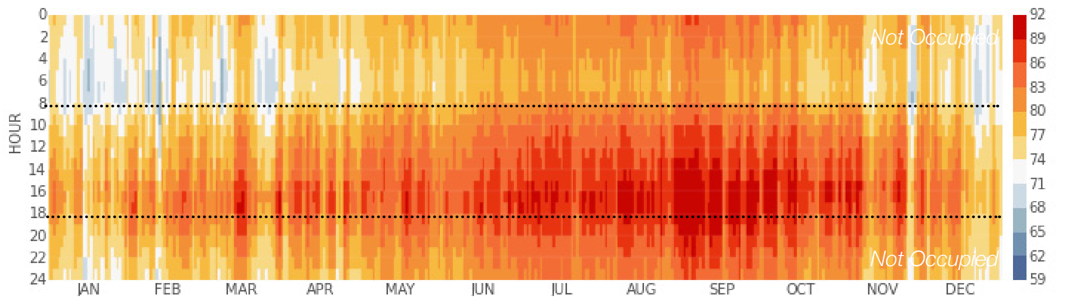


C.4.d.5. IMPROVED SUITE WITH VENTILATION

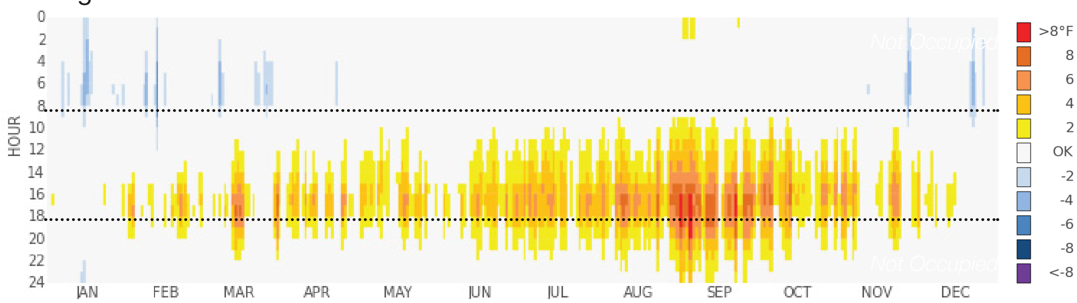
Equal to MPROVED SUITE +2ACH

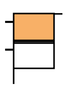


Operative temperature for bottom floor

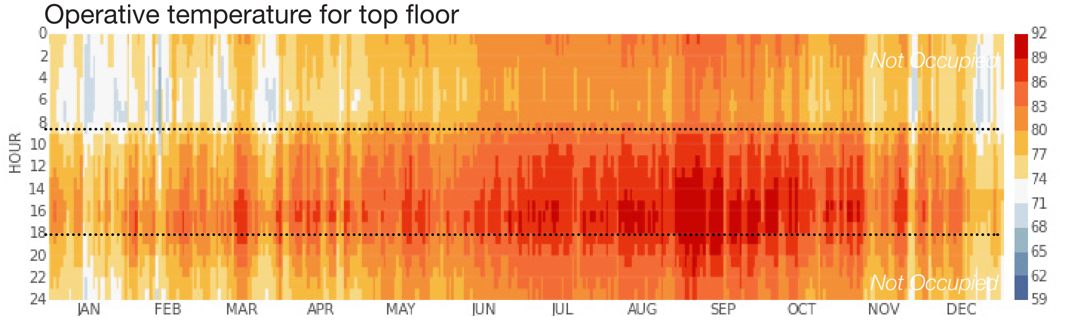


Degrees from comfort for bottom floor

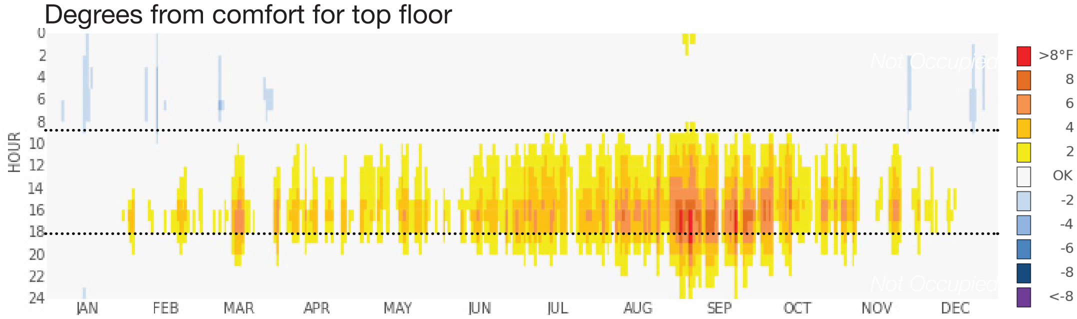




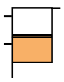
Operative temperature for top floor



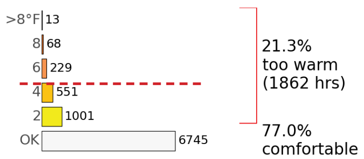
Degrees from comfort for top floor



Add/C.4.d.5 Office Analysis:: West Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1862	**21%**	**92%**
		w/ celing fans	310	4%	15%

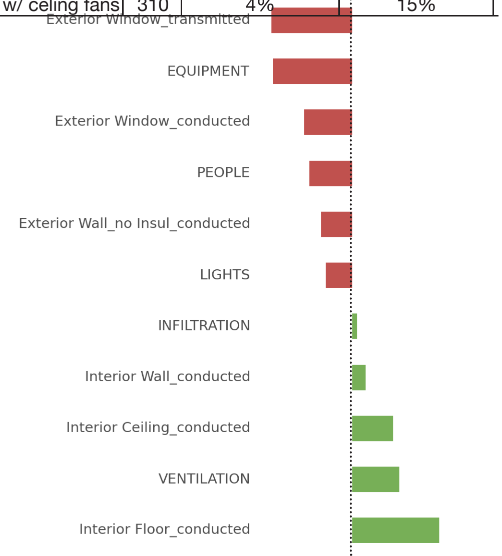


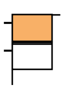
** Including all 8760 hrs of the year, not only occupied hours*

- - - - - Ceiling Fans Effective

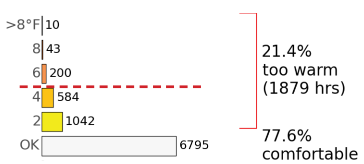
*** If considering only occupied hours (M-F 8am-5pm):: 92% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 15% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
D-2	IMPROVED SUITE + 2 ACH	too warm	1879	**21%**	**93%**
		w/ celing fans	253	3%	12%

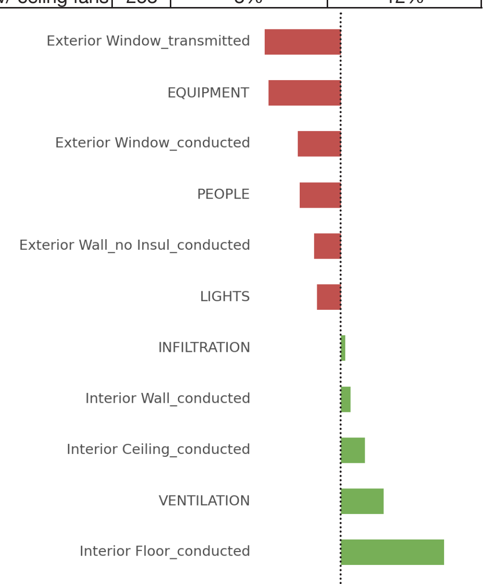


** Including all 8760 hrs of the year, not only occupied hours*

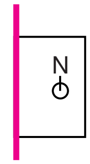
- - - - - - - - - - Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 93% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 12% too warm.*

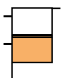


Add/C.4.d OFFICE ANALYSIS:: WEST FACING

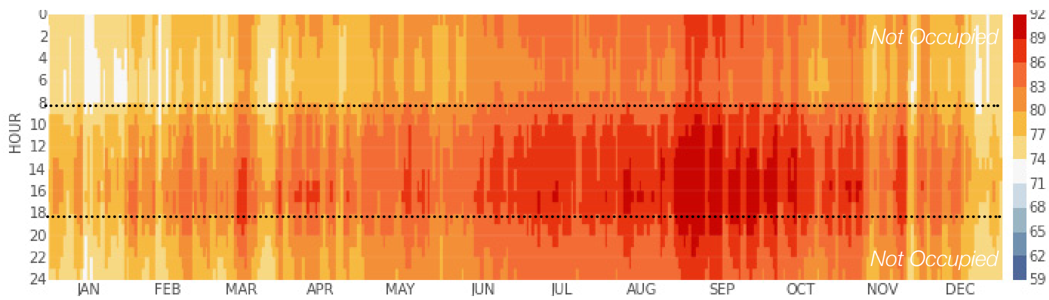


C.4.d.6. IDEAL SUITE

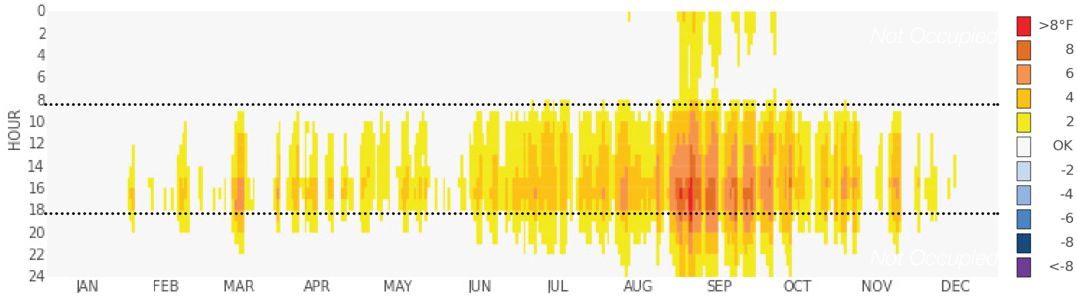
Equal to CODE SUITE + Thermal Mass

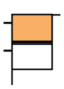


Operative temperature for bottom floor

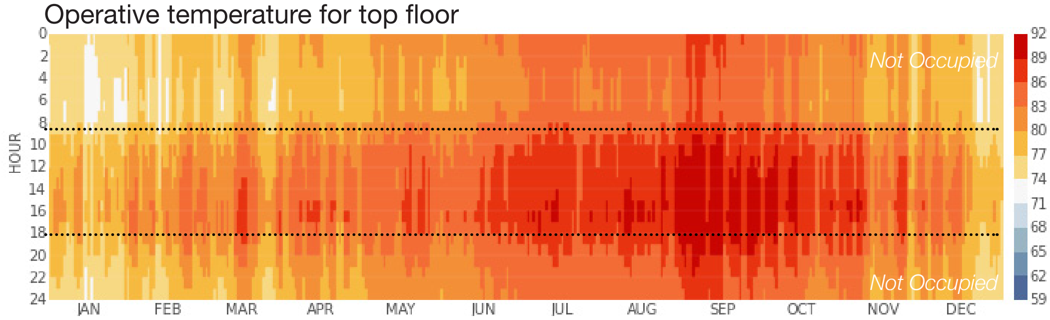


Degrees from comfort for bottom floor

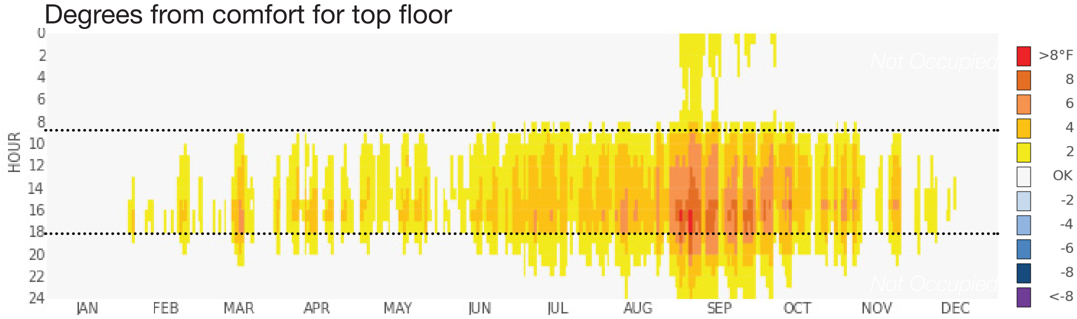




Operative temperature for top floor

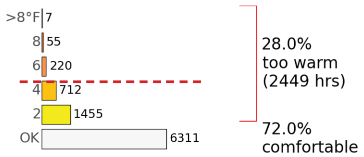


Degrees from comfort for top floor



Add/C.4.d.6 Office Analysis:: West Facing (Continued)

		Bottom Floor			
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2449	**28%**	**100%**
		w/ celing fans	282	3%	14%

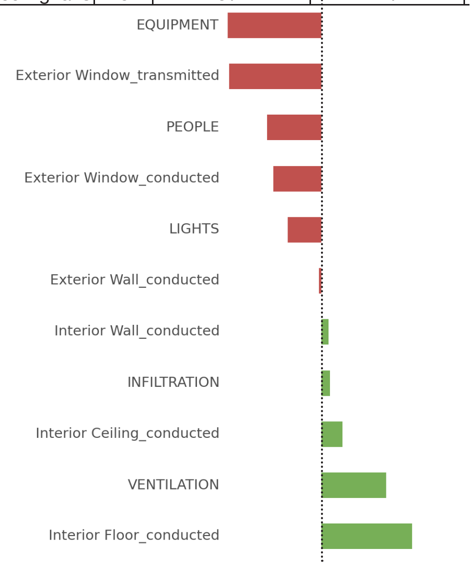


** Including all 8760 hrs of the year, not only occupied hours*

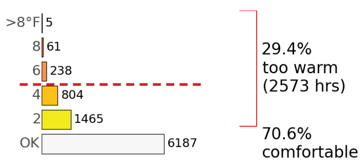
Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 14% too warm.*



		Top Floor			
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	2573	**29%**	**100%**
		w/ celing fans	304	3%	15%

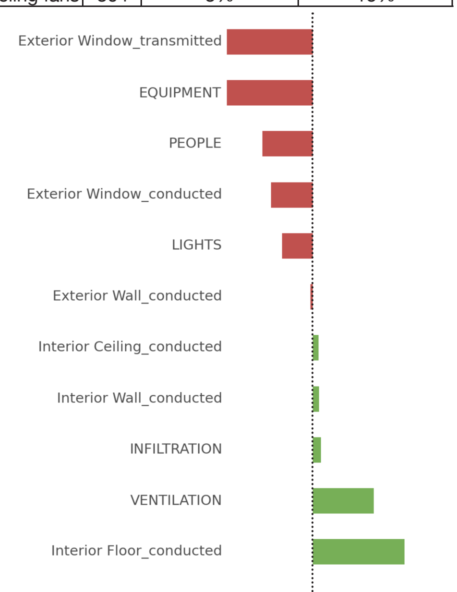


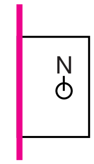
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 100% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 15% too warm.*

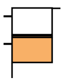




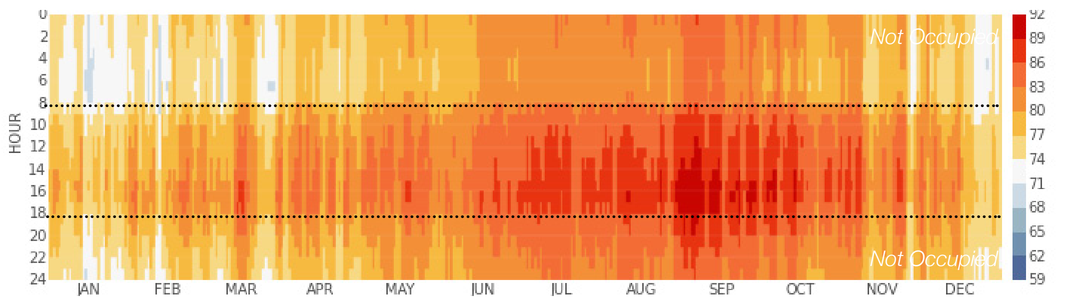
Add/C.4.d OFFICE ANALYSIS:: WEST FACING

C.4.d.7. IDEAL SUITE WITH VENTILATION

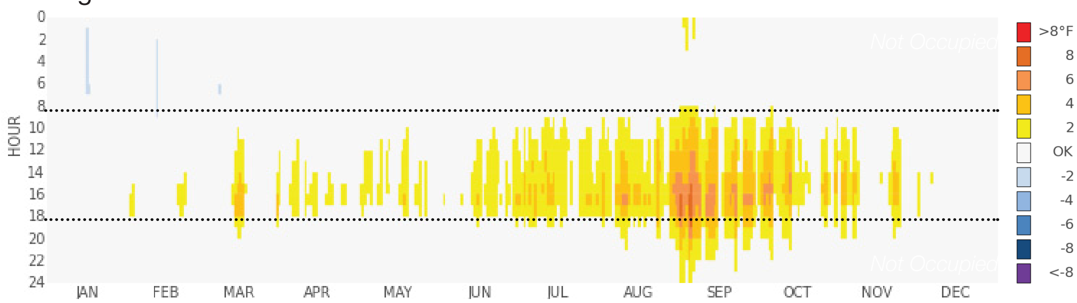
Equal to IDEAL SUITE + 2ACH

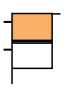


Operative temperature for bottom floor

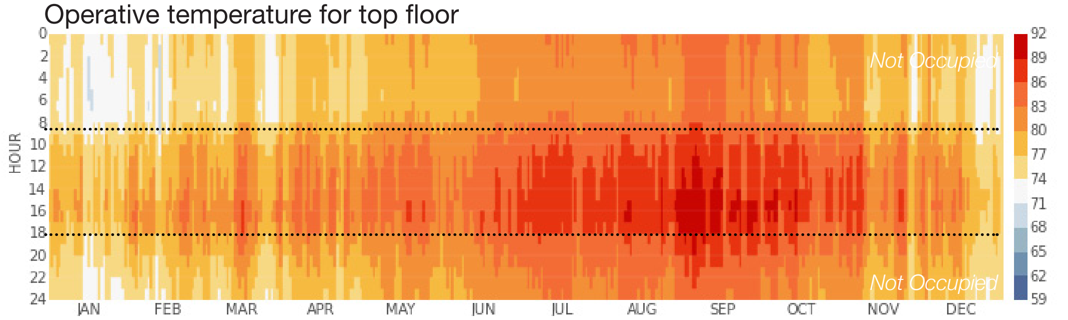


Degrees from comfort for bottom floor

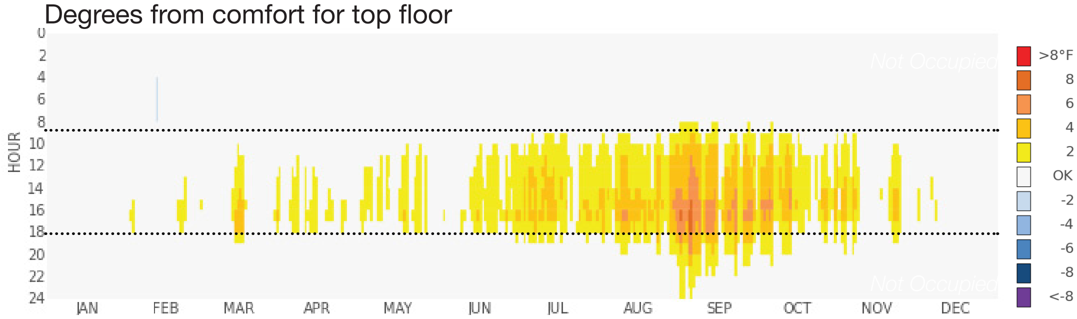




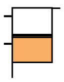
Operative temperature for top floor



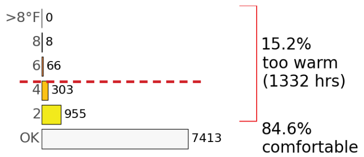
Degrees from comfort for top floor



Add/C.4.d.7 Office Analysis:: West Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL + 2 ACH	too warm	1332	**15%**	**66%**
		w/ celing fans	74	1%	4%

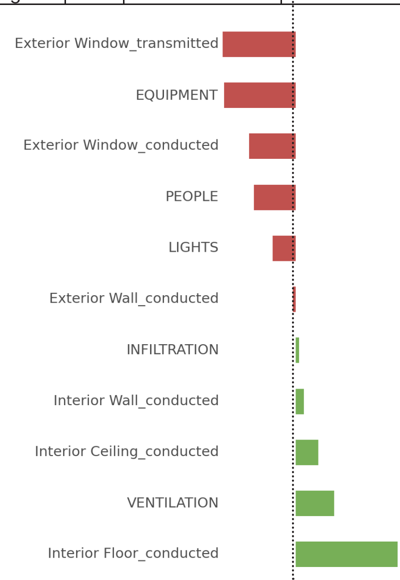


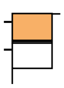
** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

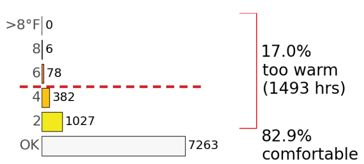
*** If considering only occupied hours (M-F 8am-5pm):: 66% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 4% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1493	**17%**	**74%**
		w/ celing fans	84	1%	4%

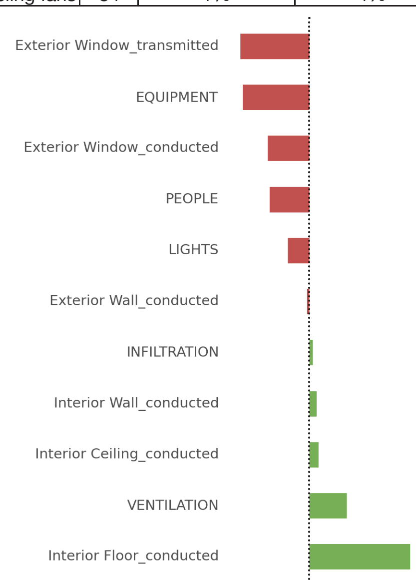


** Including all 8760 hrs of the year, not only occupied hours*

Ceiling Fans Effective

*** If considering only occupied hours (M-F 8am-5pm):: 74% too warm.*

**** With ceiling fans (M-F 8am-8pm):: 4% too warm.*



Add.3/C. HVAC AUTONOMY AND THERMAL COMFORT STUDIES

5. LABORATORY ANALYSIS

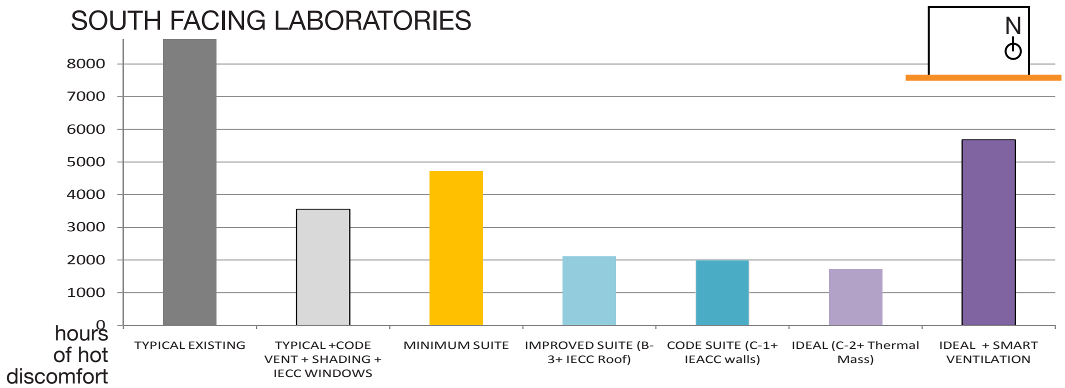
a. FOR SOUTH ORIENTATION

0. ***TYPICAL EXISTING***:: No Insulation in Opaque Surfaces, Single Pane Glass Windows
1. TYPICAL + 1ACH + Shading + IECC Glazing + Code Ventilation
2. ***MINIMUM SUITE***:: TYPICAL + IECC Glazing + Shading + Optimized Lighting and Equipment
3. ***IMPROVED SUITE***:: Minimum Suite + IECC Roof
4. ***CODE SUITE***:: Improved Suite + IECC Walls
5. ***IDEAL SUITE***:: Code Suite + Thermal Mass
6. IDEAL SUITE + VENTILATION PARAMETRICS
7. IDEAL SUITE + SMART VENTILATION

b. FOR NORTH ORIENTATION

0. ***TYPICAL EXISTING***:: No Insulation in Opaque Surfaces, Single Pane Glass Windows
1. TYPICAL + 1ACH + Shading + IECC Glazing
2. ***MINIMUM SUITE***:: TYPICAL + 1ACH + IECC Glazing + Shading +Optimized Lighting and Equipment
3. ***IMPROVED SUITE***:: Minimum Suite + IECC Roof
4. ***CODE SUITE***:: Improved Suite + IECC Walls
5. ***IDEAL SUITE***:: Code Suite + Thermal Mass
6. IDEAL SUITE + SMART VENTILATION

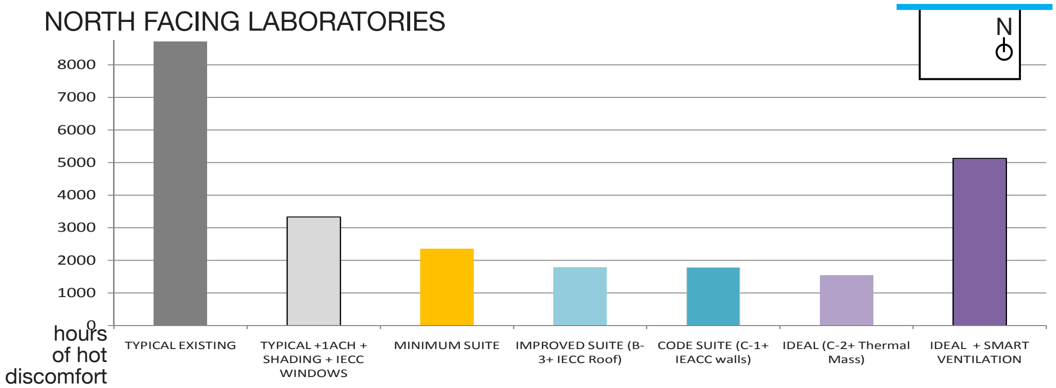
Add/C.5 Laboratory Analysis (Continued)



			Bottom Floor				Top Floor		
			hours	% of the whole year	% of occupied time		hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	8760	**100%**	**100%**	too warm	8760	**100%**	**100%**
A-3	TYPICAL +CODE VENT + SHADING + IECC WINDOWS	too warm	3422	**39%**	**100%**	too warm	3558	**41%**	**100%**
B-3	MINIMUM SUITE	too warm	2154	**25%**	**80%**	too warm	2612	**30%**	**97%**
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2140	**24%**	**79%**	too warm	2116	**24%**	**78%**
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2012	**23%**	**75%**	too warm	1991	**23%**	**74%**
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1653	**19%**	**61%**	too warm	1733	**20%**	**64%**
E-2	IDEAL + SMART VENTILATION	too warm	5684	**65%**	**100%**	too warm	5682	**65%**	**100%**

Add/C.5 Laboratory Analysis (Continued)

NORTH FACING LABORATORIES

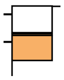


			Bottom Floor				Top Floor		
			hours	% of the whole year	% of occupied time		hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	6863	**78%**	**100%**	too warm	6181	**71%**	**100%**
		w/ celing fans	5001	57%	100%	w/ celing fans	4365	50%	100%
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3026	**35%**	**100%**	too warm	3458	**39%**	**100%**
		w/ celing fans	1077	12%	53%	w/ celing fans	1792	20%	88%
B-3	MINIMUM SUITE	too warm	2007	**23%**	**99%**	too warm	2850	**33%**	**100%**
		w/ celing fans	169	2%	8%	w/ celing fans	1162	13%	57%
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	1814	**21%**	**90%**	too warm	1835	**21%**	**91%**
		w/ celing fans	122	1%	6%	w/ celing fans	172	2%	8%
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	1881	**21%**	**93%**	too warm	1949	**22%**	**96%**
		w/ celing fans	149	2%	7%	w/ celing fans	120	1%	6%
D-2	IMPROVED SUITE + 2 ACH	too warm	1175	**13%**	**58%**	too warm	1217	**14%**	**60%**
		w/ celing fans	29	0%	1%	w/ celing fans	17	0%	1%
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1462	**17%**	**72%**	too warm	1653	**19%**	**82%**
		w/ celing fans	32	0%	2%	w/ celing fans	40	0%	2%
E-1	IDEAL + 2 ACH	too warm	728	**8%**	**36%**	too warm	934	**11%**	**46%**
		w/ celing fans	0	0%	0%	w/ celing fans	0	0%	0%

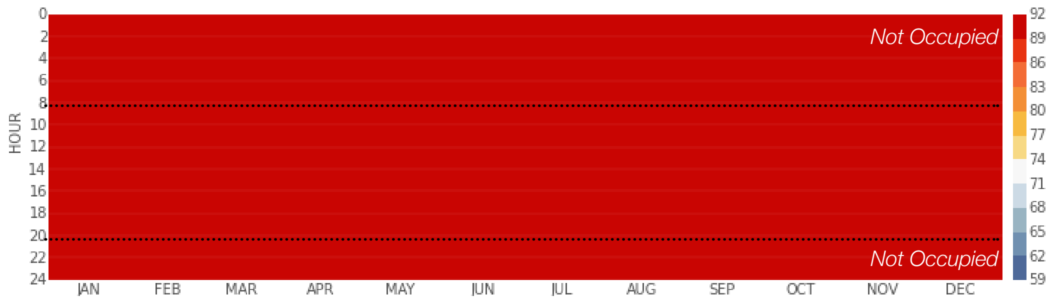
Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

C.5.a.0. TYPICAL EXISTING CONDITIONS

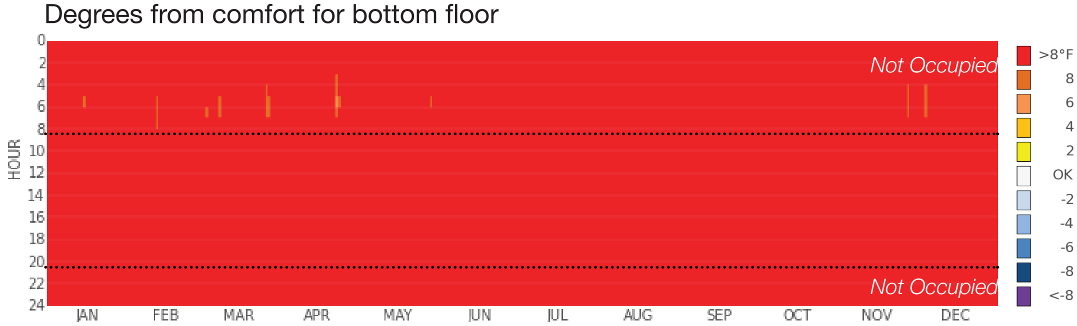
No Insulation in Opaque Surfaces and Single Pane Glass

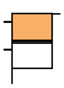


Operative temperature for bottom floor

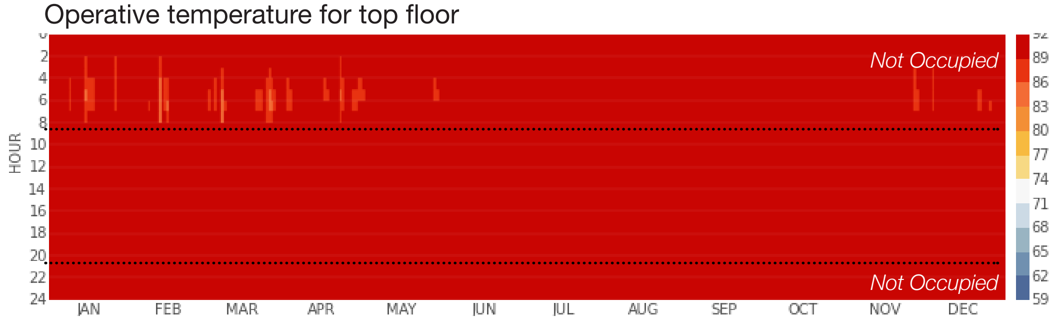


Degrees from comfort for bottom floor

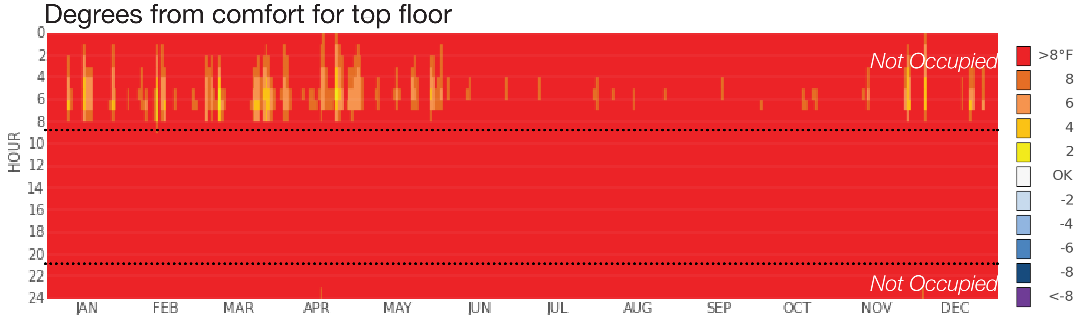




Operative temperature for top floor

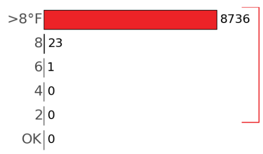


Degrees from comfort for top floor



Add/C.5.a.0 Laboratory Analysis:: South Facing (Continued)

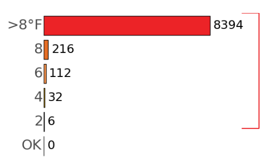
		Bottom Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	8760	**100%**	**100%**



** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

		Top Floor		
		hours	% of the whole year	% of occupied time
TYPICAL EXISTING	too warm	8760	**100%**	**100%**



** Including all 8760 hrs of the year, not only occupied hours*

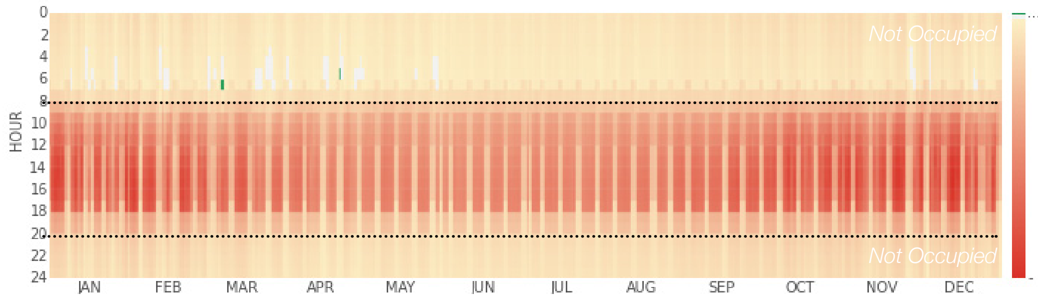
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

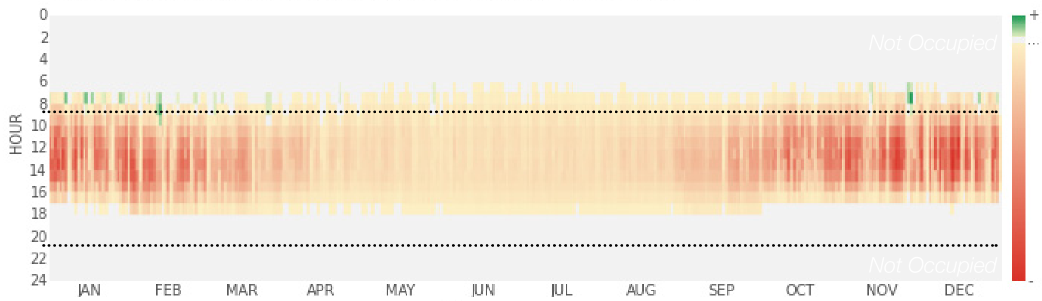
TYPICAL EXISTING CONDITIONS:: Comfort Load Factors

No Insulation in Opaque Surfaces and Single Pane Glass

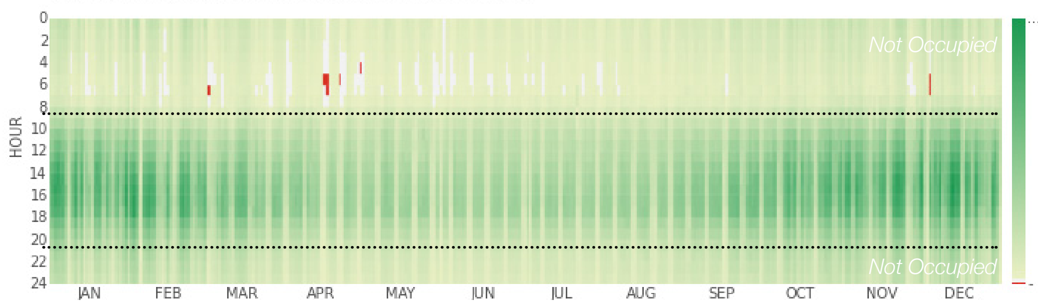
SUMMARY:EQUIPMENT COMFORT Load Factors



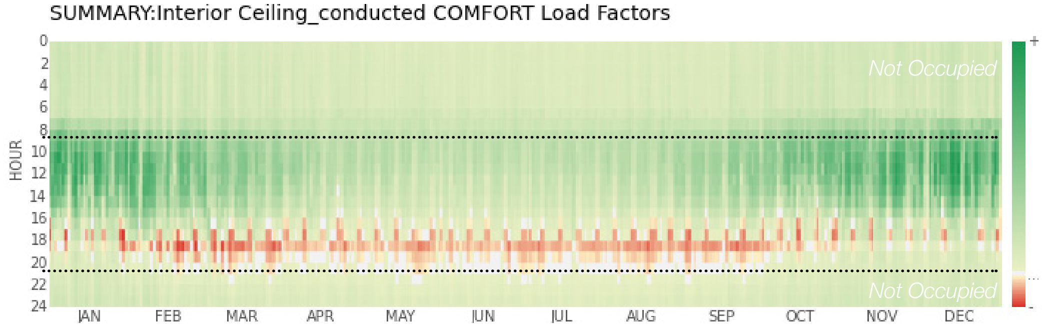
SUMMARY:Exterior Window_transmitted COMFORT Load Factors



SUMMARY:VENTILATION COMFORT Load Factors



SUMMARY:Interior Ceiling_conducted COMFORT Load Factors



Add/C.5.a.0 Laboratory Analysis:: South Facing (Continued)

In order to provide more detailed information about what is affecting comfort, we analyzed the heat flows into and out of the spaces, as well as the difference between the space temperatures and the ideal space temperature (adaptive comfort range). We compared these space loads to the ideal temperature difference to determine which loads are improving comfort and which loads are decreasing comfort. The comfort load factors indicate the degree to which a particular load is pushing the temperature of a space towards the middle of the comfort zone or away from it.

In summary, the factors associated with decreased comfort in this analysis are the solar radiation through the windows and the internal loads (heat released to the space mostly by the equiment but also lighting).

This analysis also indicates that ventilation and thermal mass (interior ceiling and floor conduction) are improving building thermal performance and thus improving comfort and reducing future HVAC loads. On the one hand, by introducing outside air when heat is building up in the space due to high internal loads or solar radiation, interior spaces can prevent overheating. On the other hand, the thermal mass in the ceiling contributes to Achievingcomfort conditions by absorbing heat during the day and releasing it at night.

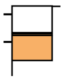
The graphs on the left show the times of the year when each load factor either decreases or increases comfort. For example, the solar transmitted radiation never increases comfort and decreases comfort the most during the fall and winter seasons, which is likely when the lower sun angles hit the windows for longer periods of time.

The internal heat coming from the equipment always decreases comfort while ventilation always increases comfort. The interior ceiling increases comfort during most of the occupied times, even if it decreases comfort during the late afternoons. This is likely due to the floors not being able to absorb any more internal heat and starting to release it into the space even if that further increases the interior temperature.

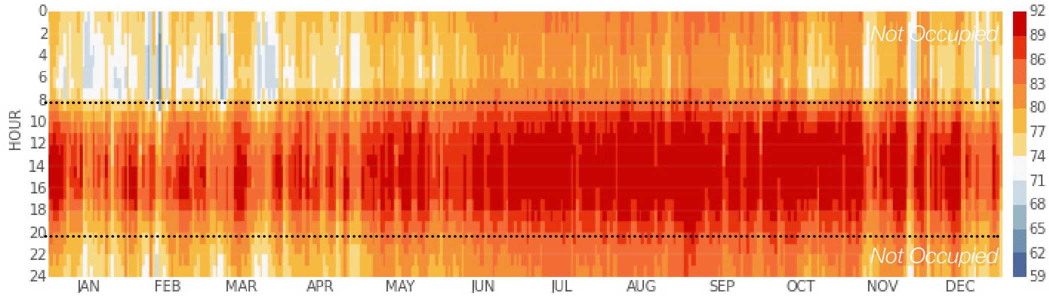
Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

C.5.a.1.TYPICAL WINDOW IMPROVEMENTS

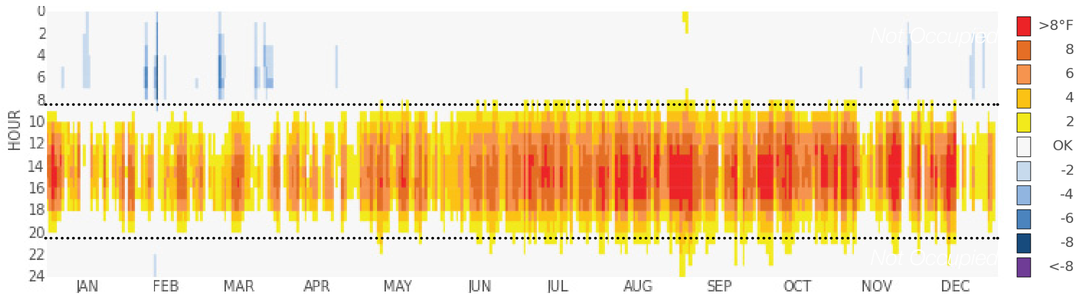
Equal to TYPICAL + 1ACH + Shading + IECC 2015 Windows + Code Ventilation

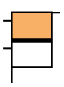


Operative temperature for bottom floor

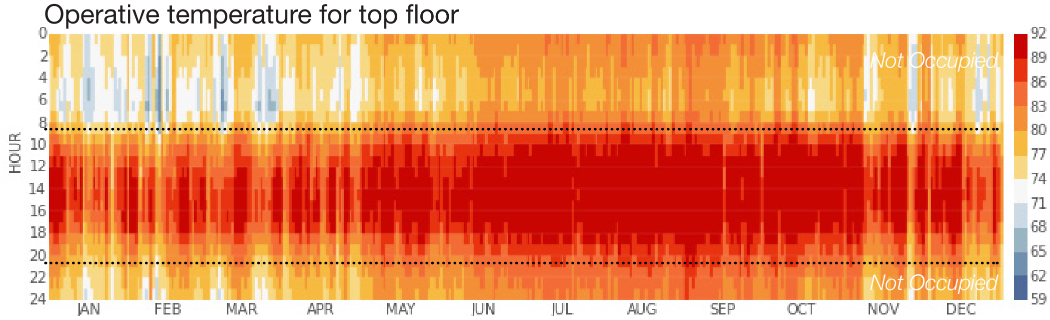


Degrees from comfort for bottom floor

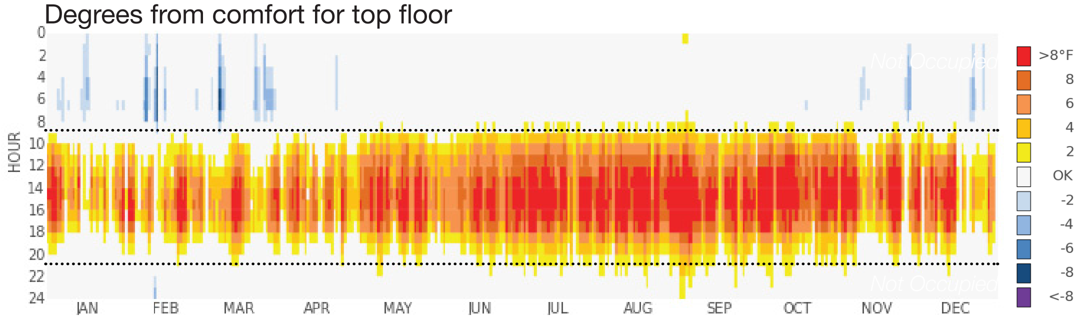




Operative temperature for top floor

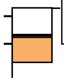


Degrees from comfort for top floor

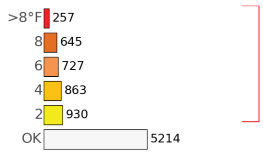


LOISOS + UBBELOHDE

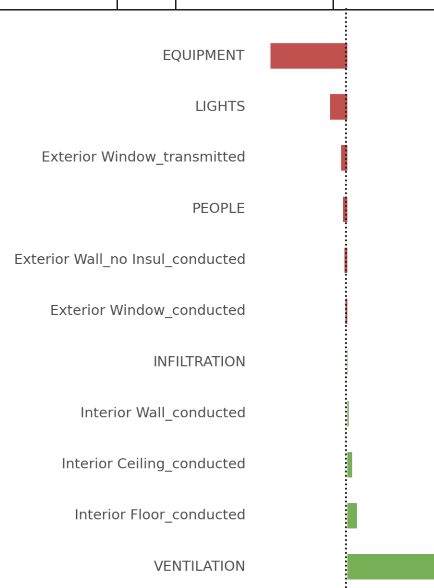
Add/C.5.a.1 Laboratory Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +CODE VENT + SHADING + IECC WINDOWS	too warm	3422	**39%**	**100%**

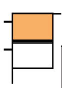


** Including all 8760 hrs of the year, not only occupied hours*

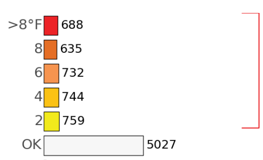


*** If considering only occupied hours*

(M-F 8am-8pm):: 100% too warm.



			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +CODE VENT + SHADING + IECC WINDOWS	too warm	3558	**41%**	**100%**



** Including all 8760 hrs of the year, not only occupied hours*

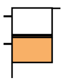
*** If considering only occupied hours*

(M-F 8am-8pm):: 100% too warm.

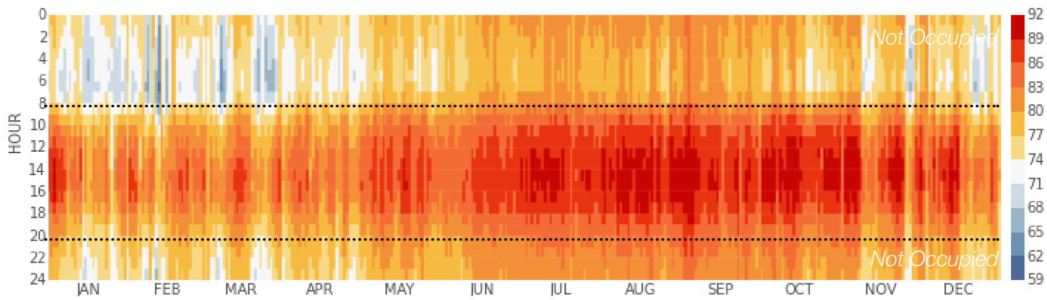
Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

C.5.a.2. MINIMUM SUITE

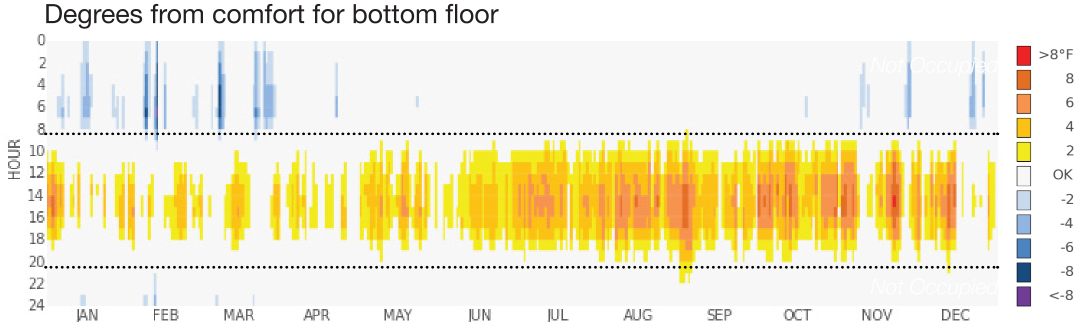
Equal to TYPICAL + IECC Windows + Shading +Optimized Lighting and Equipment

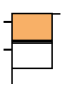


Operative temperature for bottom floor

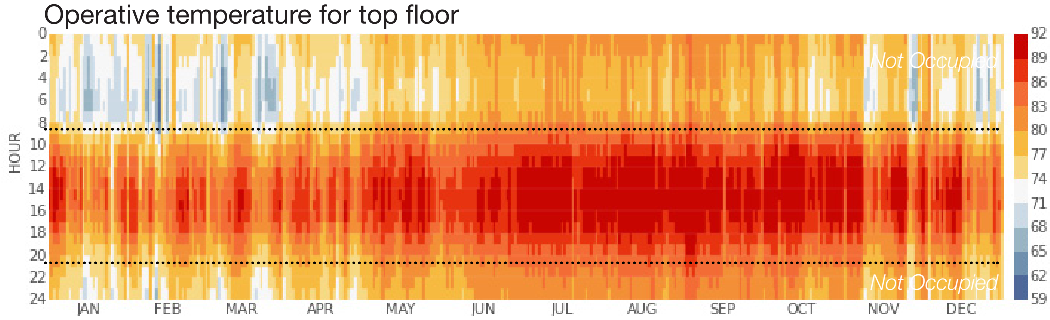


Degrees from comfort for bottom floor

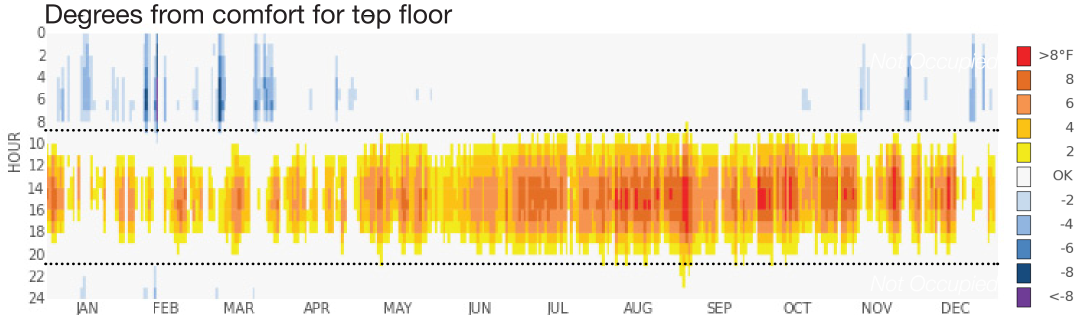




Operative temperature for top floor

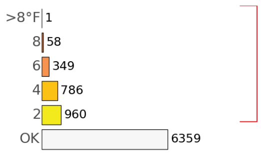


Degrees from comfort for top floor



Add/C.5.a.2 Laboratory Analysis:: South Facing (Continued)

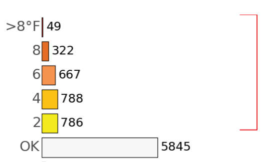
			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	2154	**25%**	**80%**



** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 80% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	2612	**30%**	**97%**



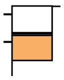
** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 97% too warm.*

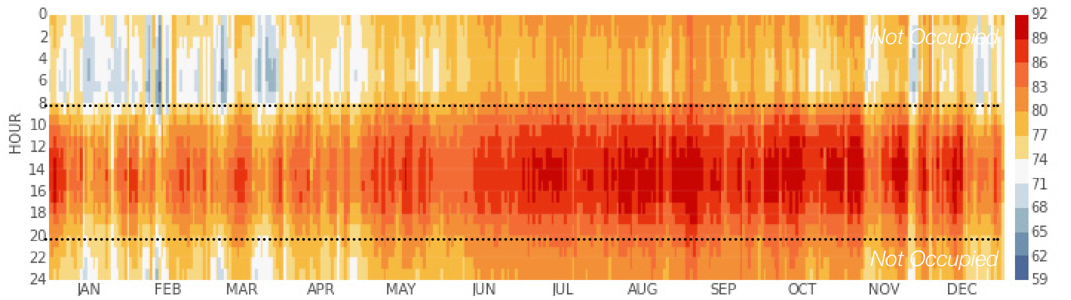
Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

C.5.a.3. IMPROVED SUITE

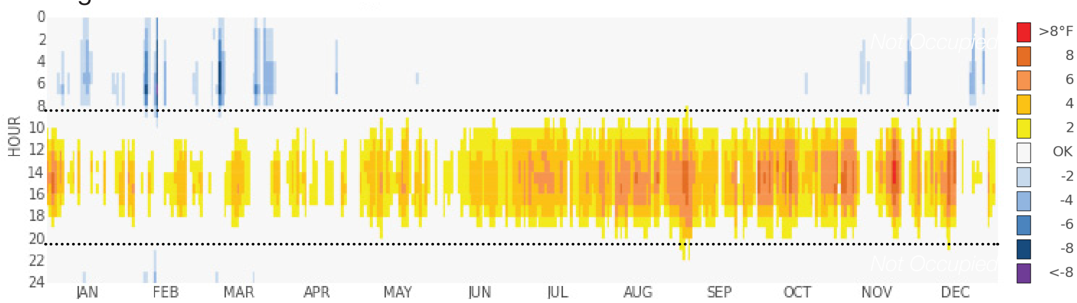
Equal to MINIMUM SUITE + IECC Roof

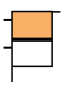


Operative temperature for bottom floor

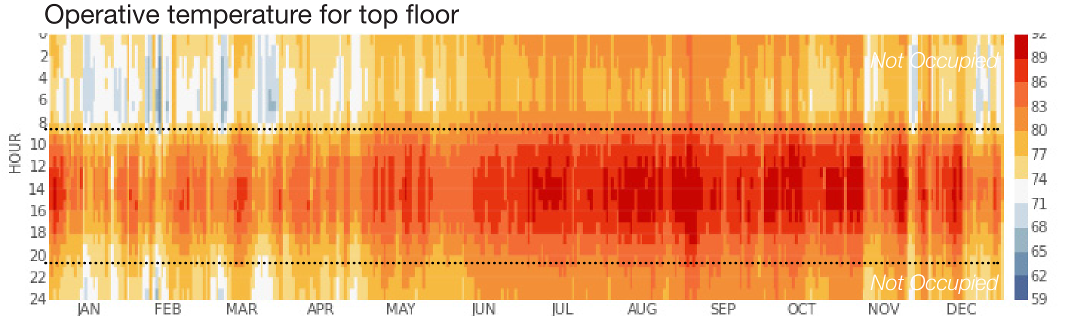


Degrees from comfort for bottom floor

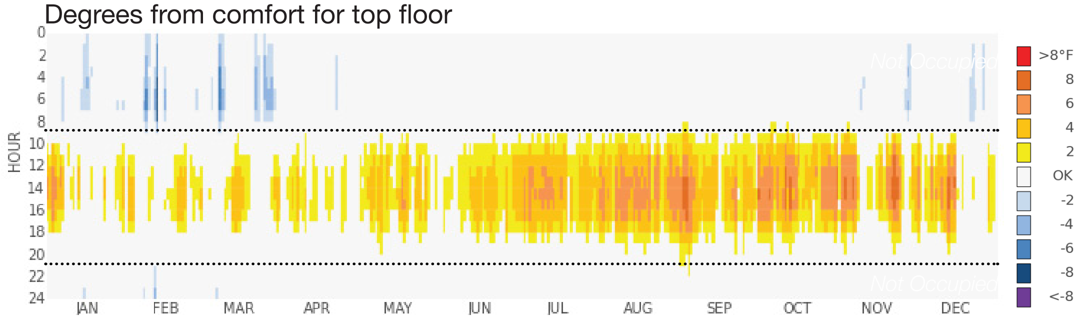




Operative temperature for top floor

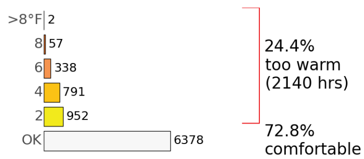


Degrees from comfort for top floor

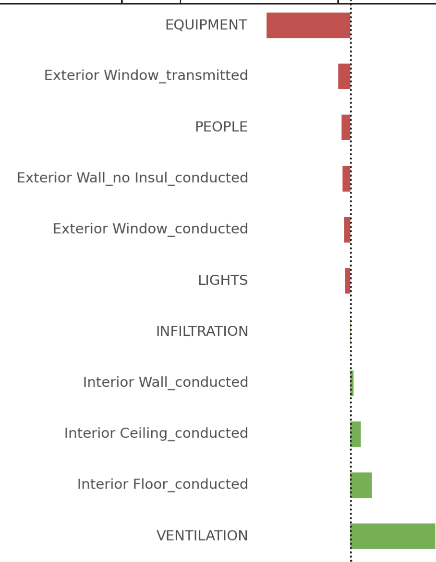


Add/C.5.a.3 Laboratory Analysis:: South Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2140	**24%**	**79%**



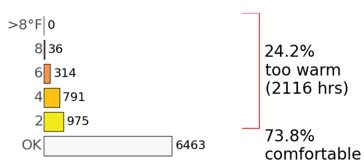
** Including all 8760 hrs of the year, not only occupied hours*



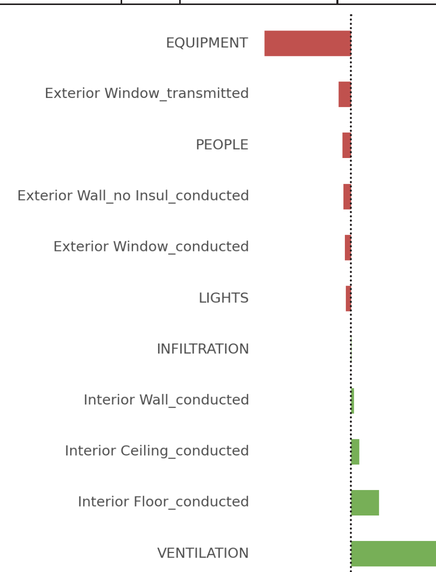
*** If considering only occupied hours*

(M-F 8am-8pm):: 79% too warm.

			Top Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	2116	**24%**	**78%**



** Including all 8760 hrs of the year, not only occupied hours*



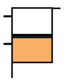
*** If considering only occupied hours*

(M-F 8am-8pm):: 78% too warm.

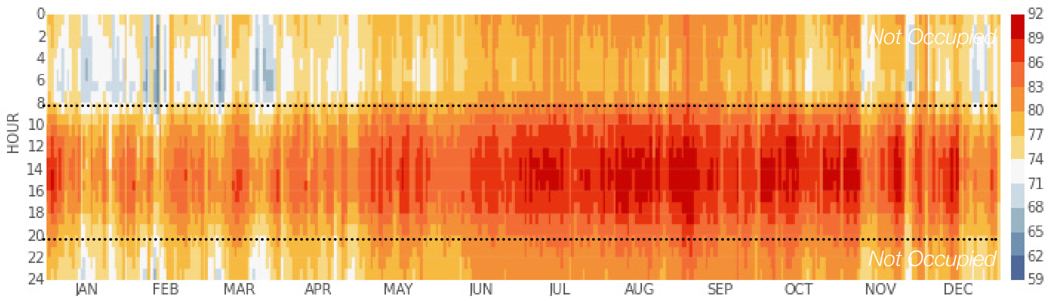
Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

C.5.a.4. CODE SUITE

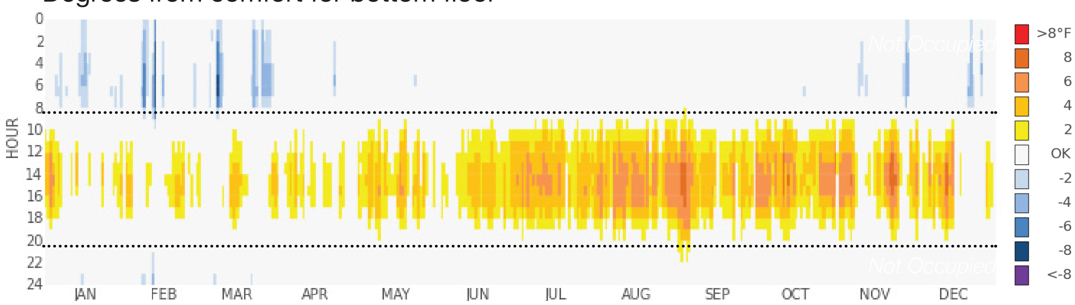
Equal to IMPROVED SUITE + IECC Walls

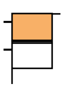


Operative temperature for bottom floor

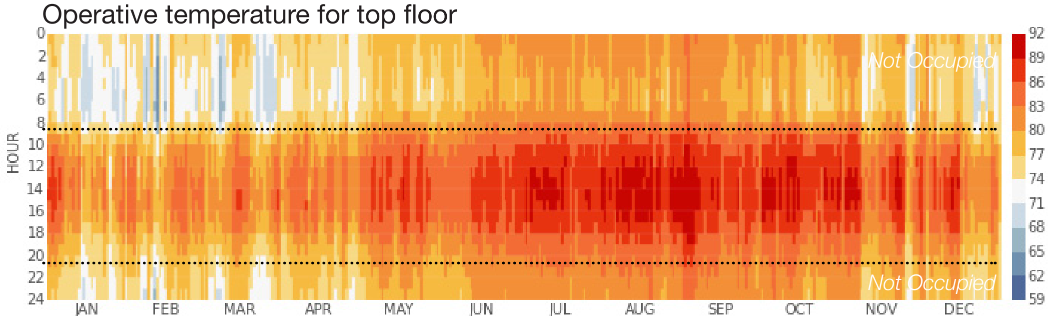


Degrees from comfort for bottom floor

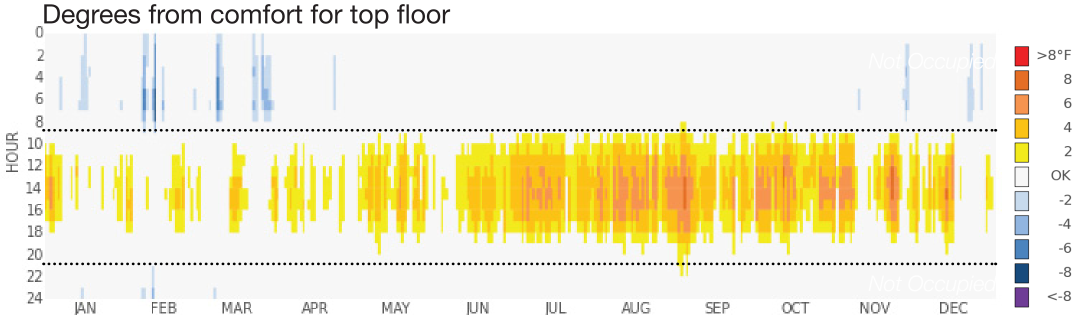




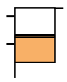
Operative temperature for top floor



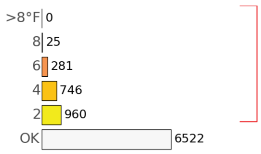
Degrees from comfort for top floor



Add/C.5.a.4 Laboratory Analysis:: South Facing (Continued)

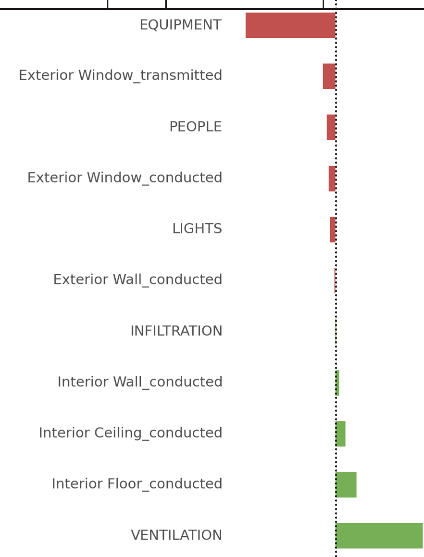


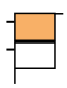
			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	2012	**23%**	**75%**



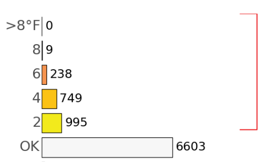
** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 75% too warm.*



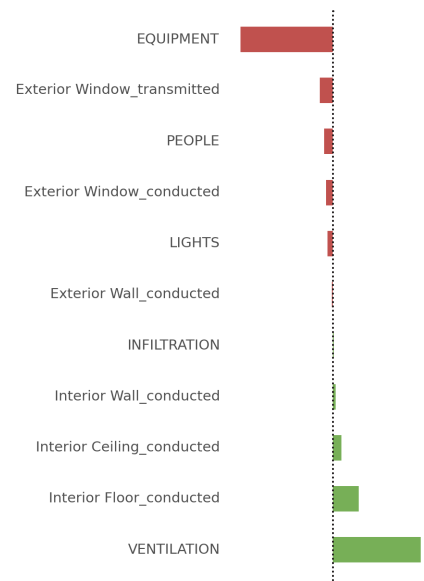


			Top Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	1991	**23%**	**74%**



** Including all 8760 hrs of the year, not only occupied hours*

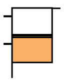
*** If considering only occupied hours (M-F 8am-8pm):: 74% too warm.*



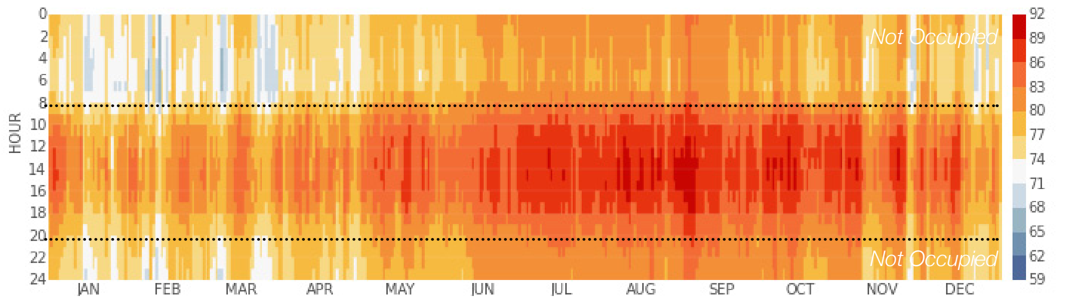
Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

C.5.a.5. IDEAL SUITE

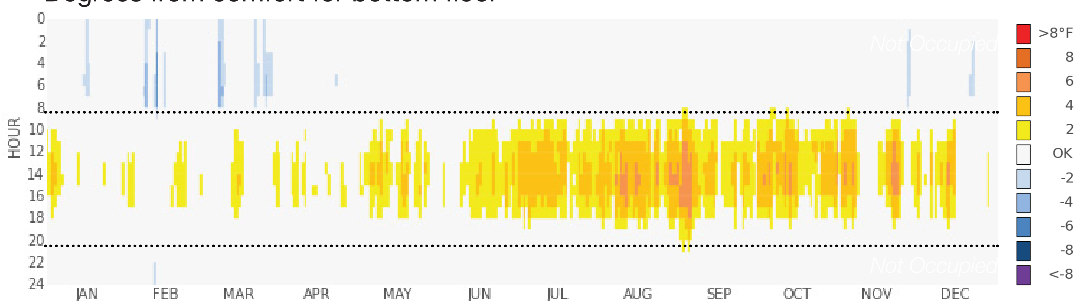
Equal to CODE SUITE + Thermal Mass

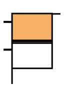


Operative temperature for bottom floor

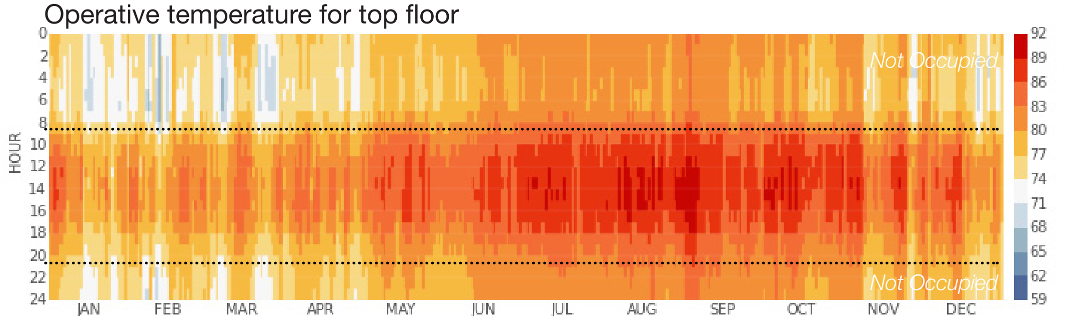


Degrees from comfort for bottom floor

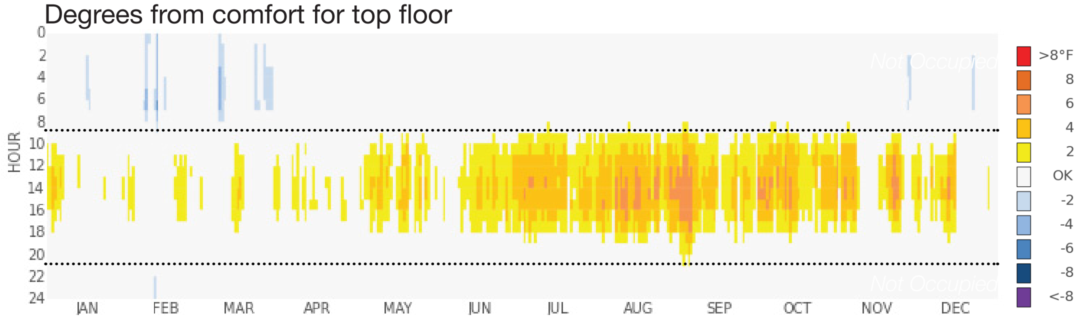




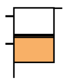
Operative temperature for top floor



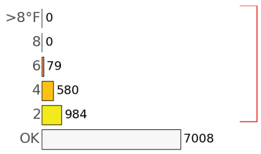
Degrees from comfort for top floor



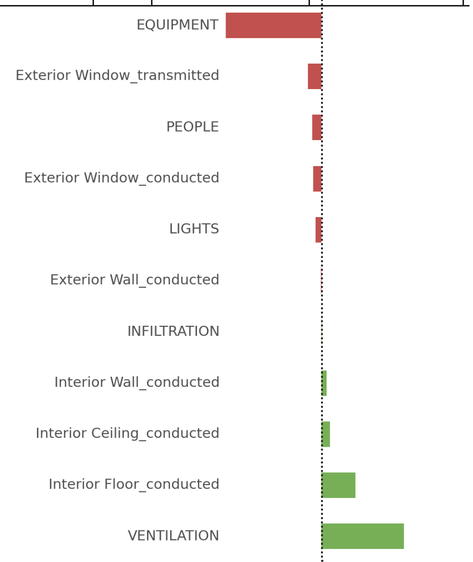
Add/C.5.a.5 Laboratory Analysis:: South Facing (Continued)



			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1653	**19%**	**61%**

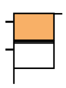


** Including all 8760 hrs of the year, not only occupied hours*

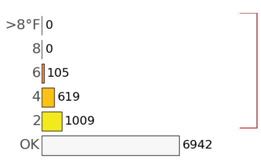


*** If considering only occupied hours*

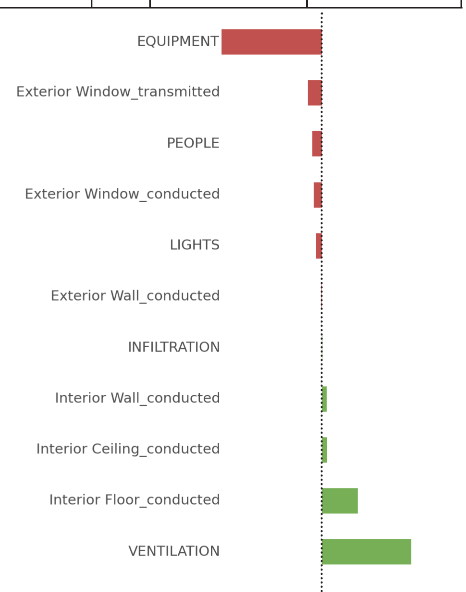
(M-F 8am-8pm):: 61% too warm.



			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1733	**20%**	**64%**



** Including all 8760 hrs of the year, not only occupied hours*



*** If considering only occupied hours*

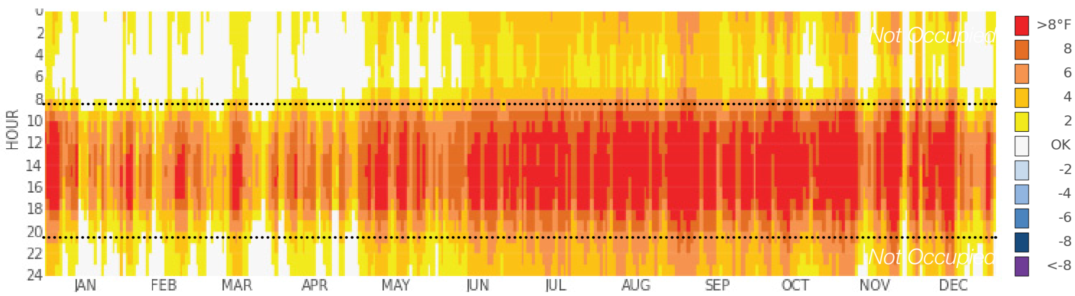
(M-F 8am-8pm):: 64% too warm.

Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

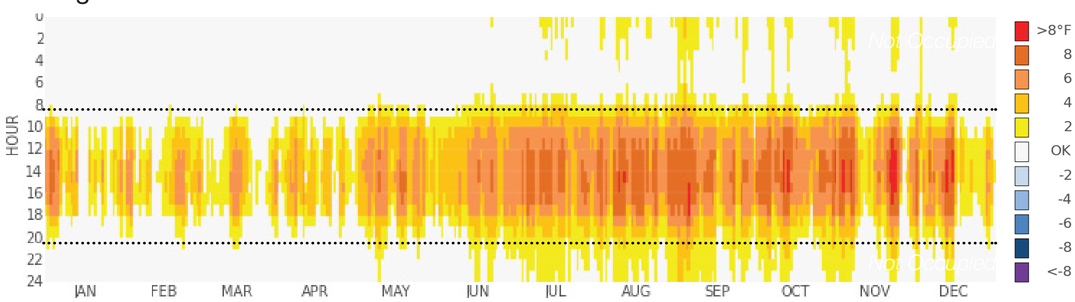
C.5.a.6. IDEAL SUITE WITH VENTILATION PARAMETRICS

IDEAL SUITE + 3ACH, 5ACH, 7ACH, 9ACH, 11ACH, 13ACH

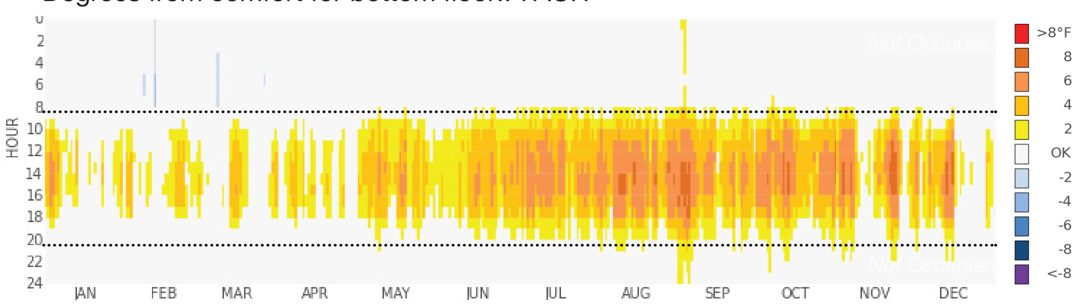
Degrees from comfort for bottom floor:: 3ACH



Degrees from comfort for bottom floor:: 5ACH

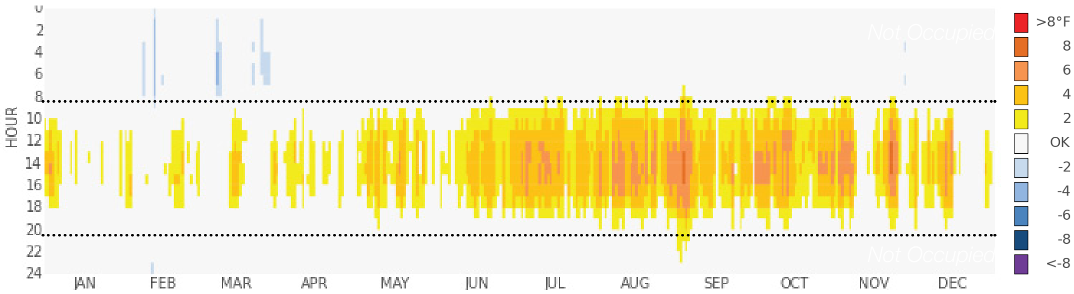


Degrees from comfort for bottom floor:: 7ACH

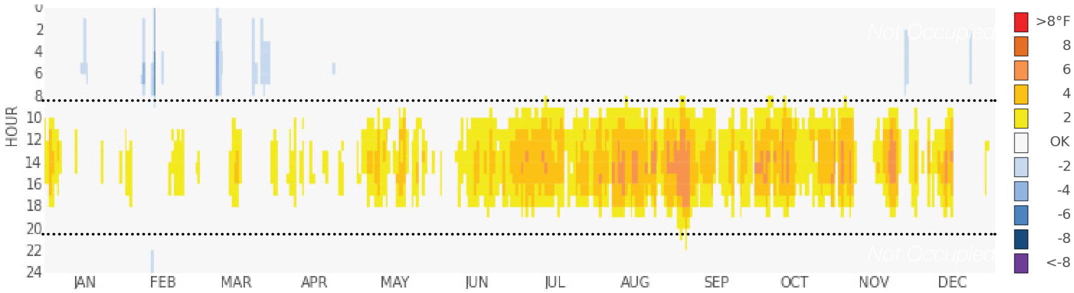


Add/C.5.a.6 Laboratory Analysis:: South Facing (Continued)

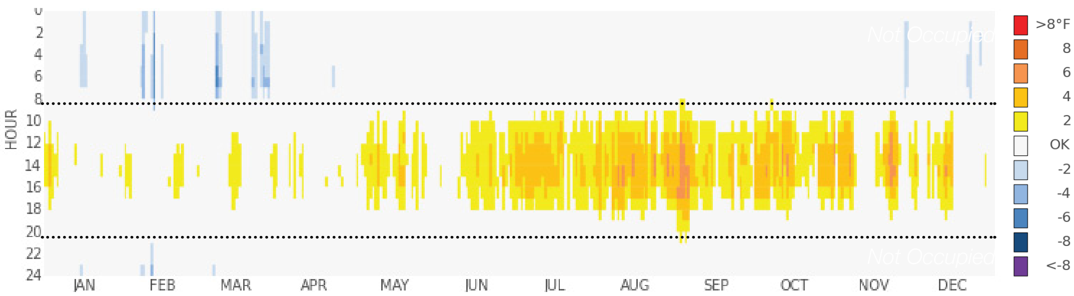
Degrees from comfort for bottom floor:: 9ACH



Degrees from comfort for bottom floor:: 11ACH



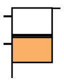
Degrees from comfort for bottom floor:: 13ACH



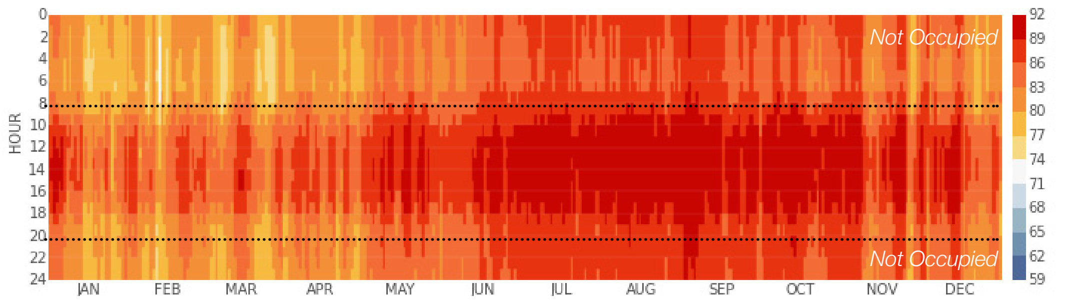
Add/C.5.a. LABORATORY ANALYSIS:: SOUTH FACING

C.5.a.7. IDEAL SUITE WITH SMART VENTILATION

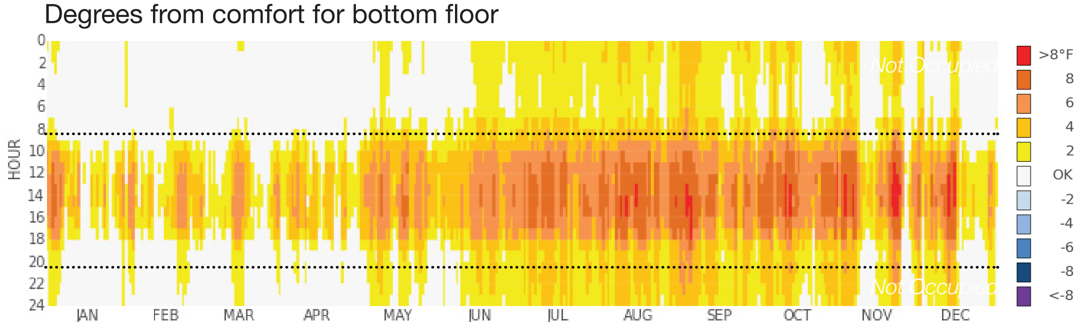
IDEAL SUITE + VARIABLE ACH (6ACH occupied, 3ACH unoccupied)

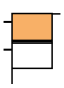


Operative temperature for bottom floor

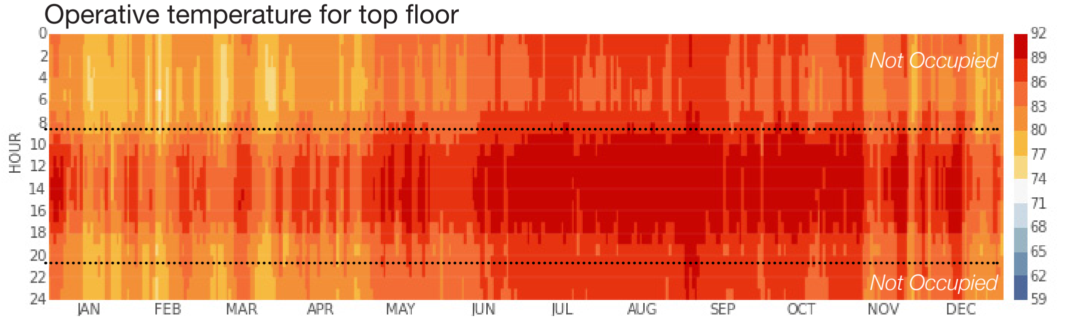


Degrees from comfort for bottom floor

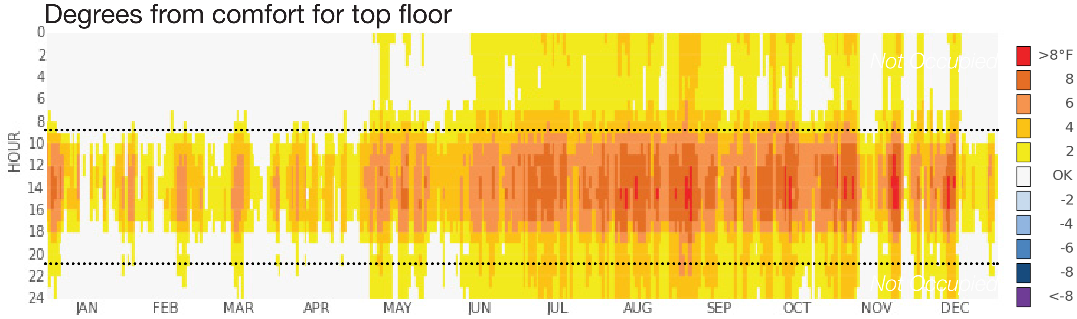




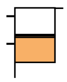
Operative temperature for top floor



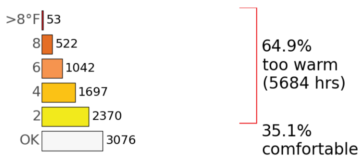
Degrees from comfort for top floor



Add/C.5.a.7 Laboratory Analysis:: South Facing (Continued)

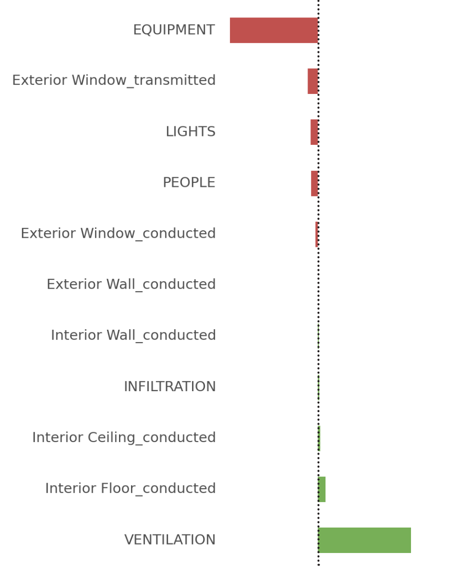


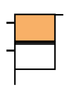
			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + SMART VENTILATION	too warm	5684	**65%**	**100%**



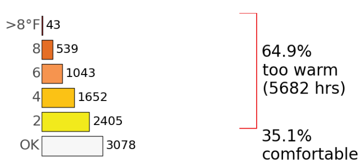
** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*



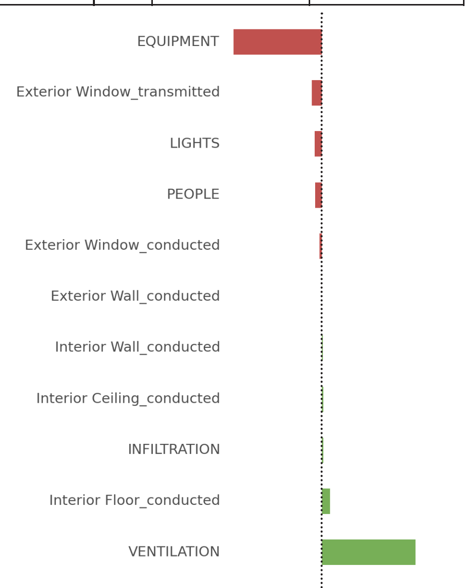


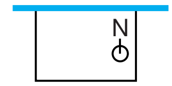
			Top Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + SMART VENTILATION	too warm	5682	**65%**	**100%**



** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

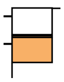




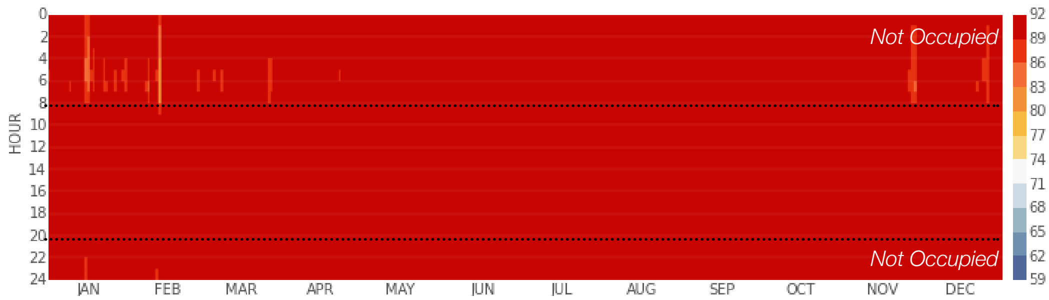
Add/C.5.b. LABORATORY ANALYSIS:: NORTH FACING

C.5.b.0. TYPICAL EXISTING

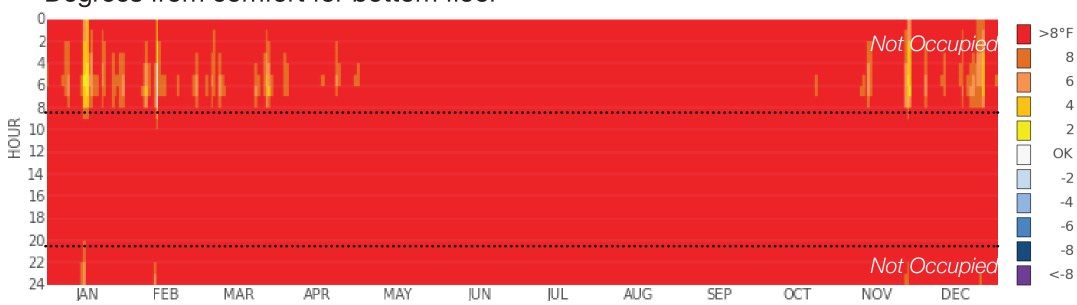
No Insulation in Opaque Surfaces and Single Pane Glass

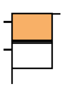


Operative temperature for bottom floor

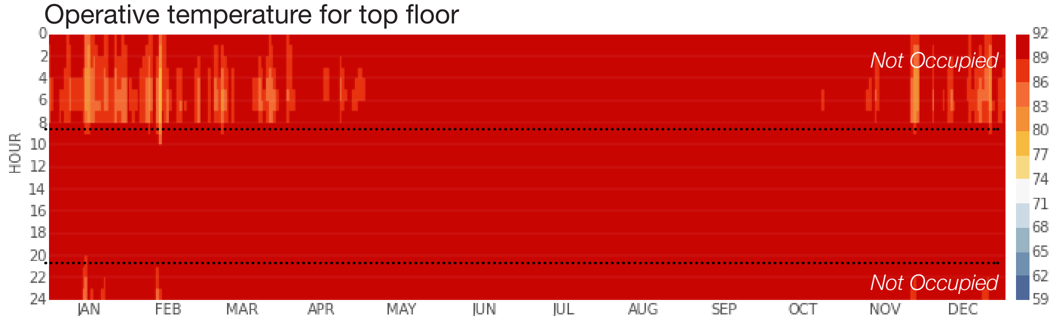


Degrees from comfort for bottom floor

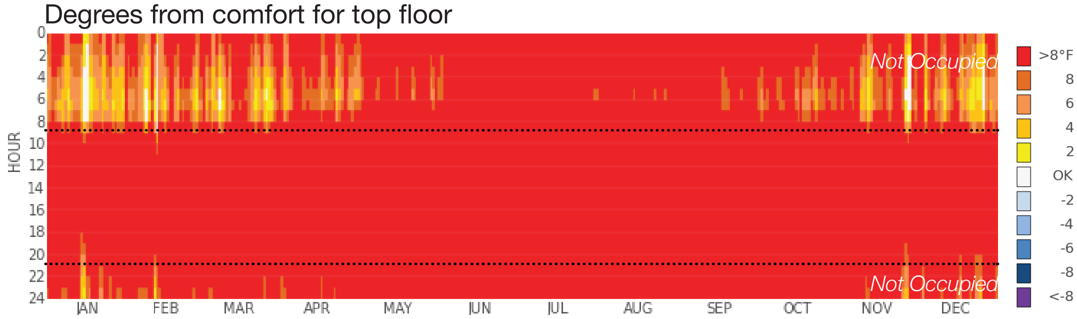




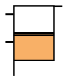
Operative temperature for top floor



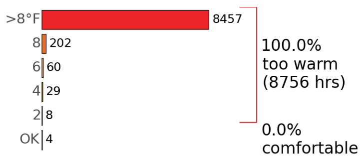
Degrees from comfort for top floor



Add/C.5.b.0 Laboratory Analysis:: North Facing (Continued)

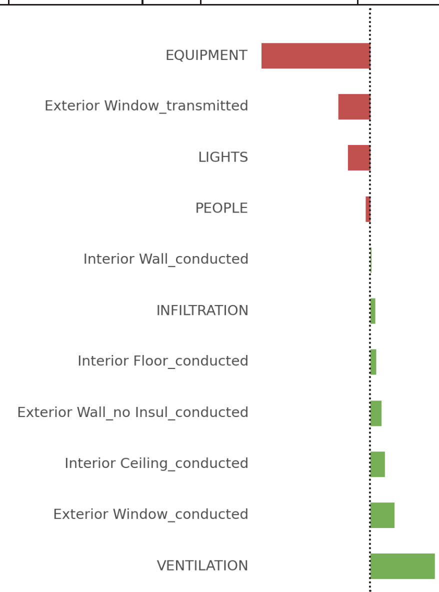


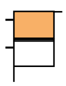
			Bottom Floor		
			hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	8756	**100%**	**100%**



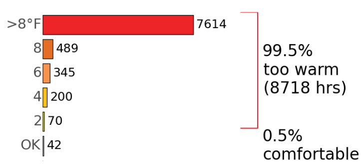
** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*



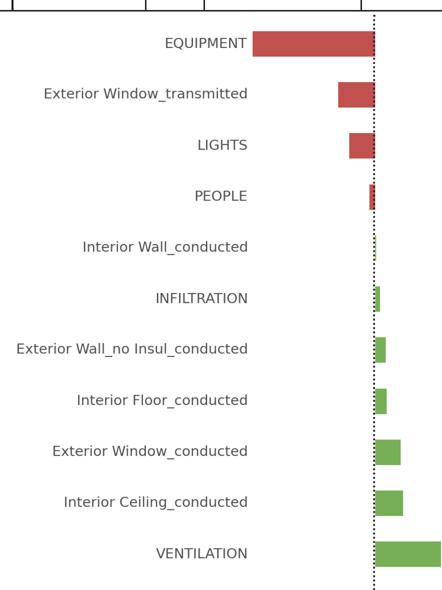


			Top Floor		
			hours	% of the whole year	% of occupied time
	TYPICAL EXISTING	too warm	8718	**100%**	**100%**

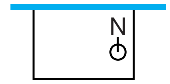


** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

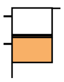


Add/C.5.b. LABORATORY ANALYSIS:: NORTH FACING

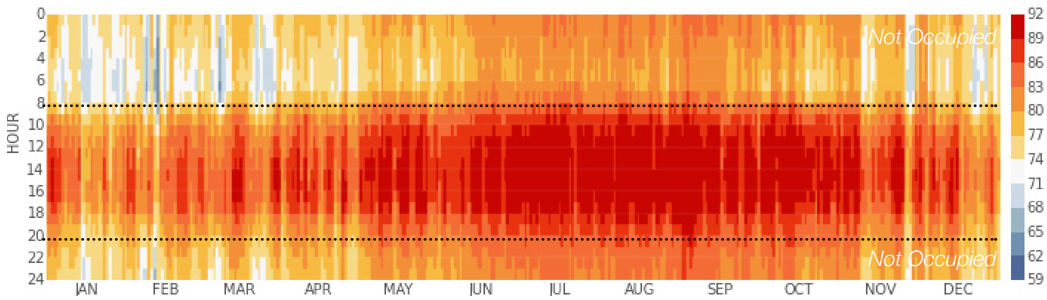


C.5.b.1. TYPICAL WITH WINDOW IMPROVEMENTS

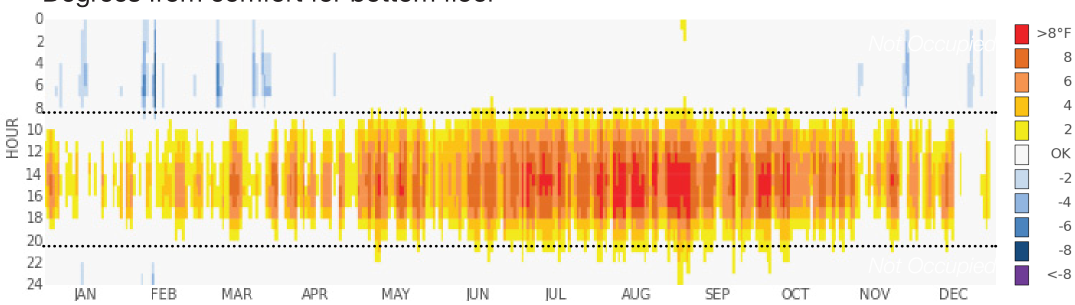
Equal to TYPICAL + Code Ventilation + Shading + IECC 2015 Windows

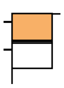


Operative temperature for bottom floor

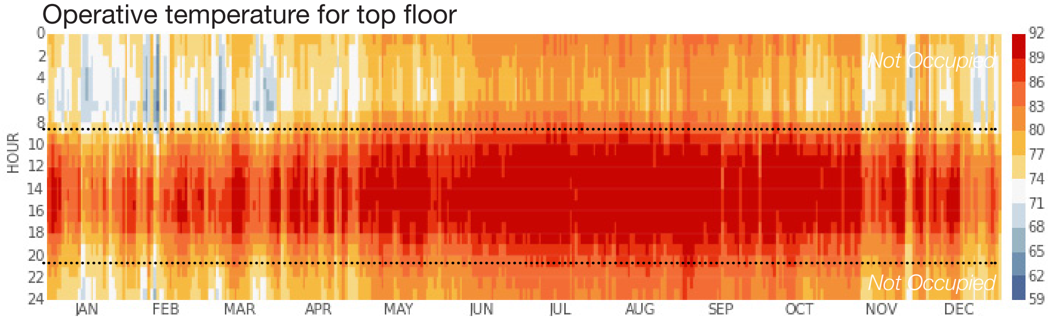


Degrees from comfort for bottom floor

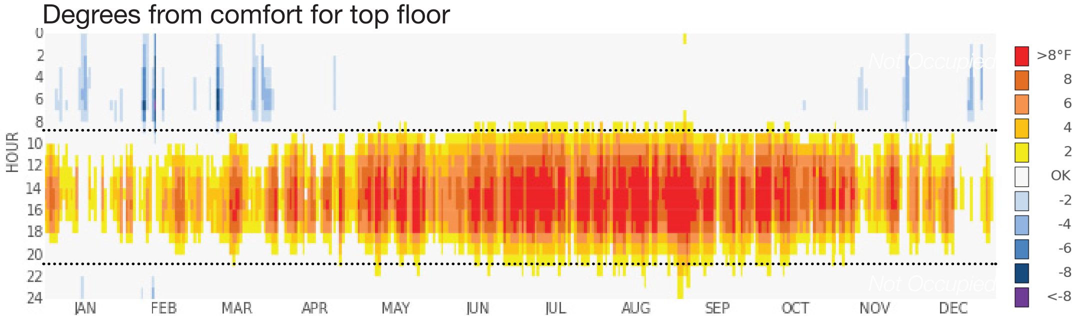




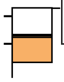
Operative temperature for top floor



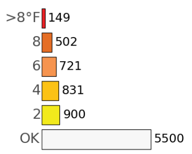
Degrees from comfort for top floor



Add/C.5.b.1 Laboratory Analysis:: North Facing (Continued)

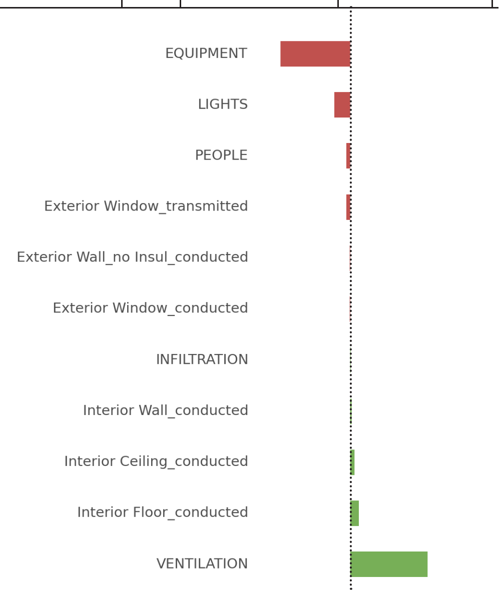


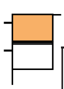
			Bottom Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3103	**35%**	**100%**



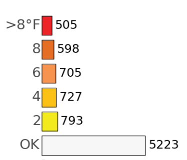
** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*





			Top Floor		
			hours	% of the whole year	% of occupied time
A-3	TYPICAL +1ACH + SHADING + IECC WINDOWS	too warm	3328	**38%**	**100%**



** Including all 8760 hrs of the year, not only occupied hours*

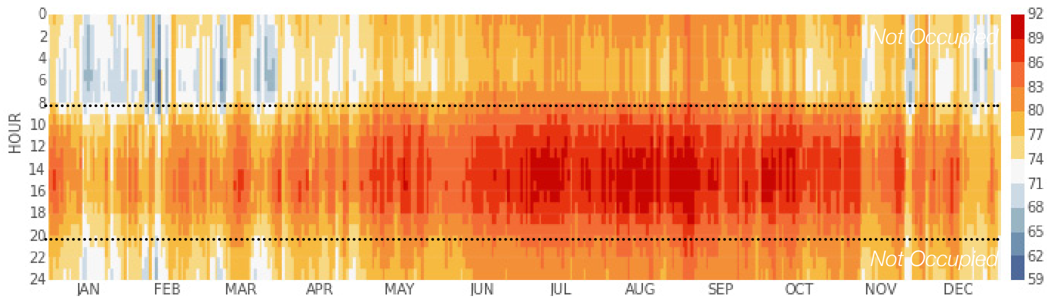
*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*

Add/C.5.b. LABORATORY ANALYSIS:: NORTH FACING

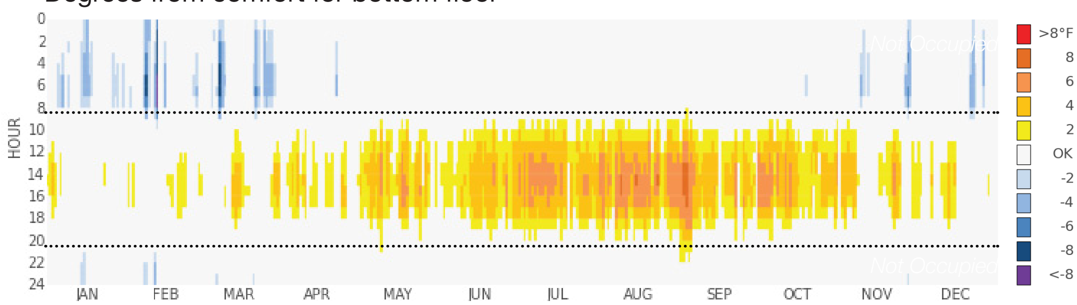
C.5.b.2. MINIMUM SUITE

TYPICAL + IECC Windows + Shading +lower LPD + Daylight Controls +1ACH

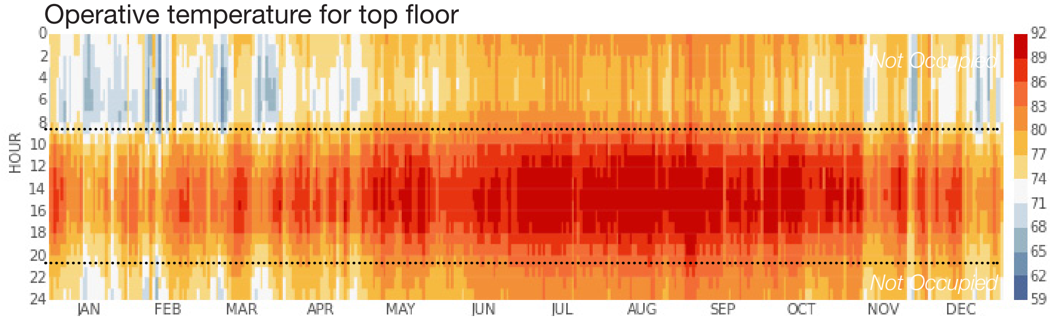
Operative temperature for bottom floor



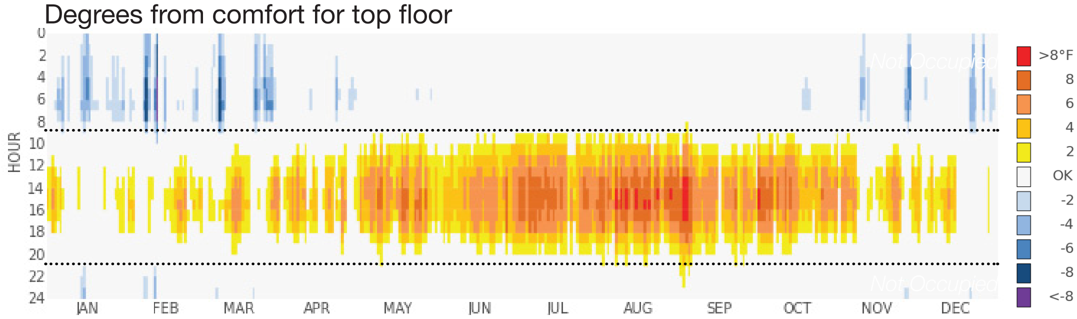
Degrees from comfort for bottom floor



Operative temperature for top floor



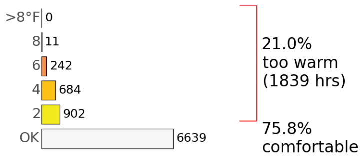
Degrees from comfort for top floor



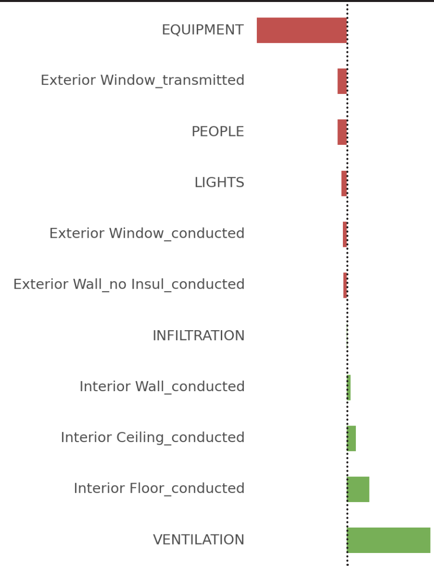
LOISOS + UBBELOHDE

Add/C.5.b.2 Laboratory Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	1839	**21%**	**68%**

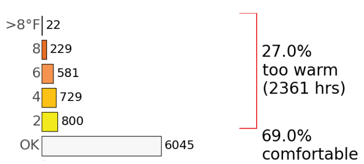


** Including all 8760 hrs of the year, not only occupied hours*

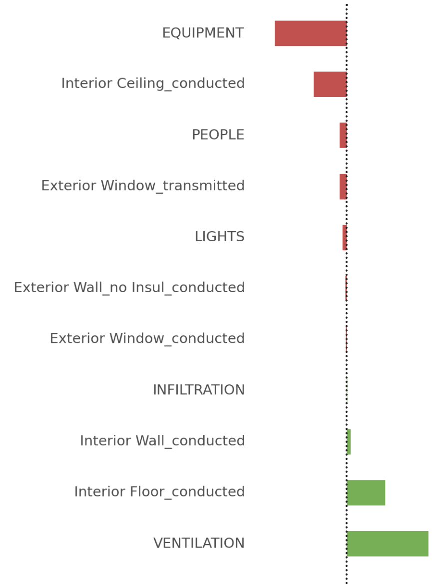


*** If considering only occupied hours (M-F 8am-8pm):: 68% too warm.*

			Top Floor		
			hours	% of the whole year	% of occupied time
B-3	MINIMUM SUITE	too warm	2361	**27%**	**87%**

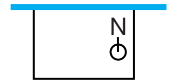


** Including all 8760 hrs of the year, not only occupied hours*



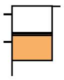
*** If considering only occupied hours (M-F 8am-8pm):: 87% too warm.*

Add/C.5.b. LABORATORY ANALYSIS:: NORTH FACING

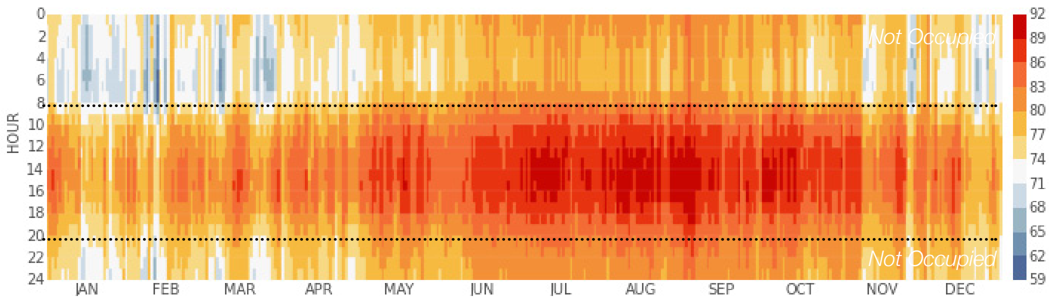


C.5.b.3. IMPROVED SUITE

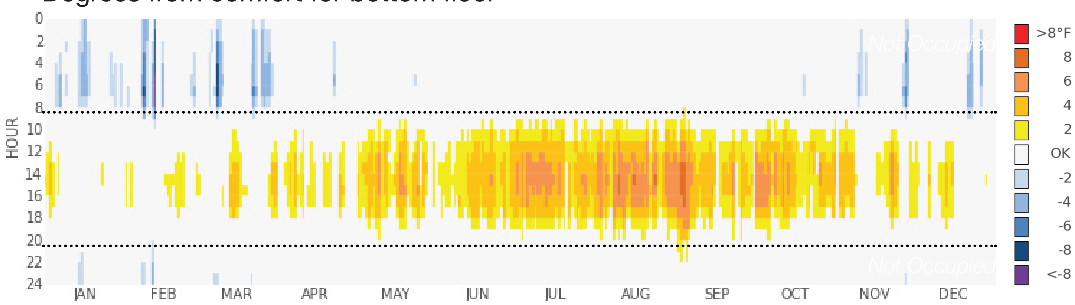
Equal to MINIMUM SUITE + IECC Roof

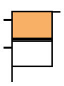


Operative temperature for bottom floor

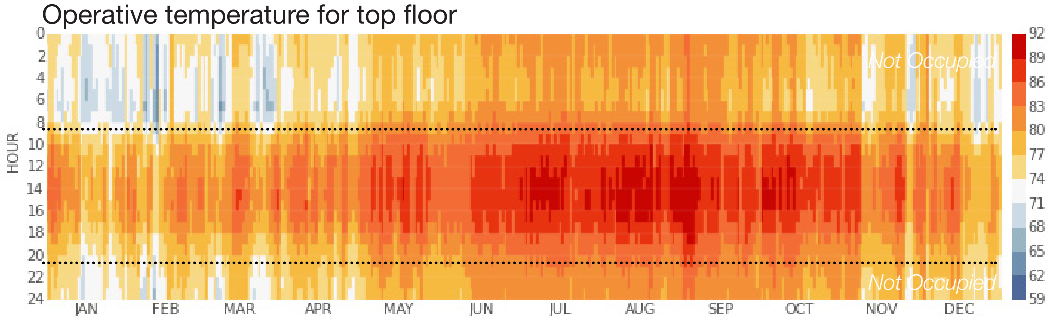


Degrees from comfort for bottom floor

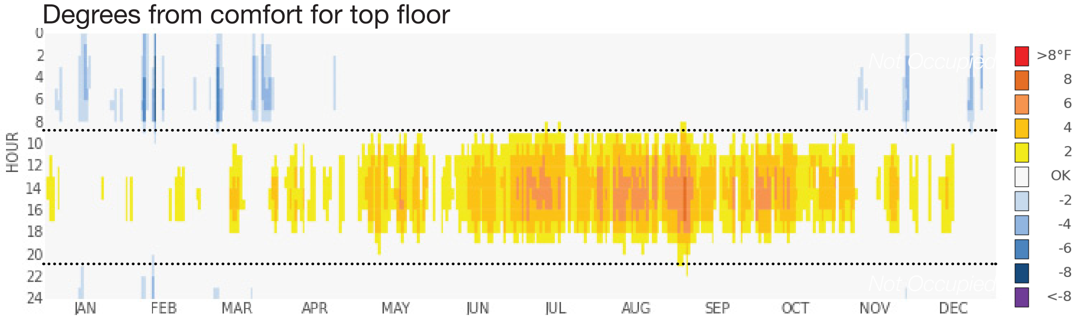




Operative temperature for top floor

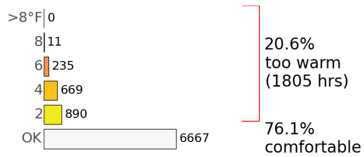


Degrees from comfort for top floor



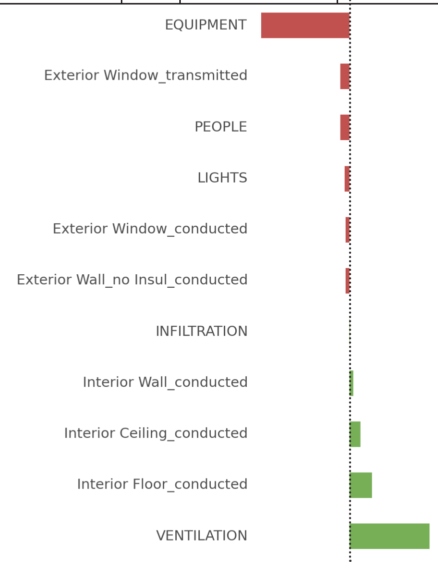
Add/C.5.b.3 Laboratory Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	1805	**21%**	**67%**

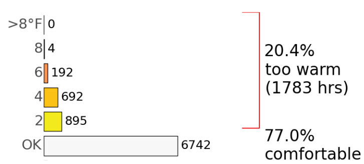


** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 67% too warm.*



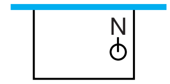
			Top Floor		
			hours	% of the whole year	% of occupied time
C-1	IMPROVED SUITE (B-3+ IECC Roof)	too warm	1783	**20%**	**66%**



** Including all 8760 hrs of the year, not only occupied hours*

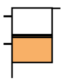
*** If considering only occupied hours (M-F 8am-8pm):: 66% too warm.*

Add/C.5.b. LABORATORY ANALYSIS:: NORTH FACING

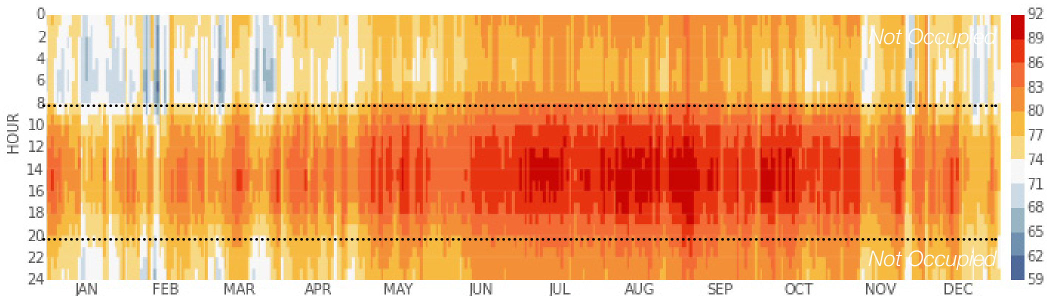


C.5.b.4. CODE SUITE

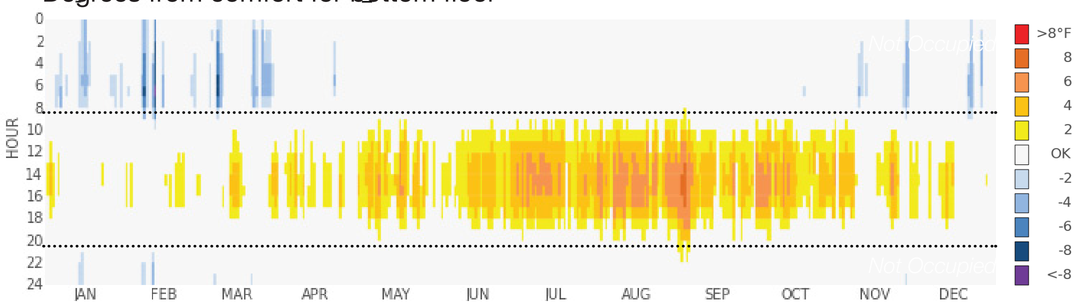
Equal to IMPROVED SUITE + IECC Walls

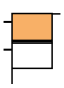


Operative temperature for bottom floor

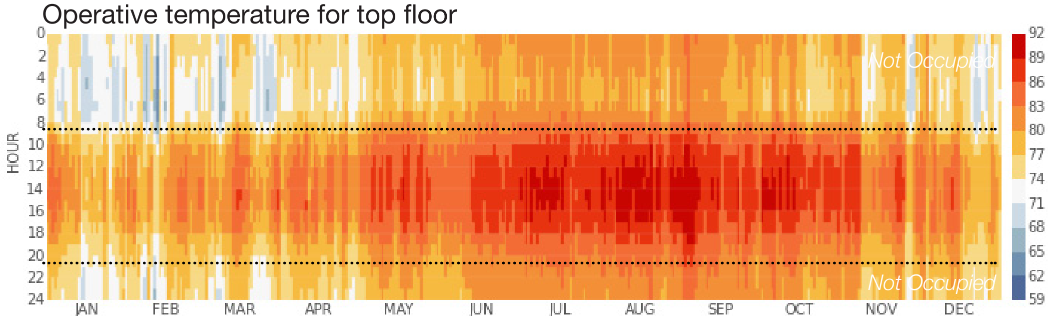


Degrees from comfort for bottom floor

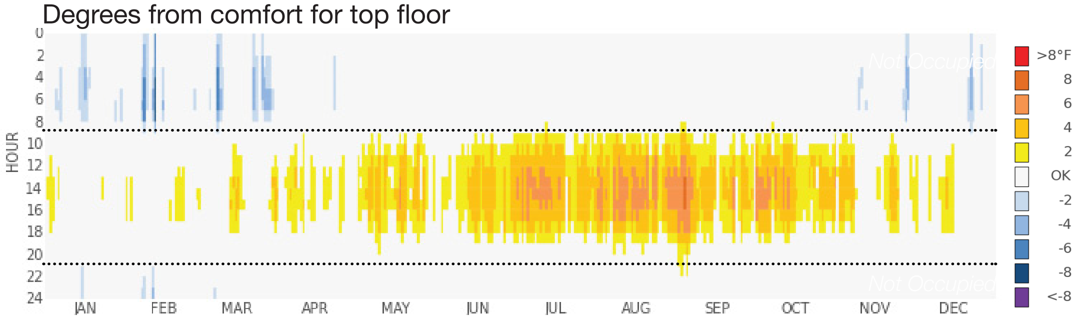




Operative temperature for top floor

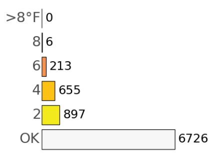


Degrees from comfort for top floor



Add/C.5.b.4 Laboratory Analysis:: North Facing (Continued)

			Bottom Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	1771	**20%**	**66%**



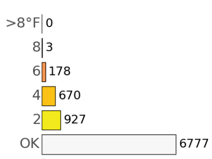
20.2% too warm (1771 hrs)

76.8% comfortable

** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 66% too warm.*

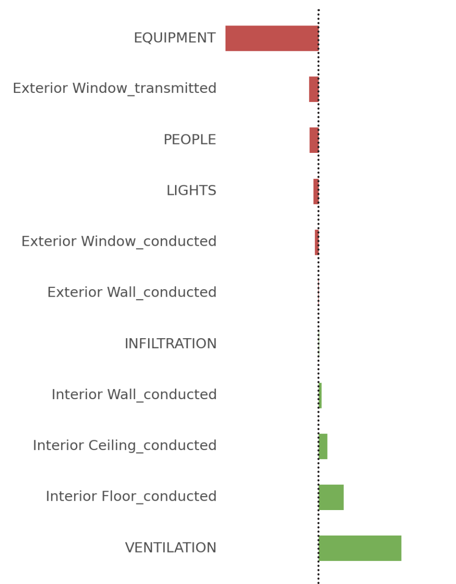
			Top Floor		
			hours	% of the whole year	% of occupied time
C-2	CODE SUITE (C-1+ IEACC walls)	too warm	1778	**20%**	**66%**



20.3% too warm (1778 hrs)

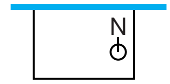
77.4% comfortable

** Including all 8760 hrs of the year, not only occupied hours*



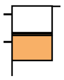
*** If considering only occupied hours (M-F 8am-8pm):: 66% too warm.*

Add/C.5.b. LABORATORY ANALYSIS:: NORTH FACING

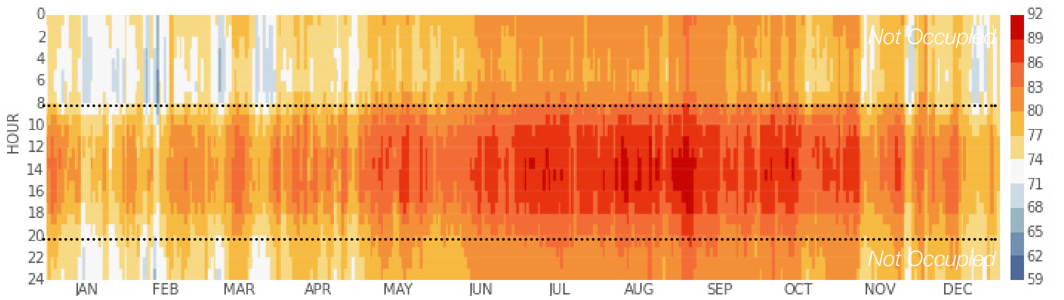


C.5.b.5. IDEAL SUITE

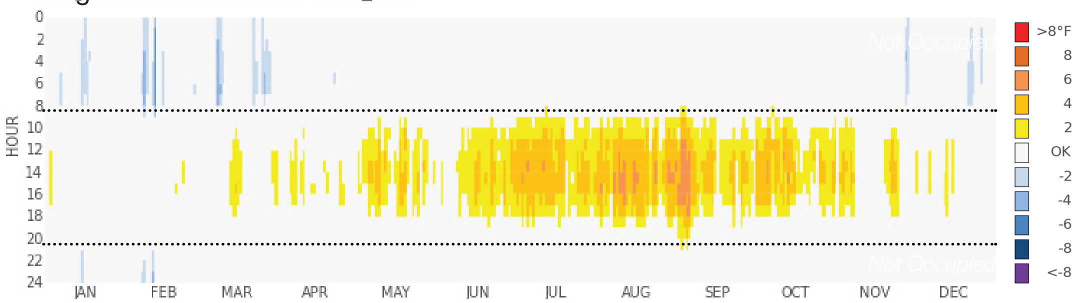
Equal to CODE SUITE + Thermal Mass

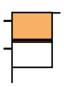


Operative temperature for bottom floor

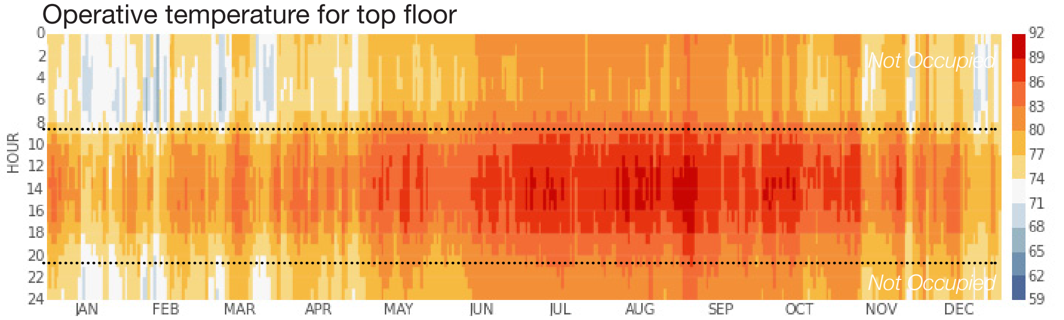


Degrees from comfort for bottom floor

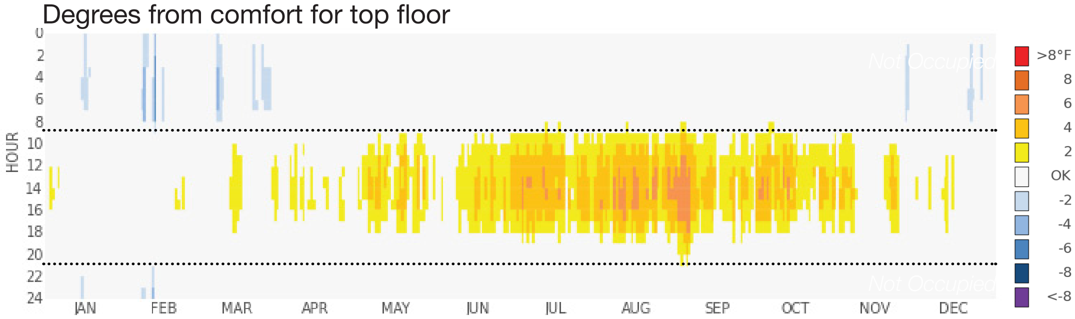




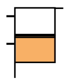
Operative temperature for top floor



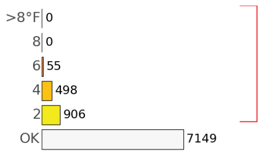
Degrees from comfort for top floor



Add/C.5.b.5 Laboratory Analysis:: North Facing (Continued)

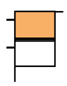


			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1459	**17%**	**54%**

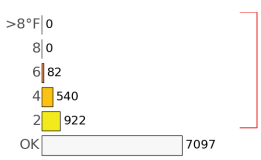


** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 54% too warm.*



			Top Floor		
			hours	% of the whole year	% of occupied time
E-1	IDEAL (C-2+ Thermal Mass)	too warm	1544	**18%**	**57%**



** Including all 8760 hrs of the year, not only occupied hours*

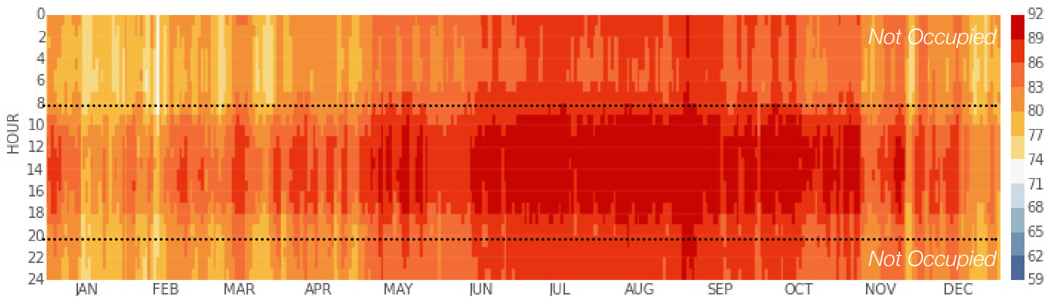
*** If considering only occupied hours (M-F 8am-8pm):: 57% too warm.*

Add/C.5.b. LABORATORY ANALYSIS:: NORTH FACING

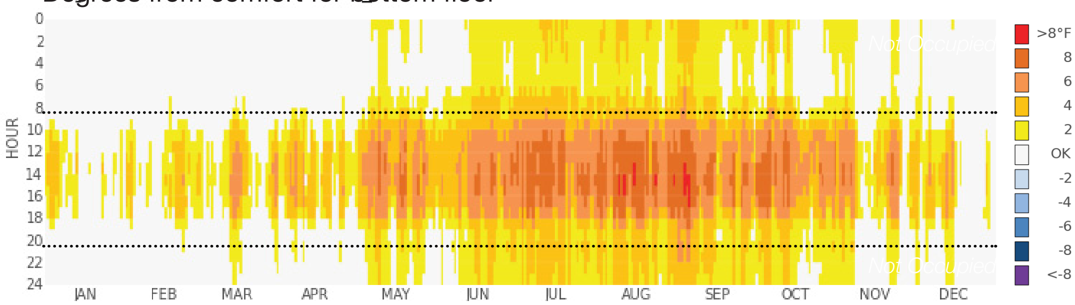
6. IDEAL SUITE WITH SMART VENTILATION

Equal to CODE SUITE + Variable ACH

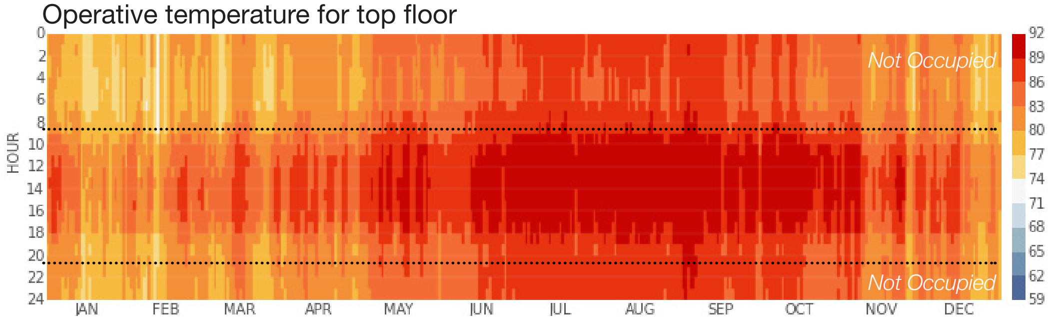
Operative temperature for bottom floor



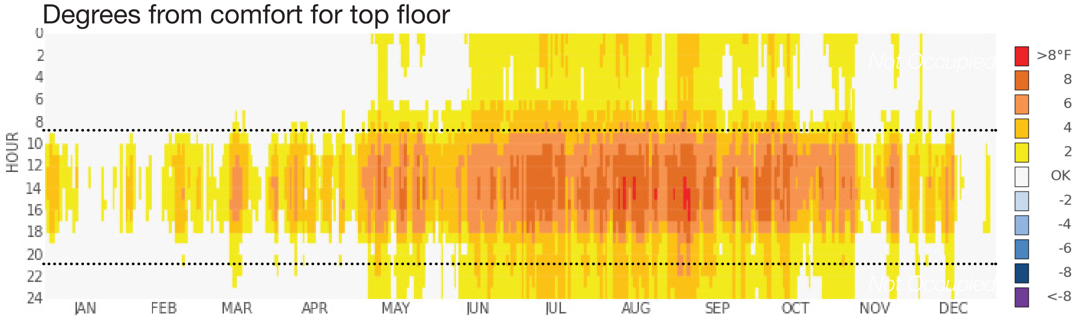
Degrees from comfort for bottom floor



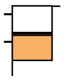
Operative temperature for top floor



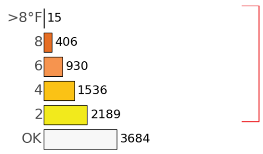
Degrees from comfort for top floor



Add/C.5.b.6 Laboratory Analysis:: North Facing (Continued)

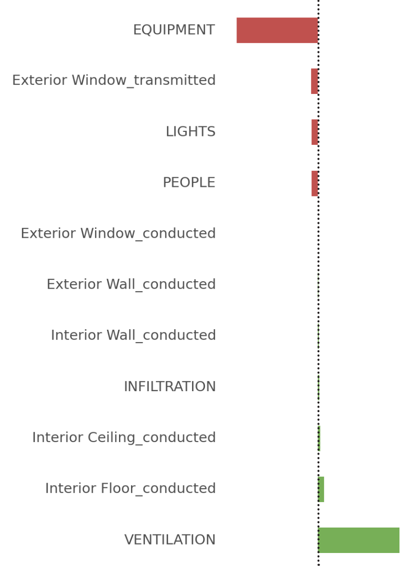


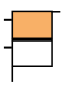
			Bottom Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + SMART VENTILATION	too warm	5076	**58%**	**100%**



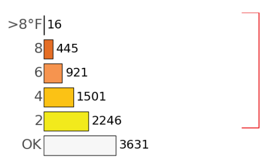
** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*



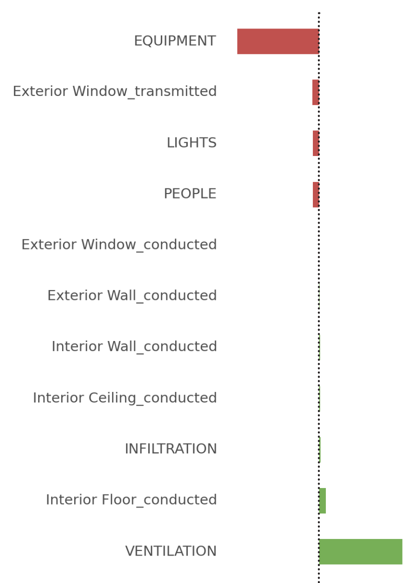


			Top Floor		
			hours	% of the whole year	% of occupied time
E-2	IDEAL + SMART VENTILATION	too warm	5129	**59%**	**100%**



** Including all 8760 hrs of the year, not only occupied hours*

*** If considering only occupied hours (M-F 8am-8pm):: 100% too warm.*



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D. ENERGY STUDIES

1. EXECUTIVE SUMMARY

Based on the models used for the HVAC autonomy/ Thermal Comfort simulations, we developed a series of scenarios that included mechanical conditioning. For each building type, we ran Typical, Minimum Improved, Code and Ideal suites and compared the estimates of the total electricity use per building type area. (Please refer to the Executive Summary in Add.3/ HVAC Autonomy- Thermal Comfort Studies for a description of each suite).

The improved, code and ideal suites assume ceiling fans and thus, the possibility of setting a higher thermostat setpoint to activate the cooling systems. An increase in airspeed increases the acceptable operative temperature limits described in the proposed Addendum to ASHRAE Std 55 to take in to account impact of airspeed on comfort.

These results were then compared to data from the Commercial Buildings Energy Consumption Survey (CBECS) for similar buildings and UHM data from the UHM Benchmarking Study 2004 and the UHM Strategic Energy Plan 2011. Some of these comparisons are not as straight forward as expected, as they depend on the buildings included in or the definition of each "building type" category. For example, the CBECS data includes mostly K-12 schools under the "Education" category. Occupancy schedules and building form are likely very different from the assumptions included in our models. The UHM data from 2004 combines different occupancy types (Lab and classroom or Lab/ classroom/ office) and is not directly comparable with our modeling results either. However, all these data give a sense of the range of acceptable results.

Building Occupancy Type	Total Occupied Building Space (sq.ft.)	% Building Space (sq.ft.)	Total Building Electricity Use (kWh/year)	Building Electricity Use per square foot (kWh/sq.ft.-year)	% of Total Energy Use	Ratio of Energy Use to Area
LAB/CLASS	94,133	2	5,964,206	64.3	4.3	2.2
LAB/CLASS /OFFICE	855,234	14	38,263,645	44.7	27.4	2.0
OFFICE/LAB	476,381	8	16,487,311	34.7	11.6	1.5
OFFICE	426,497	7	10,111,205	23.7	7.2	1.0
CLASS/OFFICE	1,390,020	22	30,277,275	21.8	21.7	1.0

Fig 3.14. UHM Building Square Feet and Yearly Electricity Use*

** Source: UH Manoa Benchmarking Study 2004*

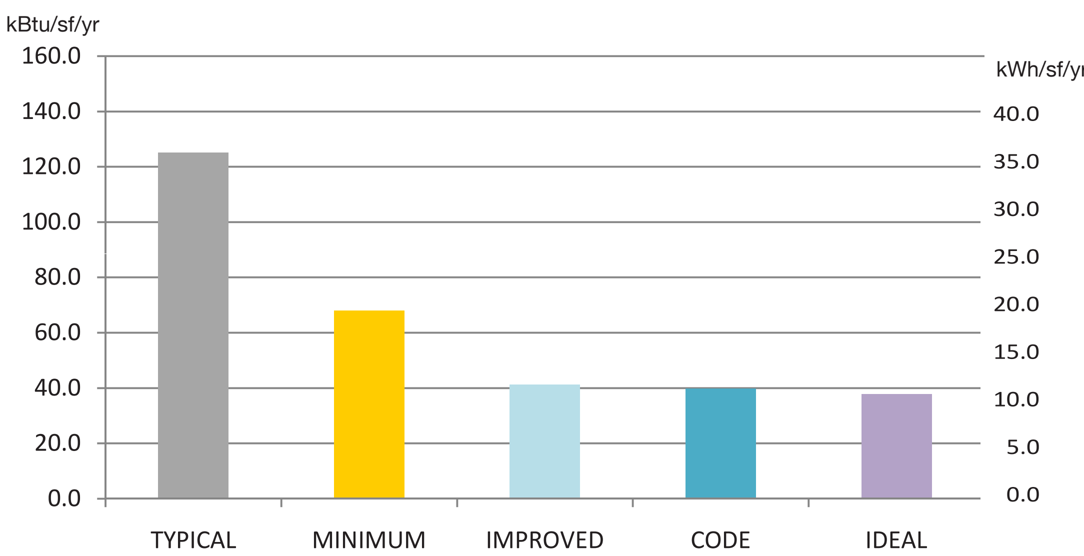
Add/D.1 Executive Summary (Continued)

a. Classroom Model Results

On average, for all orientations, classrooms in existing UHM buildings (Typical Existing) would use 122.1 kBtu/sqft/yr (35.8 kWh/sqft/yr). Examples and benchmarking data are on the next page.

By improving the windows (glazing specifications, installing shading devices and making those windows operable), in Addition to controlling the time the lights are on and effectively reducing the lighting loads during daytime hours (Minimum Suite), total energy use is reduced by 43%. This is due to both the reduction in lighting energy use (75%) but also the impact of turning off the lights on the interior temperature and consequently on the cooling energy needed for each classroom.

Adding IECC 2015 prescriptive requirements for the roof (Improved Suite), further reduces the energy use intensity to 65% less than typical existing conditions. Other improvements such as IECC 2015 prescriptive wall specifications (Code Suite) and exposed thermal mass (Ideal Suite) do not have such a significant impact on the total energy use (66% and 68% less than typical respectively),



	EUI (kBtu/sqft/yr)		Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	**122.1**		286952		255599		22177		8942	233
MINIMUM	**69.4**	43%	163204	43%	148524	42%	5525	75%	8942	212
IMPROVED	**42.5**	65%	99872	65%	82042	68%	5525	75%	11625	680
CODE	**41.3**	66%	97173	66%	79286	69%	5525	75%	11625	736
IDEAL	**39.4**	68%	92608	68%	74602	71%	5525	75%	11625	855

Add/D.1 Executive Summary (Continued)

	EUI (kWh/sqft/yr)
TYPICAL	35.8
MINIMUM	20.3
IMPROVED	12.5
CODE	12.1
IDEAL	11.5

	EUI (kWh/sqft/yr)		
	class/office		
UHM Benchmarking Study 2004	21.8		
CBECS	*by size*	*by age*	*by use*
2003	12.2	11.9	8.2
Strategic Energy Plan 2011 data	34.6		

1175 - MOORE HALL

1017 - SHIDLER

UHM CLASSROOM BUILDINGS

Avg Size: *46,000 sqft*

Avg. Age: *51 years, built 1964*

Avg. EUI: *34.6 kWh/sf**

Avg. EUI by end use:

- lighting *4.6 kWh/sf** *~13%*

1047 - SAKAMAKI HALL

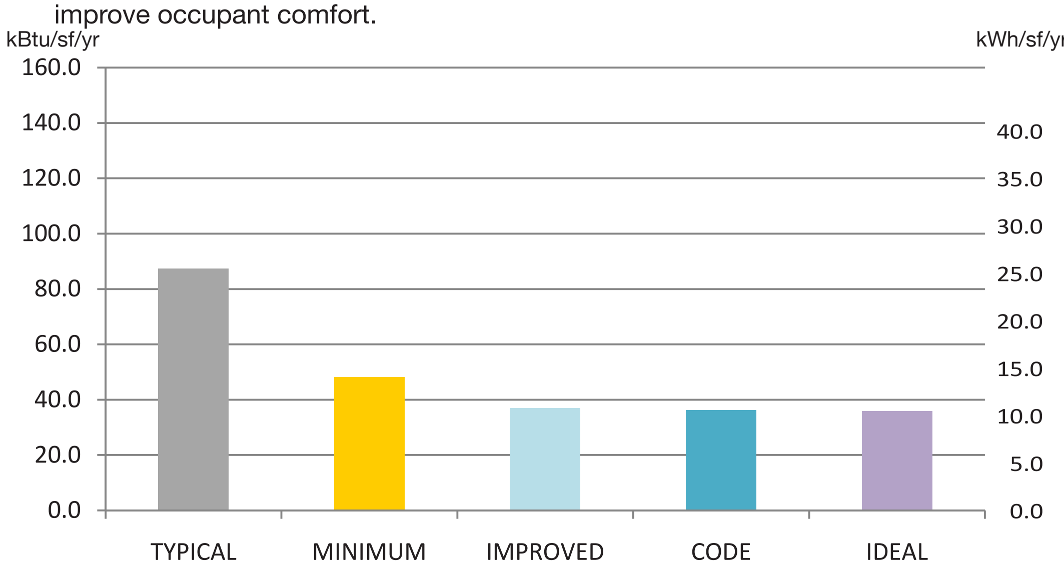
Add/D.1 Executive Summary (Continued)

b. Office Model Results

On average, for all orientations, offices in existing UHM buildings (Typical Existing) would use 87.3 kBtu/sqft/yr (25.6 kWh/sqft/yr). These results are higher than the CBECS data for similar building types in the same climate zone, due probably to non UHM buildings being included in the data.

By improving the windows (glazing specifications, installing shading devices and making those windows operable), in Addition to controlling the time the lights are on and effectively reducing the lighting loads during daytime hours (Minimum Suite), total energy use is reduced by 45%. This is due to both the reduction in lighting energy use (50%) but also the impact of turning off the lights on the interior temperature and consequently on the cooling energy needed for each classroom (48% reduction).

Adding IECC 2015 prescriptive requirements for the roof (Improved Suite), further reduces the energy use intensity to 58% less than typical existing conditions Other improvements such as IECC 2015 prescriptive wall specifications (Code Suite) and exposed thermal mass (Ideal Suite) do not have such a significant impact on the total energy use (59% less than typical maximum), although they improve occupant comfort.



		EUI (kBtu/sqft/yr)		Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL		**87.3**		205280		169237		22517		13414	113
MINIMUM		**48.2**	45%	113340	45%	88504	48%	11297	50%	13414	125
IMPROVED		**37.0**	58%	86937	58%	56240	67%	11297	50%	19004	395
CODE		**36.3**	58%	85288	58%	54561	68%	11297	50%	19004	425
IDEAL		**35.8**	59%	84254	59%	53474	68%	11297	50%	19004	479

Add/D.1 Executive Summary (Continued)

		EUI (kWh/sqft/yr)
TYPICAL		25.6
MINIMUM		14.1
IMPROVED		10.8
CODE		10.6
IDEAL		10.5

	EUI (kWh/sqft/yr)		
	class/office		
UHM Benchmarking Study 2004	23.7		
CBECS	by size	by age	by use
2003	10.5	15.9	13.9
Strategic Energy Plan 2011 data	30.6		

1020 - Q.L. CENTER FOR STUDENT SERVICES

1012 - INSTITUTE FOR ASTRONOMY

UHM OFFICE BUILDINGS - TYPICAL

Avg Size: *12,000 sqft*

Avg. Age: *45 years, built 1970*

Avg. EUI: *30.6 kWh/sf**

**Strategic Energy Plan 2011 data*

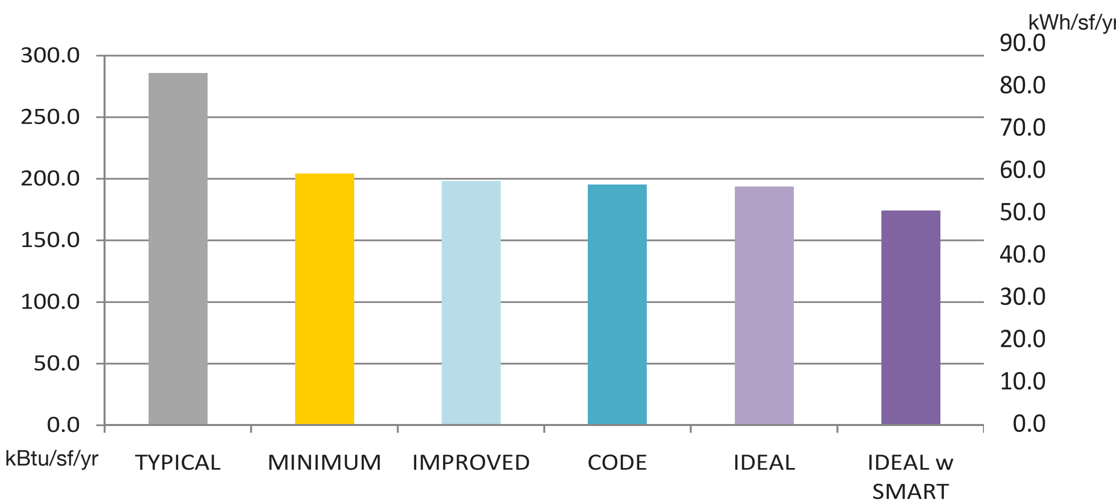
1011 - WOODLAWN BLDG.S

Add/D.1 Executive Summary (Continued)

c. Laboratory Model Results

In laboratory facilities, observation of facility operation reveals that laboratory air systems and the associated HVAC loads are the primary end-use of energy in UC laboratory buildings, averaging roughly three times the energy intensity of non-laboratory buildings (Huizenga, Van Liere and Bauman 1998).

The results from our models confirm these observations. On average, for all orientations, laboratories in existing UHM buildings (Typical Existing) would use 285.6.3 kBtu/sqft/yr (83.7 kWh/sqft/yr). The Labs 21 toolkit only provides energy use data for a subset of the database – facilities located in cool-humid climate zone, with total site energy use intensity that varies from about 200 kBTU/sf-yr to almost 600 kBTU/sf-yr. Labs 21 emphasizes the correlation between the energy use intensity and the lab area ratio, underscoring the importance of normalizing for this parameter when comparing labs. However, these values are out of range compared to both CBECS and UHM data. As mentioned before, the UHM data combines laboratory uses with offices and classrooms, which lowers the averaged energy use intensity.



		EUI (kBtu/sqft/yr)		Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL		**285.6**		671378		409550		42910		218907	6
MINIMUM		**203.9**	**29%**	479322	**29%**	335037	**18%**	11755	**73%**	131344	594
IMPROVED		**198.2**	**31%**	465859	**31%**	321613	**21%**	11755	**73%**	131344	576
CODE		**195.1**	**32%**	458513	**32%**	314241	**23%**	11755	**73%**	131344	589
IDEAL		**193.7**	**32%**	455161	**32%**	310882	**24%**	11755	**73%**	131344	592
IDEAL w SMART		**174.3**	**39%**	409599	**39%**	265743	**35%**	11755	**73%**	131344	391

Add/D.1 Executive Summary (Continued)

Simulations for improved suites show that lighting energy use can be reduced by 73% on average for all orientations and that cooling energy use and total energy use intensity Achieve up to 32% reductions with overestimated airflow rates or up to 39% reductions if airflow rates follow the best-practices recommendations

		EUI (kWh/sqft/yr)
TYPICAL		83.7
MINIMUM		59.8
IMPROVED		58.1
CODE		57.2
IDEAL		56.8
IDEAL w SMART		51.1

	EUI (kWh/sqft/yr)		
	lab/class	*lab/class/office*	*office/lab*
UHM Benchmarking Study 2004	64.3	44.7	34.7
CBECS	*by size*	*by age*	*by use*
2003	15.7	15.9	23.1
Strategic Energy Plan 2011 data	35.6		

C-More Hale, Most recent Laborarory Building on UHM campus

Avg Size: *54,900 sqft*

Avg. Age: *45 years, built 1970*

Avg. EUI: *35.6 kWh/sf**

**Strategic Energy Plan 2011 data*

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Add/D ENERGY STUDIES

2. MODEL ASSUMPTIONS

All assumptions are the same as for the HVAC Autonomy/ Thermal Comfort Models. The models also now use a purchased air system where the supply air temperature is at 13C. The thermostat set-point for cooling is either 25C (77F) or 27C (80.6F). The system has a differential dry bulb economizer that will use the outside air if the outside air temperature is below the cooling set-point.

It is also important to note that the controls for the HVAC system in these simulations are not fine tuned to mixed mode conditioning. This means that the system is available at all times and brings in the required airflow rates for breathing (and one Additional Air Change per Hour for some models) whenever cooling is not needed.

We have prepared a template summarizing the critical information per building type, that should be included in the "project definition" and submitted to the design teams for both new or retrofit projects, in order to provide useful assumptions for predictive performance models.

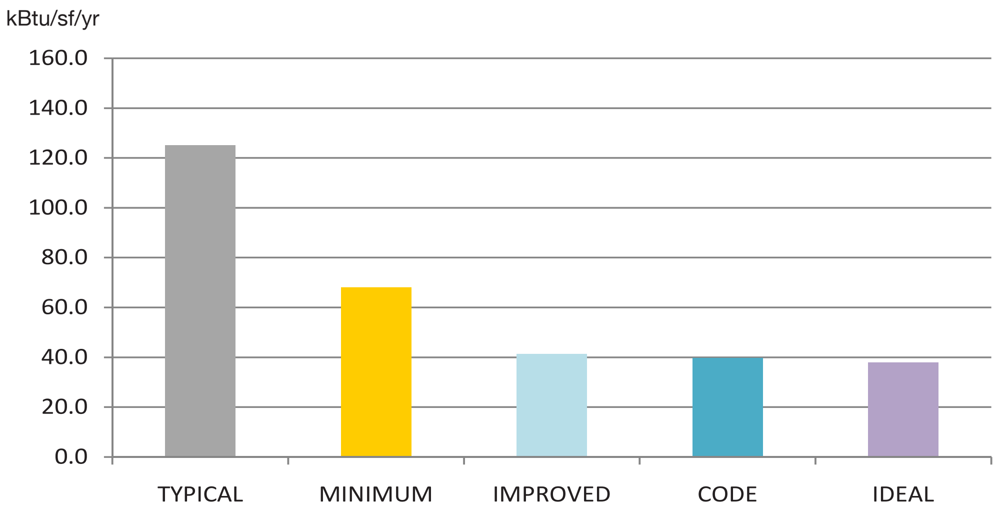
Information included in these templates would be as follows:

1. Energy Benchmarks:
   By Building Type (for new building projects) + Building Specific (for renovation projects), UHM data::
   - Average Size / Building Squarefootage
   - Average Age / Year built
   - Average Energy Use Intensity / Total Energy Use
   - Average or Total Lighting Energy Use
   - Average or Total HVAC Energy Use
   - Average or Total Equipment Energy Use
   - Average Water Use / Total Water Use

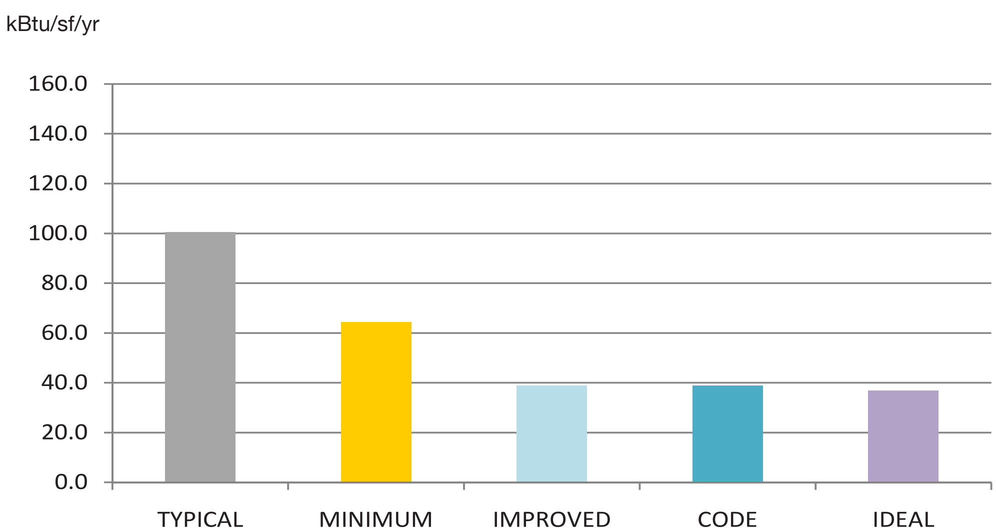
2. Internal loads::
   Typical occupancy (sft/ person)
   Typical existing Lighting Power and Equipment Power Density
   Typical Schedules

Add/D ENERGY STUDIES

3. CLASSROOM ANALYSIS

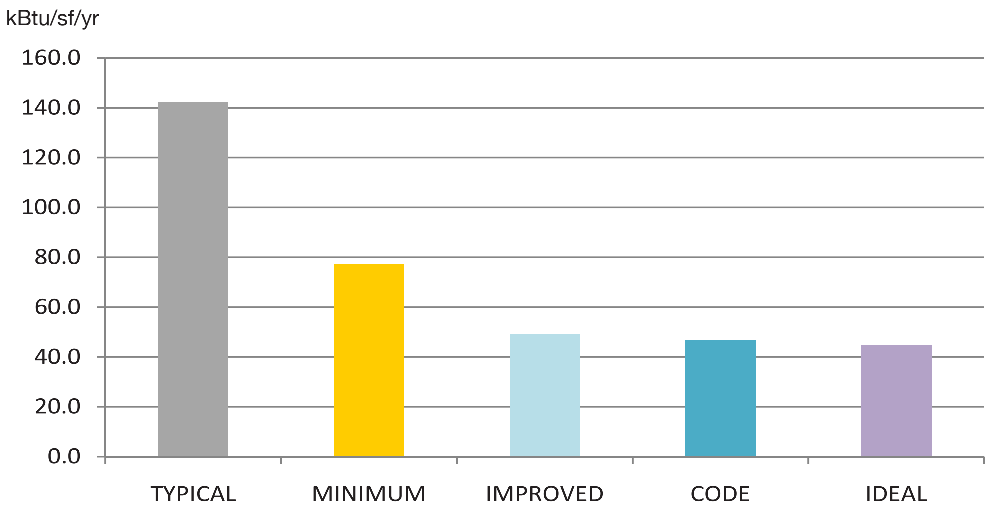


	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	125.0	293834		262447		22177		8942	267
MINIMUM	68.0	159860	46%	145828	44%	4879	78%	8942	211
IMPROVED	41.3	97037	67%	79738	70%	4879	78%	11625	794
CODE	39.8	93636	68%	76259	71%	4879	78%	11625	873
IDEAL	37.9	89150	70%	71571	73%	4879	78%	11625	1075

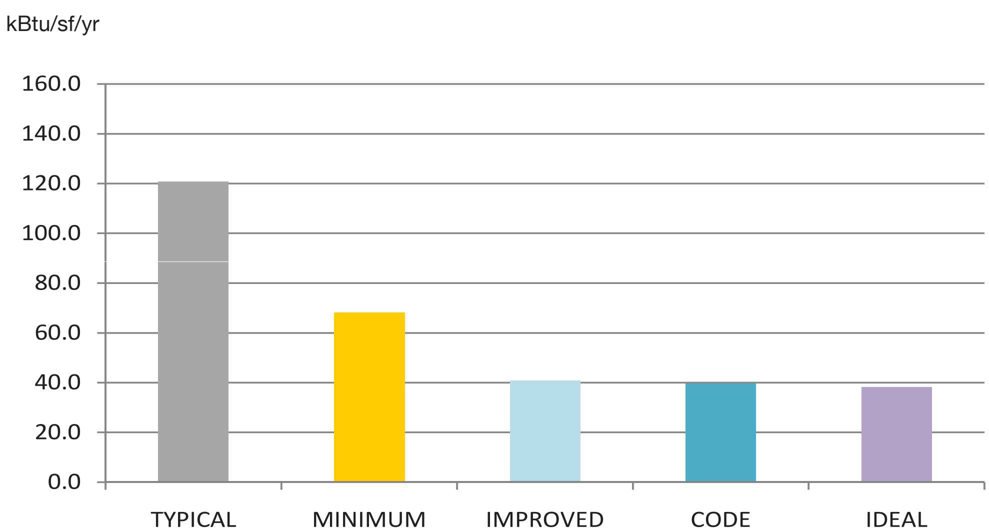


	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	100.4	236080		204768		22177		8942	192
MINIMUM	64.3	151119	36%	135537	34%	6438	71%	8942	201
IMPROVED	38.9	91377	61%	72868	64%	6438	71%	11625	445
CODE	38.9	91396	61%	72814	64%	6438	71%	11625	518
IDEAL	36.8	86449	63%	67804	67%	6438	71%	11625	581

Add/D.3 Classroom Analysis (Continued)



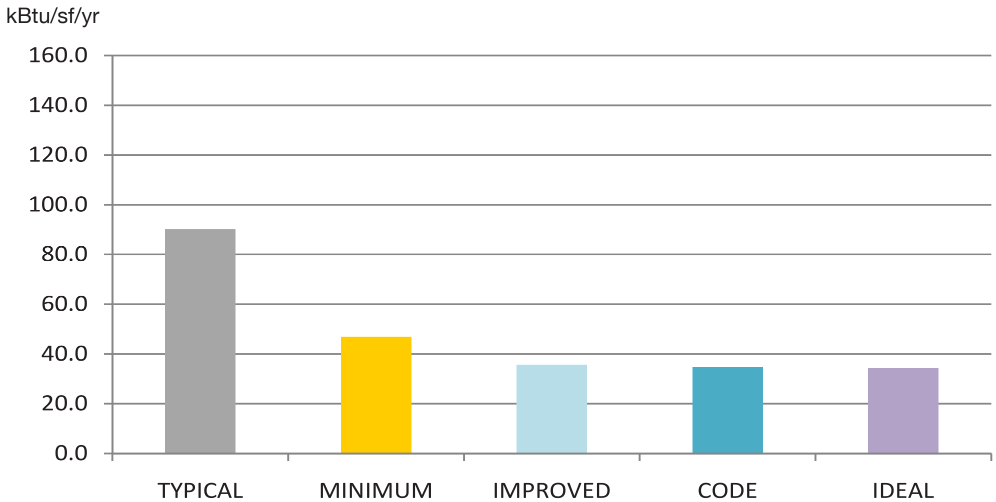
	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	142.2	334149		302794		22177		8942	235
MINIMUM	77.2	181380	46%	166574	45%	5640	75%	8942	224
IMPROVED	49.0	115159	66%	97074	68%	5640	75%	11625	820
CODE	46.9	110121	67%	91996	70%	5640	75%	11625	860
IDEAL	44.7	104973	69%	86722	71%	5640	75%	11625	986



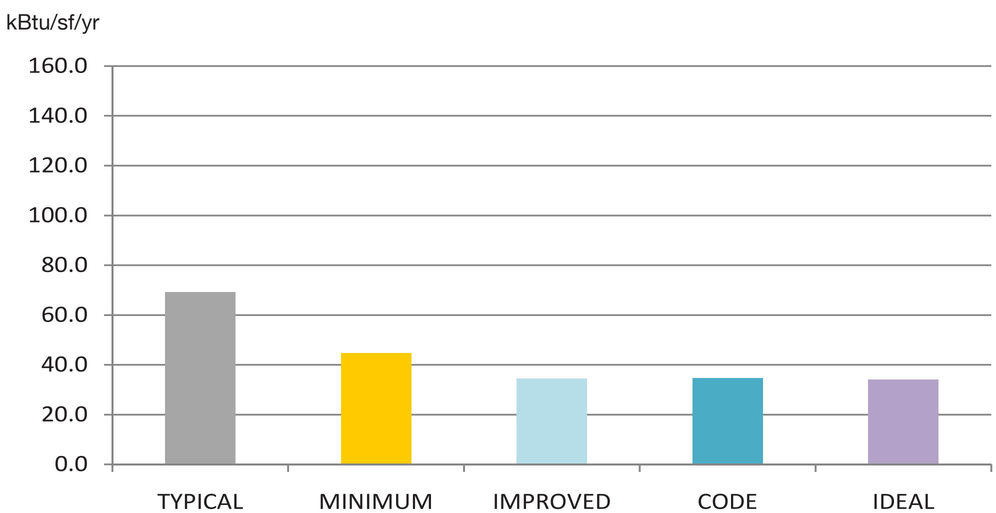
	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	120.7	283744		252387		22177		8942	236
MINIMUM	68.3	160458	43%	146157	42%	5145	77%	8942	214
IMPROVED	40.8	95916	66%	78486	69%	5145	77%	11625	660
CODE	39.8	93538	67%	76075	70%	5145	77%	11625	692
IDEAL	38.2	89861	68%	72311	71%	5145	77%	11625	780

Add/D ENERGY STUDIES

4. OFFICE ANALYSIS

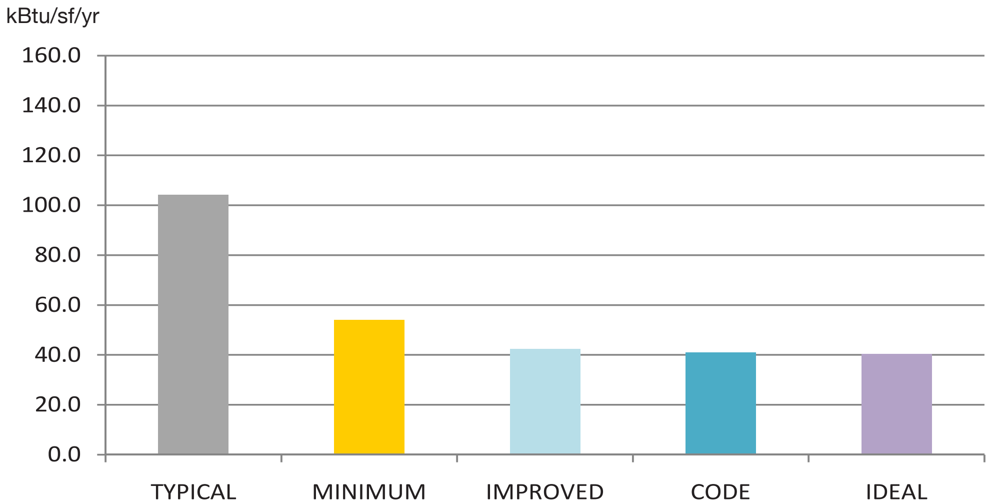


		EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL		**90.1**	211807		175767		22517		13414	109
MINIMUM		**46.9**	110148	**48%**	86403	**103%**	10208	**55%**	13414	124
IMPROVED		**35.5**	83488	**61%**	53862	**69%**	10208	**55%**	19004	414
CODE		**34.7**	81468	**62%**	51818	**71%**	10208	**55%**	19004	438
IDEAL		**34.2**	80483	**62%**	50762	**71%**	10208	**55%**	19004	509

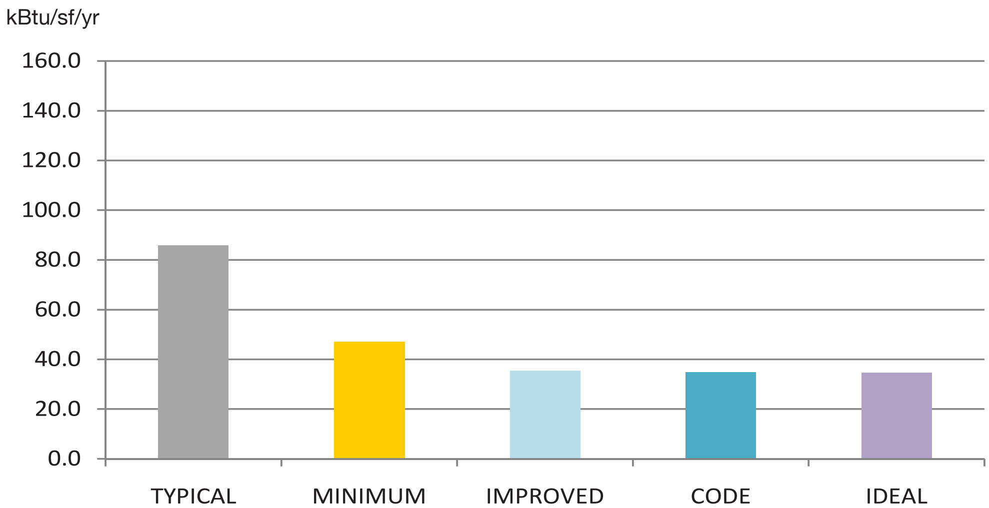


		EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL		**69.1**	162507		126456		22517		13414	121
MINIMUM		**44.8**	105308	**35%**	78774	**38%**	12988	**42%**	13414	132
IMPROVED		**34.5**	81026	**50%**	48687	**61%**	12988	**42%**	19004	347
CODE		**34.6**	81325	**50%**	48944	**61%**	12988	**42%**	19004	388
IDEAL		**34.1**	80198	**51%**	47790	**62%**	12988	**42%**	19004	416

Add/D.4 Office Analysis (Continued)



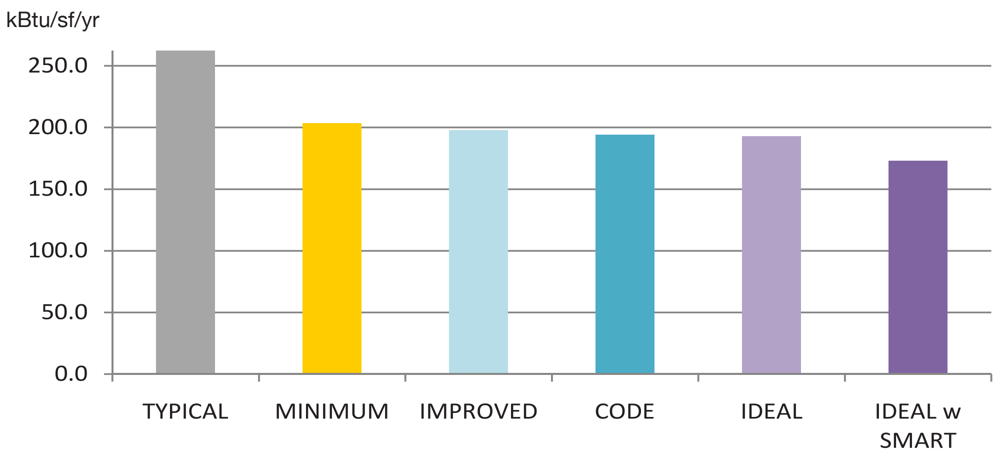
	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	**104.2**	244816		208777		22517		13414	108
MINIMUM	**54.2**	127323	**48%**	102443	**51%**	11342	**50%**	13414	125
IMPROVED	**42.5**	99899	**59%**	69144	**67%**	11342	**50%**	19004	409
CODE	**41.0**	96401	**61%**	65623	**69%**	11342	**50%**	19004	432
IDEAL	**40.4**	94855	**61%**	64009	**69%**	11342	**50%**	19004	500



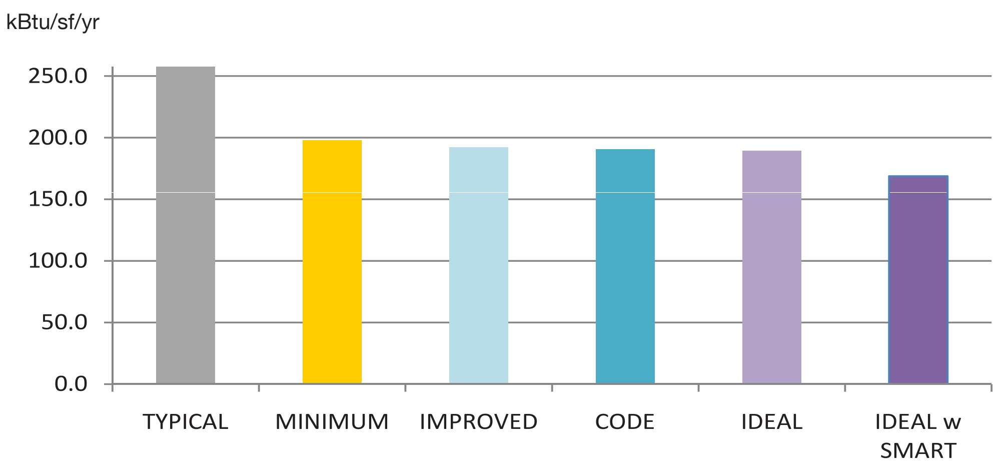
	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	**85.9**	201991		165947		22517		13414	114
MINIMUM	**47.0**	110579	**45%**	86395	**48%**	10651	**53%**	13414	120
IMPROVED	**35.5**	83335	**59%**	53269	**68%**	10651	**53%**	19004	411
CODE	**34.9**	81958	**59%**	51860	**69%**	10651	**53%**	19004	443
IDEAL	**34.7**	81481	**60%**	51336	**69%**	10651	**53%**	19004	490

Add/D ENERGY STUDIES

5. LABORATORY ANALYSIS

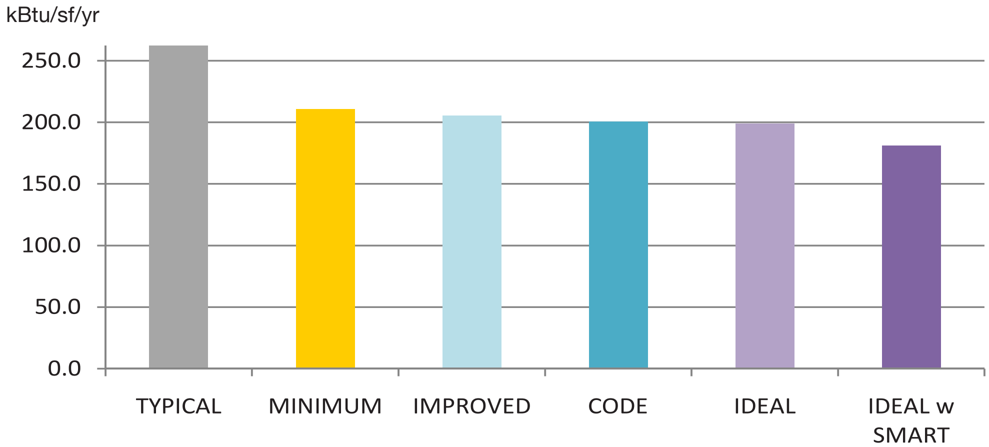


	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)		Reheat?
TYPICAL	**286.8**	674007		412181		42910		218907		9
MINIMUM	**203.5**	478351	**29%**	334088	**19%**	11741	**73%**	131344	**40%**	1178
IMPROVED	**197.7**	464719	**31%**	320466	**22%**	11741	**73%**	131344	**40%**	1168
CODE	**194.2**	456554	**32%**	312267	**24%**	11741	**73%**	131344	**40%**	1202
IDEAL	**192.7**	452861	**33%**	308554	**25%**	11741	**73%**	131344	**40%**	1222
IDEAL w SMART	**173.0**	406684	**40%**	262938	**36%**	11741	**73%**	131344	**40%**	661

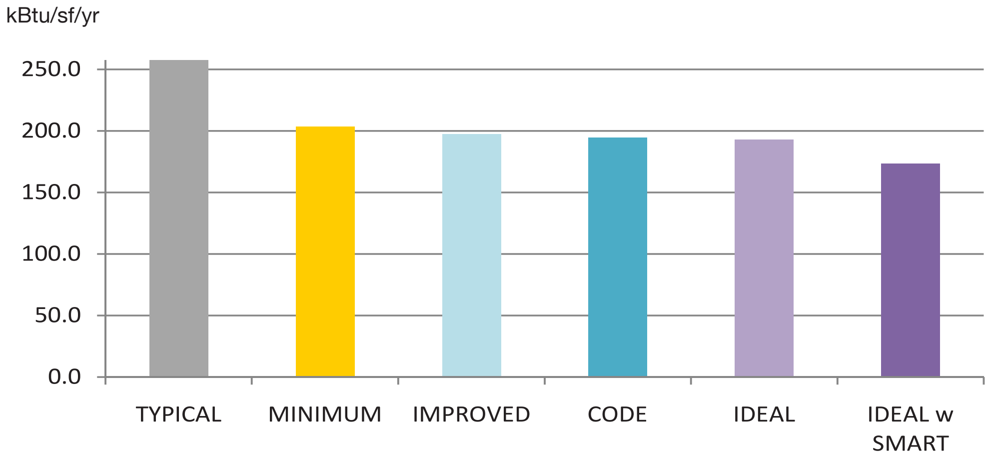


	EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)	Reheat?
TYPICAL	**271.2**	637387		375555		42910		218907	15
MINIMUM	**198.1**	465526	**27%**	321135	**14%**	11849	**72%**	131344	1198
IMPROVED	**192.2**	451696	**29%**	307369	**18%**	11849	**72%**	131344	1133
CODE	**190.7**	448147	**30%**	303799	**19%**	11849	**72%**	131344	1154
IDEAL	**189.6**	445706	**30%**	301367	**20%**	11849	**72%**	131344	1146
IDEAL w SMART	**168.9**	396983	**38%**	252885	**33%**	11849	**72%**	131344	904

Add/D.5 Laboratory Analysis (Continued)



		EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)		Reheat?
TYPICAL		302.3	710509		448680		42910		218907		12
MINIMUM		210.7	495257	30%	350824	22%	11963	72%	131344	40%	1126
IMPROVED		205.3	482634	32%	338211	25%	11963	72%	131344	40%	1117
CODE		200.9	472194	34%	327739	27%	11963	72%	131344	40%	1148
IDEAL		199.1	467901	34%	323419	28%	11963	72%	131344	40%	1175
IDEAL w SMART		181.4	426473	40%	282501	37%	11963	72%	131344	40%	666



		EUI (kBtu/sqft/yr)	Total Energy (Site) (kBtu)		Cooling (kBtu)		Lighting (kBtu)		Equipment (kBtu)		Reheat?
TYPICAL		282.4	663611		401786		42910		218907		8
MINIMUM		203.5	478154	28%	334100	17%	11467	73%	131344	40%	1243
IMPROVED		197.6	464386	30%	320405	20%	11467	73%	131344	40%	1171
CODE		194.5	457158	31%	313159	22%	11467	73%	131344	40%	1188
IDEAL		193.3	454174	32%	310189	23%	11467	73%	131344	40%	1174
IDEAL w SMART		173.7	408255	38%	264647	34%	11467	73%	131344	40%	797

4/ ENERGY

Add/D ENERGY STUDIES

6. NET ZERO FEASIBILITY

A preliminary basic net zero feasibility study assuming potential PV output for both typical and high performance PV panels in this climate was developed to establish the potential of each building type from achievingthe net zero performance goal.

We modeled generic PV performance for a panel mounted horizontally in order to establish a relationship between effective (vs nameplate) total PV array power rating and yearly energy production. We performed this analysis using PVWatts, a tool for estimating PV energy production. PVWatts was created by and is maintained through the National Renewable Energy Laboratory (NREL). We analyzed the performance of a generic 1 kW system using degradation factors slightly greater than the default settings used in PVWatts.

See below for a summary of assumptions used in the analysis:

Location and Station Identification

Requested Location	96822
Weather Data Source	(TMY3) HONOLULU INTL ARPT, HI 7.6 mi
Latitude	21.32° N
Longitude	157.93° W

PV System Specifications

DC System Size	1 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	0°
Array Azimuth	180°
System Losses	14%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

PV kWh per kW installed 1,454 kWh per kW.

In summary, as described in the table shown in the next page, for both the classrooms and the offices, only the Improved, Code and Ideal Suites have the potential for Achievingnet zero performance in two story buildings. Office buildings have the greatest potential to be net zero as they Achieve the best energy performance results in our models. Laboratory buildings are unlikely to achieve net zero performance as long as the PVs must be roof mounted on the building itself, and limited to the roof area.

Add/D.6 Net Zero Feasibility (Continued)

Month	Solar Radiation (kWh / m2 / day)	AC Energy (kWh)	Energy Value ($)
January	3.81	90	29
February	4.49	96	31
March	5.25	124	40
April	5.74	132	43
May	6.16	144	47
June	6.39	146	47
July	6.41	150	49
August	6.40	149	48
September	5.82	132	43
October	4.79	111	36
November	4.11	94	31
December	3.65	86	28
Annual	**5.25**	**1,454 kWh**	**$ 472**

A typical PV panel (230 Watts per 17.5sqft) would produce 18.9 kWh/sqft
A high performance panel (335 Watts per 17.5 sqft) would produce 27.6 kWh/sqft

CLASSROOMS	**Energy use**	**Net Performance (Single Story)**	
	EUI (kWh/sqft/yr)	w typical PV panel	w high performance PV panel
TYPICAL	35.78	16.88	8.15
MINIMUM	20.35	1.45	-7.28
IMPROVED	12.45	-6.45	-15.17
CODE	12.12	-6.79	-15.51
IDEAL	11.55	-7.36	-16.08

OFFICES	**Energy use**	**Net Performance (Single Story)**	
	EUI (kWh/sqft/yr)	w typical PV panel	w high performance PV panel
TYPICAL	25.60	6.69	-2.03
MINIMUM	14.13	-4.77	-13.49
IMPROVED	10.84	-8.06	-16.79
CODE	10.63	-8.27	-16.99
IDEAL	10.51	-8.40	-17.12

LABORATORIES	**Energy use**	**Net Performance (Single Story)**	
	EUI (kWh/sqft/yr)	w typical PV panel	w high performance PV panel
TYPICAL	83.72	64.81	56.09
MINIMUM	59.77	40.87	32.14
IMPROVED	58.09	39.19	30.46
CODE	57.17	38.27	29.55
IDEAL	56.75	37.85	29.13
IDEAL w SMART	51.07	32.17	23.45

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Add/E. EFFICIENT ELECTRIC LIGHTING EXAMPLES

Daylighted spaces and reducing the demand of electric lights are an important part of reducing energy consumption. Per the Benchmarking Study for UHM, 2004, Lighting accounts for 30% of all electricity consumption on the UHM campus.

Reducing use of electric lights by good daylighting design is the most effective way of saving energy from lighting loads while maintaining comfortably illuminated spaces. Electric Lighting and controls should be designed to supplement daylight only as needed in the daytime, and to provide a comfortably illuminated spaces at night with minimal energy use.

The University of Hawaii's oudated lighting standard was updated in 2011 to reflect current standards and to be consistent with both the campus wide energy goals.

Superceded standard:

d. Foot candles:

- i. Minimum uniform light level at desk height is to be 50 FC, after bulb burn-in and after dirt level.
- ii. Final lighting (with all lights fully on and none dimmed) FC measurement to be in 12 spots from front to back, thus: IL IC IR (Instructor left section, center section and right section) FL FC FR (Front row seating, left, center and right at any seat in each section) CL CC CR (Center row seating, left, center and right at any seat in each section) BL BC BR (Back row seating, left, center and right at any seat in each section)
- iii. These 12 measurements will be averaged to check the 50 FC in each classroom before project closeout - any "under-designs", especially at corners, will require Additional placements of light fixtures as part of errors and omissions.

Revised standard:

d. Light Levels:

- i. Average maintained lighting at work surfaces shall be 30fc, with minimum of 25fc
- ii. Measurements shall be taken at least 3' from any wall on a 5'grid.
- iii. Measurements shall be taken with an illuminance meter with a valid calibration

Add/E Efficient Electric Lighting Design Examples (Continued)

certificate.

iv. Measurements shall be taken with non-dimmed warmed up lamps after a 10-hour burn in before project closeout. If measured lighting is below 15% of recomended measurements then adjustments, Additional placements, or reconfiguration of light fixtures will be required as part of errors and omissions.

The following pages show a compilation of examples of efficient lighting designs for the three space types Addressed in the modeling and Standards. These examples serve as a reference for the design teams and validate the assumptions made in thermal comfort and energy models using lower lighting power densities than those required by ASHRAE Standards.

In summary, the following assumptions are described through these examples:

- Classrooms 0.6 W/sqft, (examples show ranges between 0.44W/sqft and 0.56W/sqft)
- Offices 0.6 W/sqft, (examples show ranges between 0.3W/sqft and 0.56W/sqft)
- Labs 1 W/sqft. (examples several designs achieving0.92W/sqft)

Add/E Efficient Electric Lighting Design Examples (Continued)

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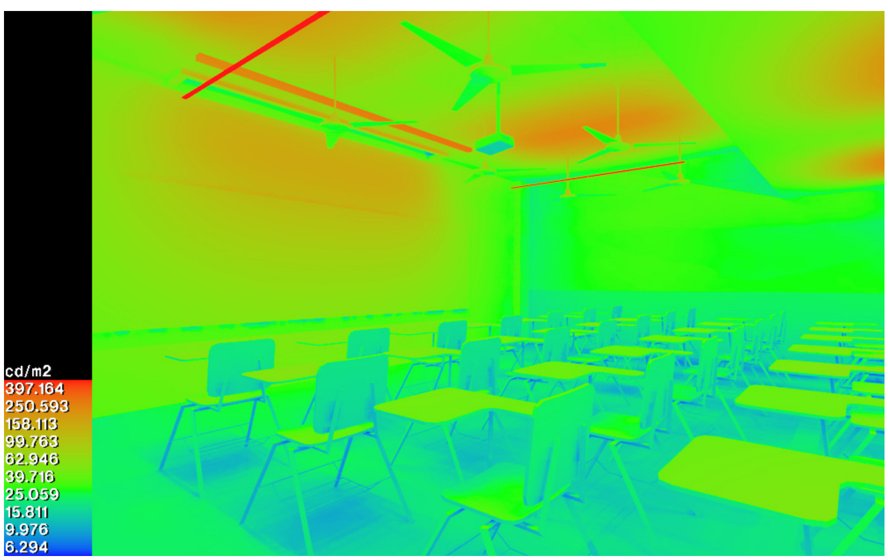
Add/E EFFICIENT ELECTRIC LIGHTING DESIGN EXAMPLES

1. CLASSROOMS

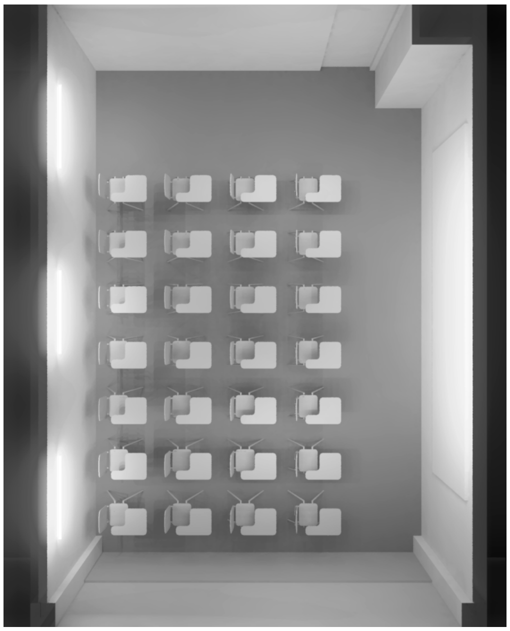
Surface reflectances:

Ceiling: 0.9
Walls: 0.8
Floor: 0.5
Interior blinds (deployed at night): 0.6



RADIANCE simulation showing luminance values of interior surfaces at night.

Add/E 1. Classrooms (Continued)

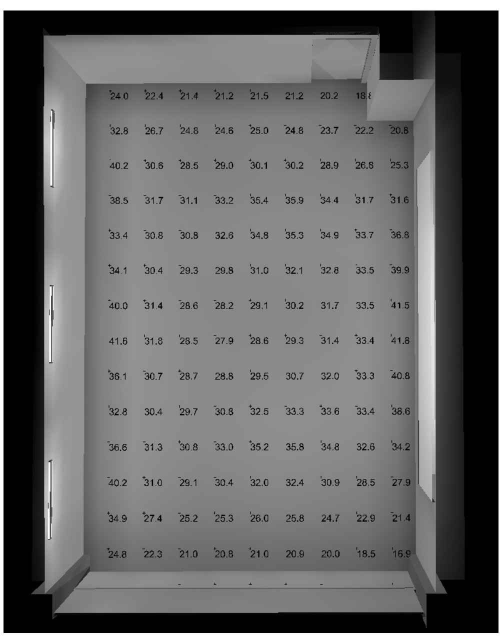


RADIANCE simulation showing plan perspective.

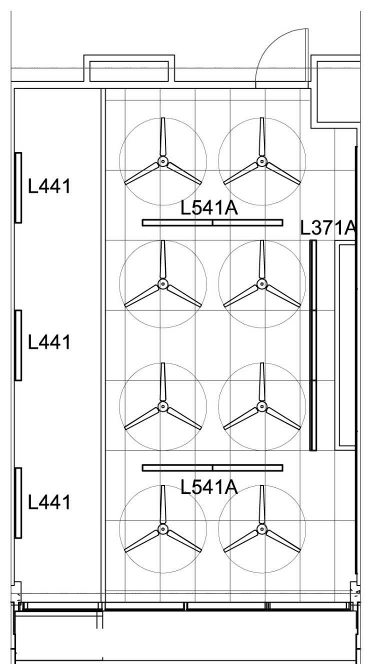
LPD:: 0.56 W/sqft

Statistics for points on 30” work-plane at least 3’ from any wall:

Average:	30.57 fc
Maximum:	35.9 fc
Minimum:	22.9 fc
Avg/ Min Ratio:	1.33
Max/Min Ratio:	1.57



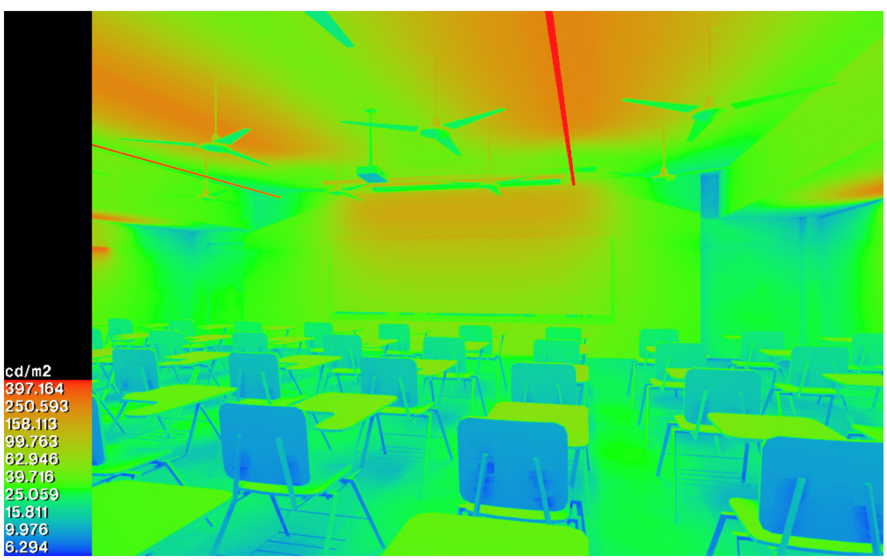
AGI simulation with illumination (fc) on 30” work-plane (2’ calcution grid)



Reflected Ceiling Plan

E. ELECTRIC LIGHTING

Add/E.1 Classrooms (Continued)

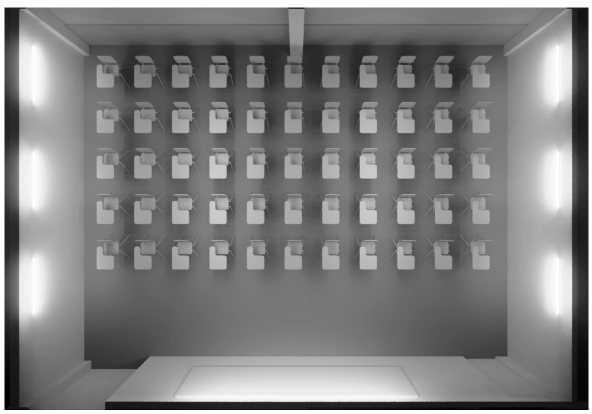


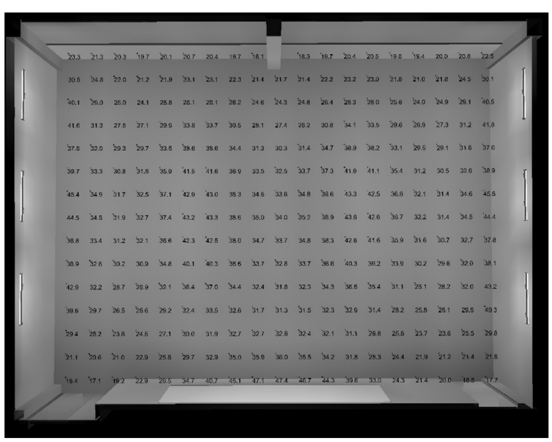
Add/E.1 Classrooms (Continued)

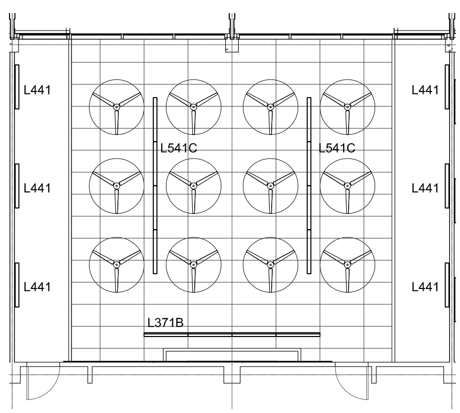
Statistics for points on 30” work-plane at least 3’ from any wall:

Average:	32.72 fc
Maximum:	43.6 fc
Minimum:	23.6 fc
Avg/ Min Ratio:	1.39
Max/Min Ratio:	1.85

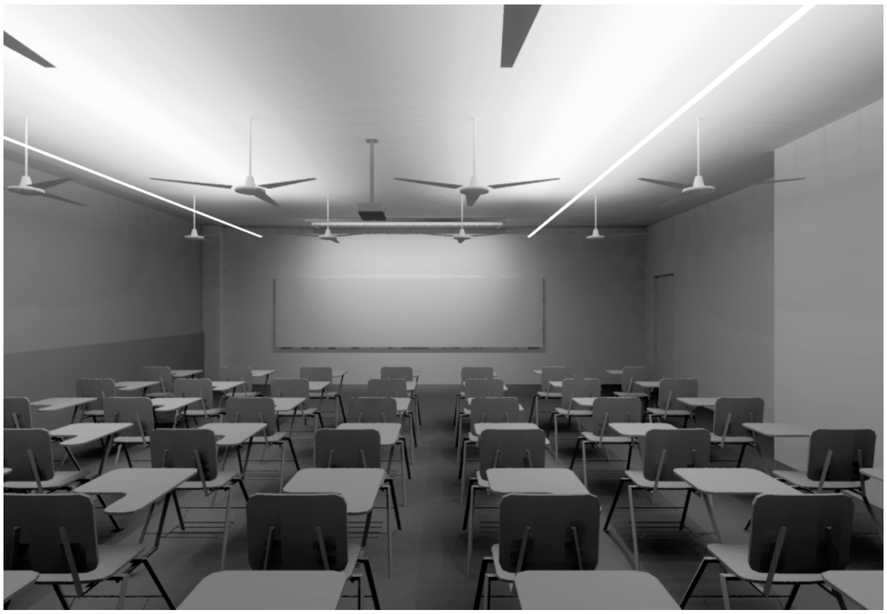
LPD:: 0.50 W/sqft



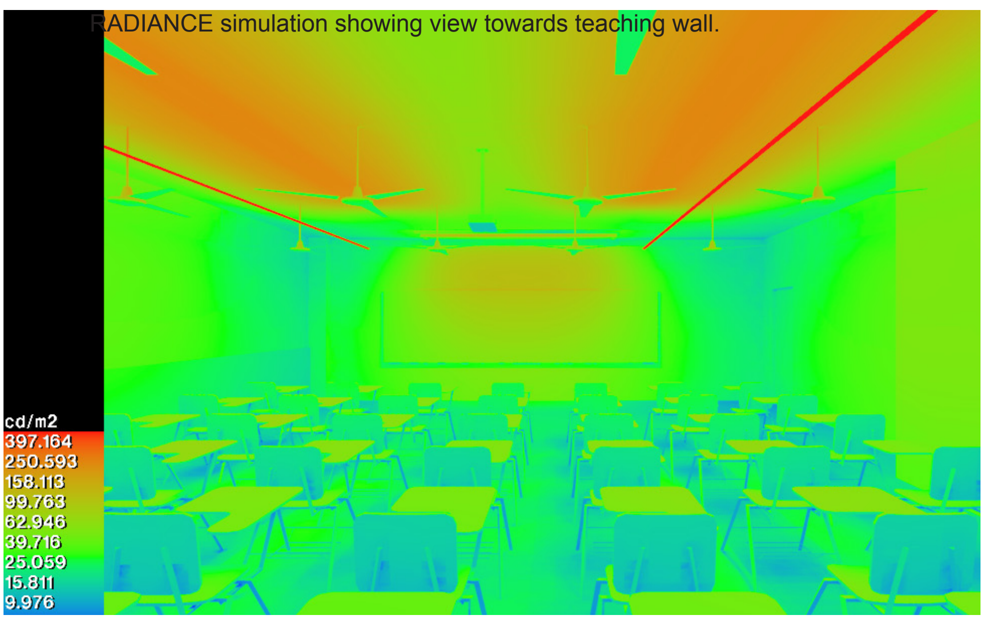




Add/E.1 Classrooms (Continued)



RADIANCE simulation showing view towards teaching wall.



RADIANCE simulation showing luminance values of interior surfaces at night.

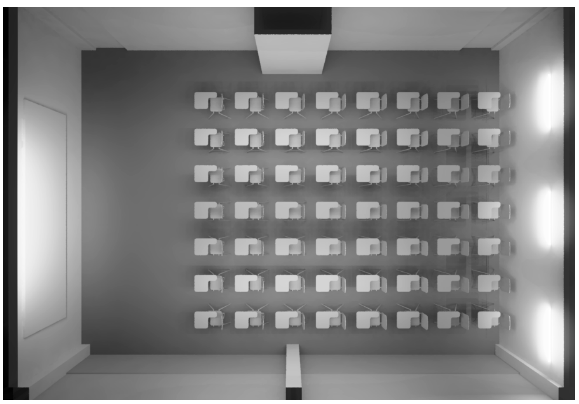
Add/E.1 Classrooms (Continued)

Statistics for points on 30” work-plane at least 3’ from any wall:

Average:	35.7 fc
Maximum:	49.5 fc
Minimum:	19.3 fc *
Avg/ Min Ratio:	1.85
Max/Min Ratio:	2.56

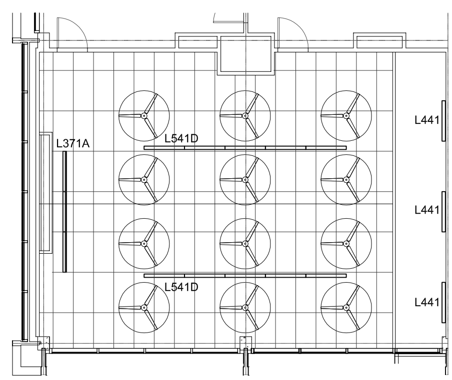
LPD:: 0.44 W/sqft

* Note:
There are (2) points near northwest door which are below threshold of lighting standard. Per furniture plan, illumination at these points is not critical. Alternatively, pendants runs L541D could be lengthened from (5) to (6) fixtures each, resulting in an LPD of .5 W/sf for this room.



RADIANCE simulation showing plan perspective.

AGI simulation with illumination (fc) on 30” workplane (2’ calcution grid)

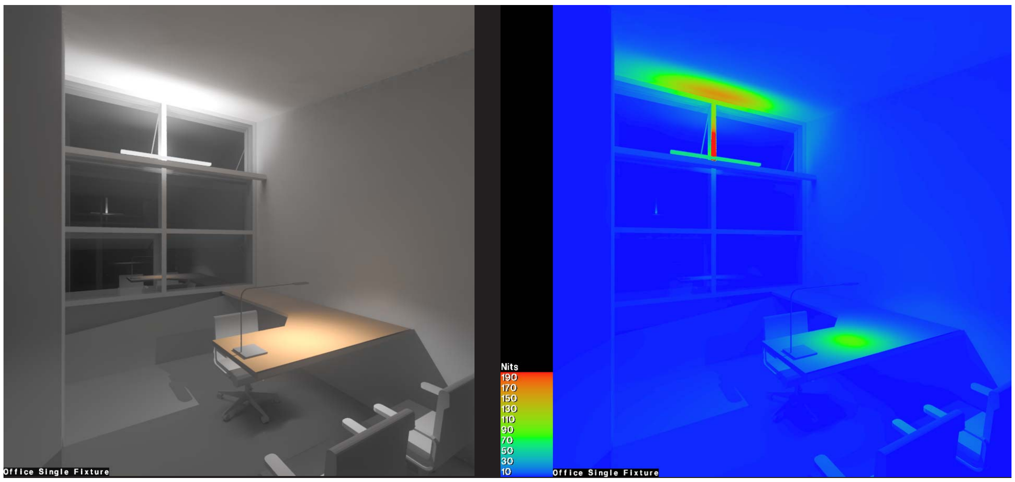


Reflected Ceiling Plan. Note that recess for screen to be moved to be centered on lighting fixture layout.

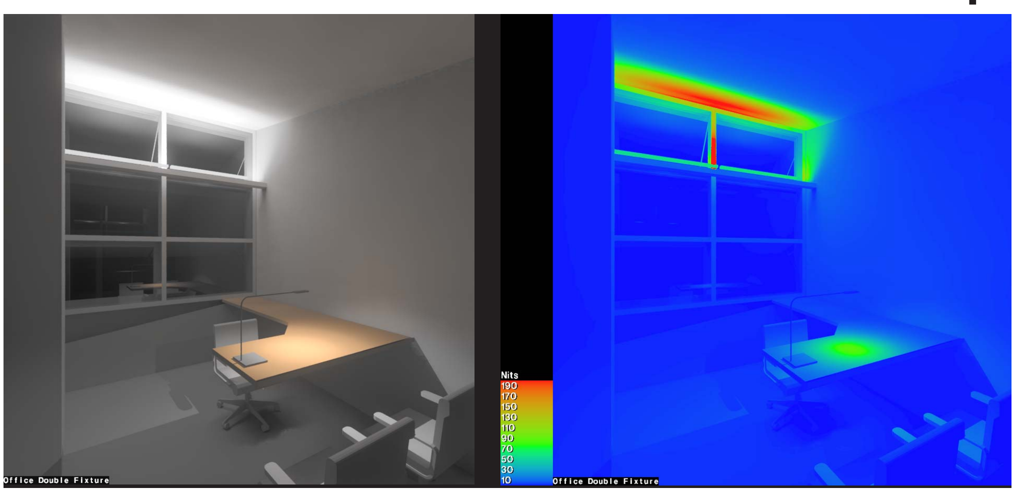
<u>Add/E</u> EFFICIENT ELECTRIC LIGHTING DESIGN EXAMPLES

2. OFFICES

LPD:: 0.3 W/sqft

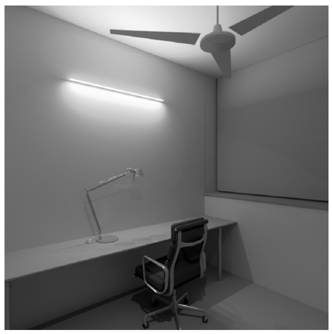


LPD:: 0.48 W/sqft

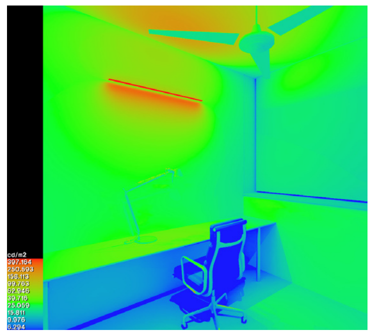


Add/E.2 Offices (Continued)

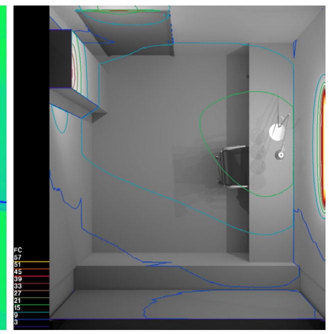
LPD:: 0.563 W/sqft



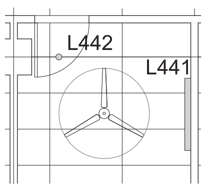
RADIANCE simulation showing office desk.



RADIANCE simulation showing luminance values of interior surfaces at night.



RADIANCE simulation showing illumination (fc) on 30" workplane.



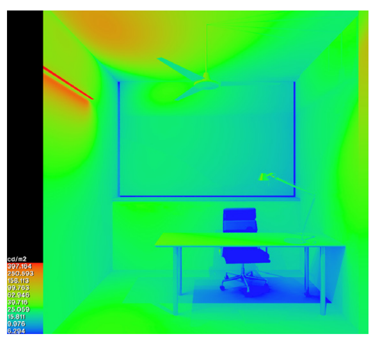
(1) WALL MOUNTED CHOPSTICK (1T5)
(1) RECESSED LED WALL WASHER DIRECTED TO COLUMN

LPD: 0.563 W/sf

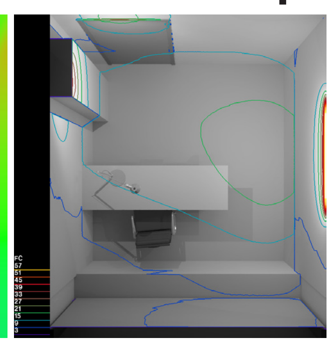
DESK CONFIGURATION: aligned to side wall

LPD:: 0.563 W/sqft

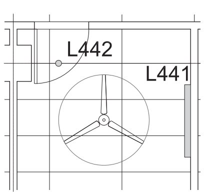
RADIANCE simulation showing office desk.



RADIANCE simulation showing luminance values of interior surfaces at night.



RADIANCE simulation showing illumination (fc) on 30" workplane.



(1) WALL MOUNTED CHOPSTICK (1T5)
(1) RECESSED LED WALL WASHER DIRECTED TO COLUMN

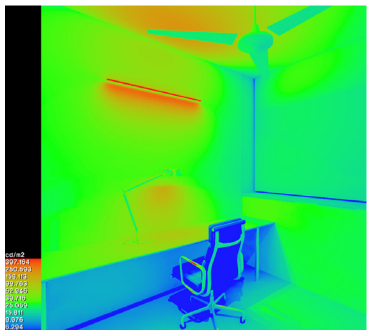
LPD: 0.563 W/sf

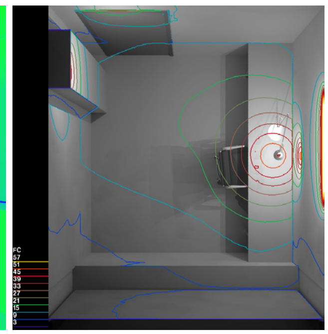
DESK CONFIGURATION: centered in space

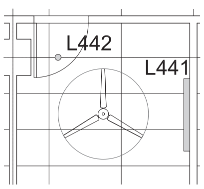
Add/E.2 Offices (Continued)

LPD:: 0.3 W/sqft


RADIANCE simulation showing office desk.


RADIANCE simulation showing luminance values of interior surfaces at night.


RADIANCE simulation showing illumination (fc) on 30" workplane.



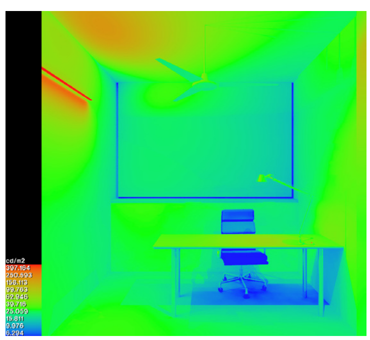
(1) WALL MOUNTED CHOPSTICK (1T5)
(1) RECESSED LED WALL WASHER DIRECTED TO COLUMN
(1) LED POINT SOURCE TASKLIGHT

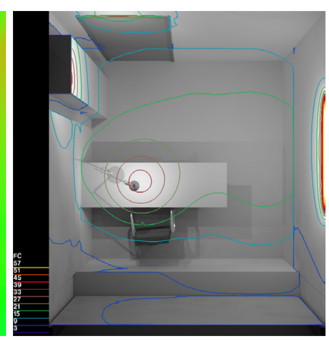
LPD: 0.649 W/sf

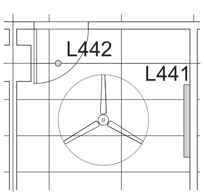
DESK CONFIGURATION: aligned to side wall

LPD:: 0.48 W/sqft


RADIANCE simulation showing office desk.


RADIANCE simulation showing luminance values of interior surfaces at night.


RADIANCE simulation showing illumination (fc) on 30" workplane.

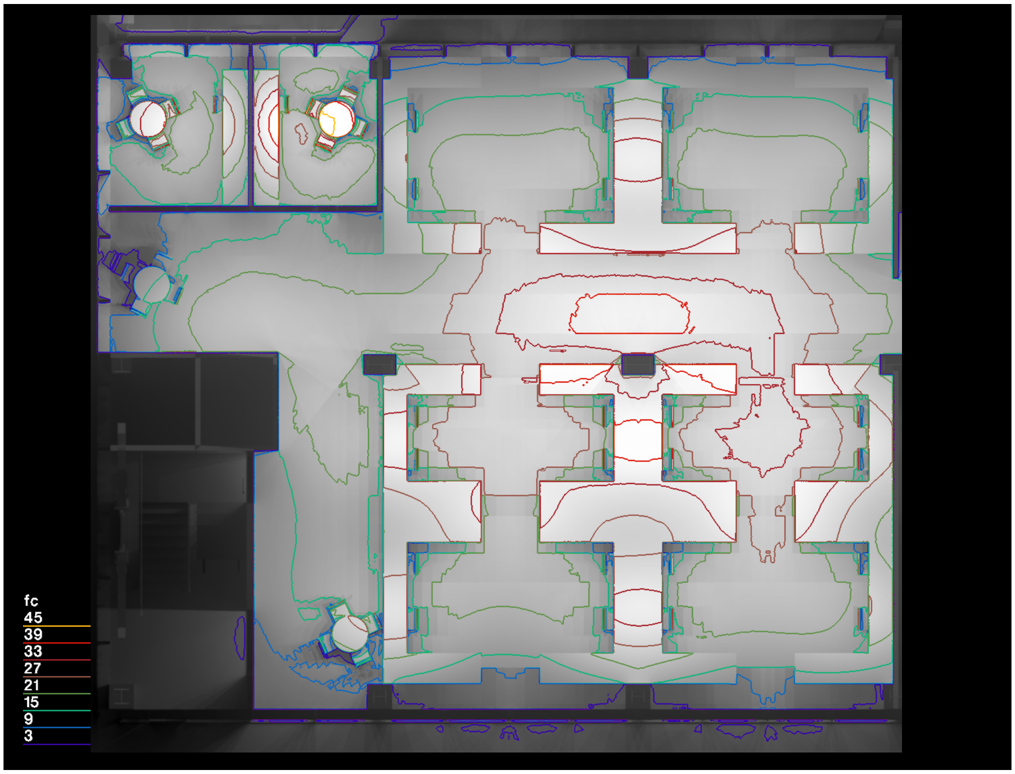


(1) WALL MOUNTED CHOPSTICK (1T5)
(1) RECESSED LED WALL WASHER DIRECTED TO COLUMN
(1) LED POINT SOURCE TASKLIGHT

LPD: 0.649 W/sf

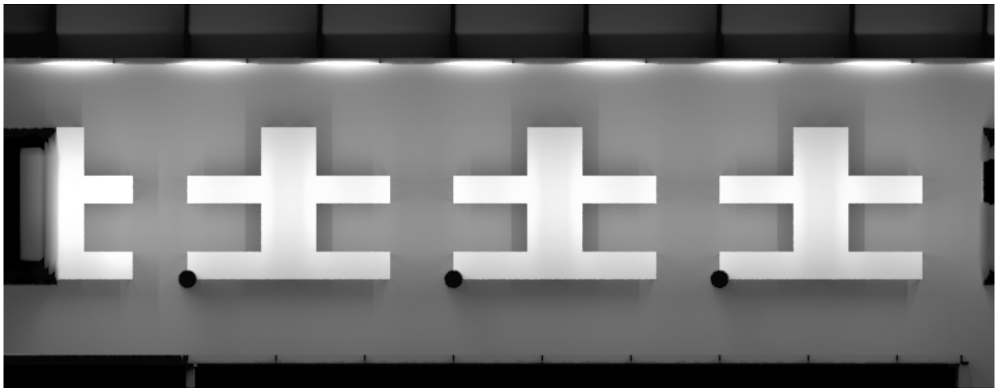
DESK CONFIGURATION: centered in space

Add/E.2 Offices (Continued)



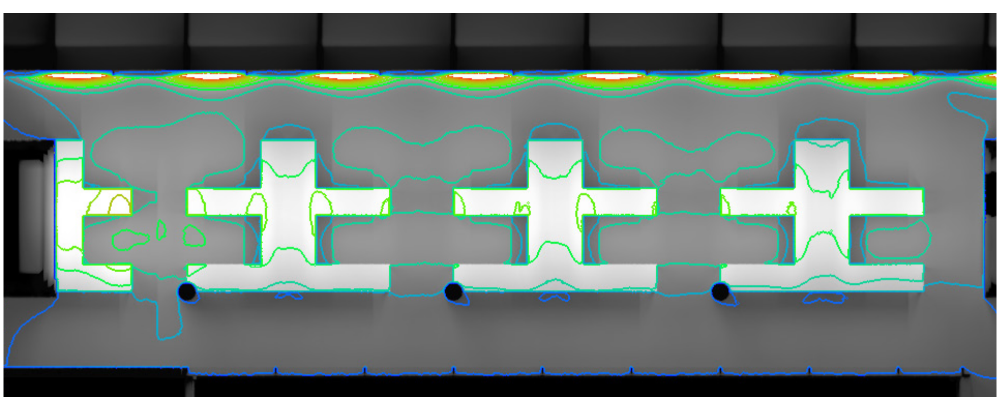
Add/E.2 Offices (Continued)

Top View Rendering



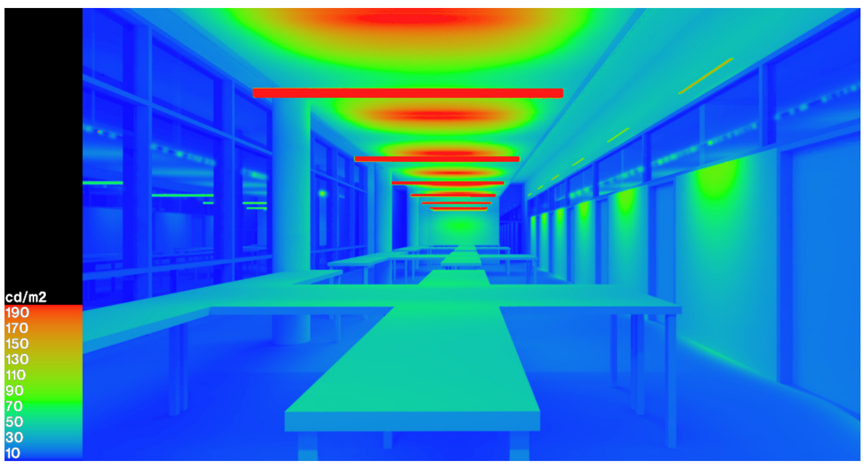
Falsecolor Luminance Map

LPD:: 0.44 W/sqft

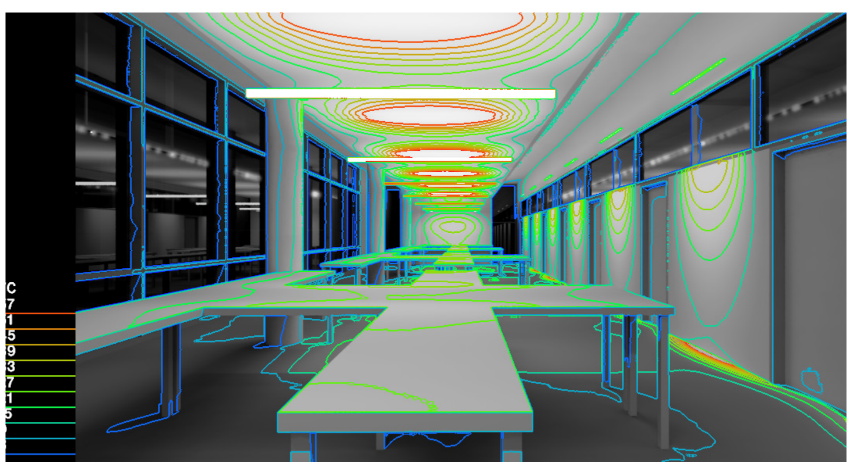


Add/E.2 Offices (Continued)

Perspective View Rendering



Falsecolor Luminance Map



Illuminance Contours

Add/E EFFICIENT ELECTRIC LIGHTING DESIGN EXAMPLES

3. LABORATORIES

IESNA 1993 Recommended horizontal Fc for Laboratories	75-100Fc
IESNA 2000 Recommended Horizontal Fc for Laboratories	50Fc
Labs 21 Standard Practice Benchmark for task + Ambient	80-100Fc
Labs 21 Better Practice" benchmark for ambient lighting	30Fc
Labs 21 "Better Practice" Benchmark for task	50Fc

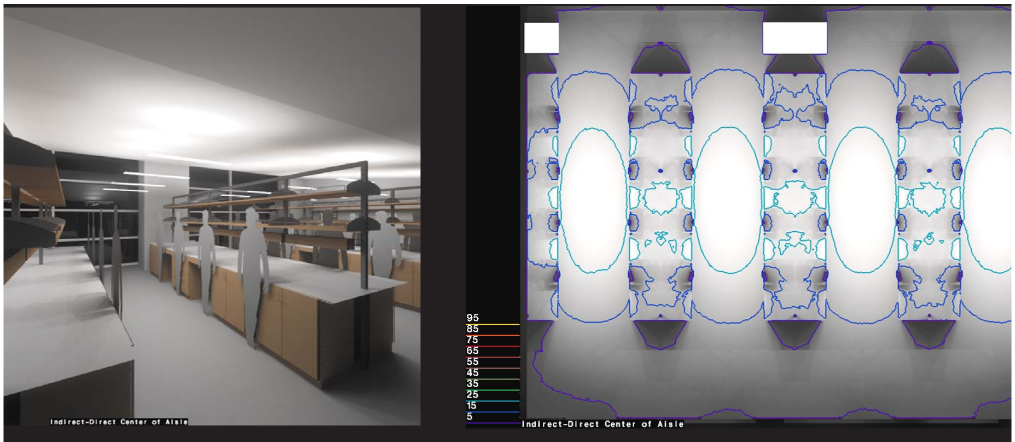
LPD:: 0.92 W/sqft

A. 100% INDIRECT PENDANTS CENTERED OVER AISLE

B. 100% INDIRECT PENDANTS AND UNDERCABINETS

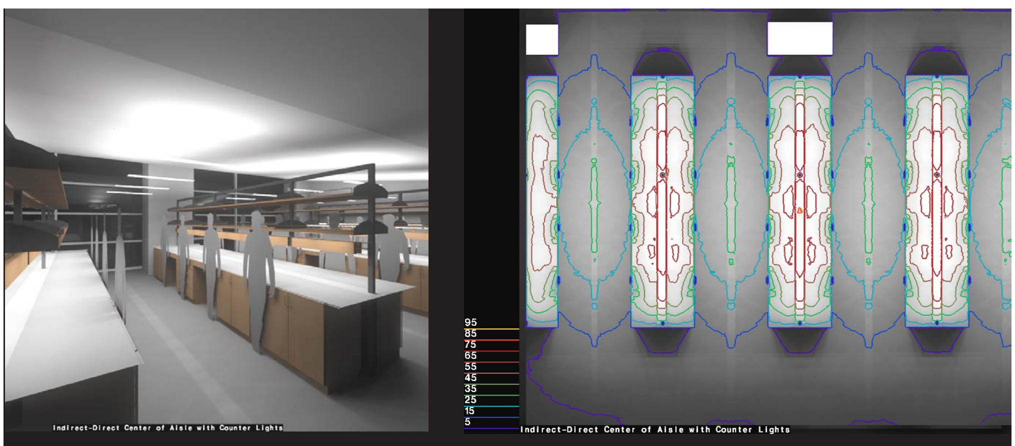
Add/E.3. Laboratories (Continued)

LPD:: 0.92 W/sqft



SHADOW STUDY 3: INDIRECT/DIRECT PENDANTS CENTER OF AISLE:
JUST AMBIENT LIGHT

LPD:: 0.92 W/sqft



SHADOW STUDY 3: INDIRECT/DIRECT PENDANTS CENTER OF AISLE:
WITH UNDERCABINET LIGHTS ON

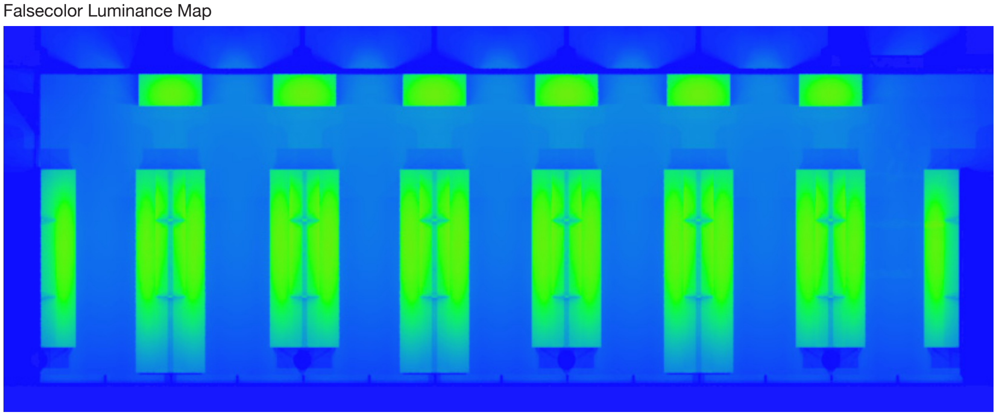
Ambient Lighting provided by daylight supplemented by indirect illumination with photo-sensor controls

Task lighting provided on the bench by LED fixtures with occupancy controls.

Add/E.3. Laboratories (Continued)

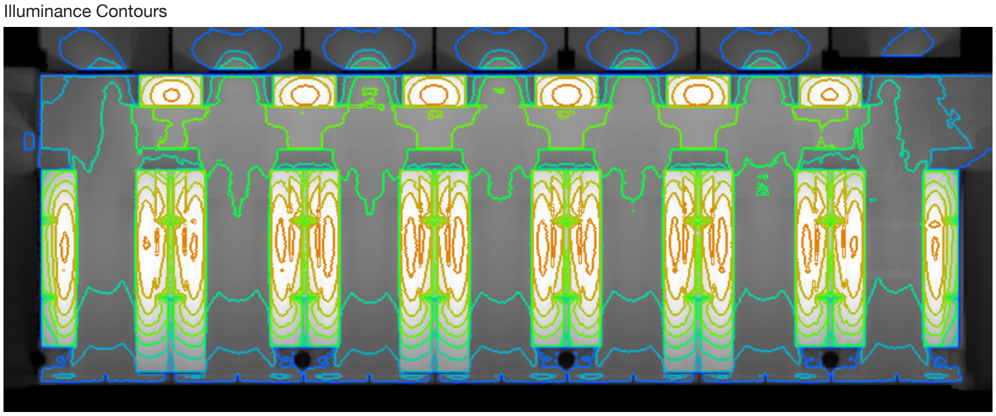
Top View Rendering

Falsecolor Luminance Map



CD/M²

Illuminance Contours

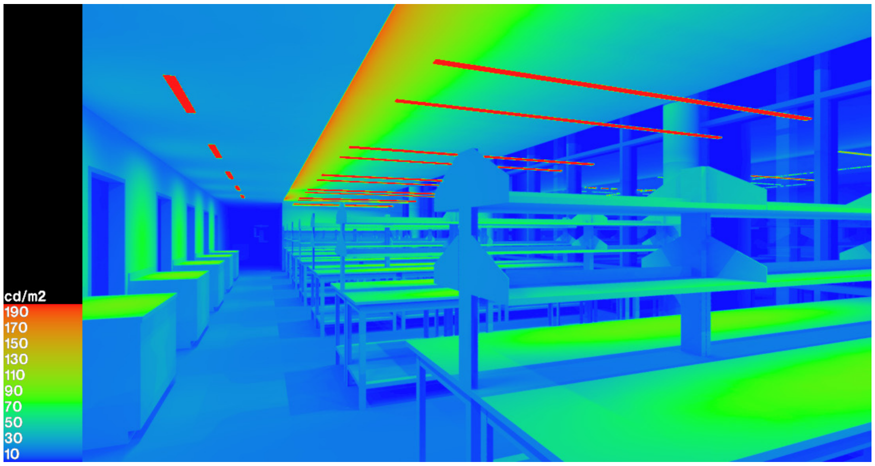


FOOTCANDLES

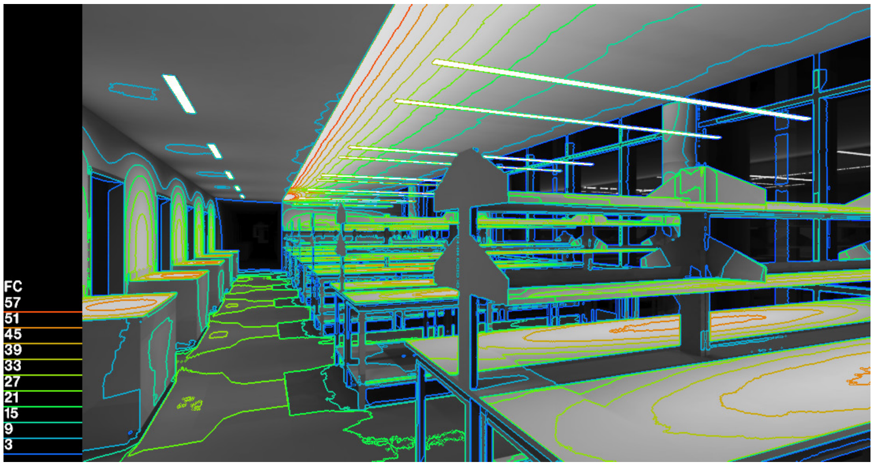
Note: Tasklights not included in simulation.
With tasklights, illumination levels on work surface will be increased by 40 to 60 footcandles, for a total of 60 to 100 footcandles.

Add/E.3. Laboratories (Continued)

Perspective View Rendering



Falsecolor Luminance Map



Illuminance Contours

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