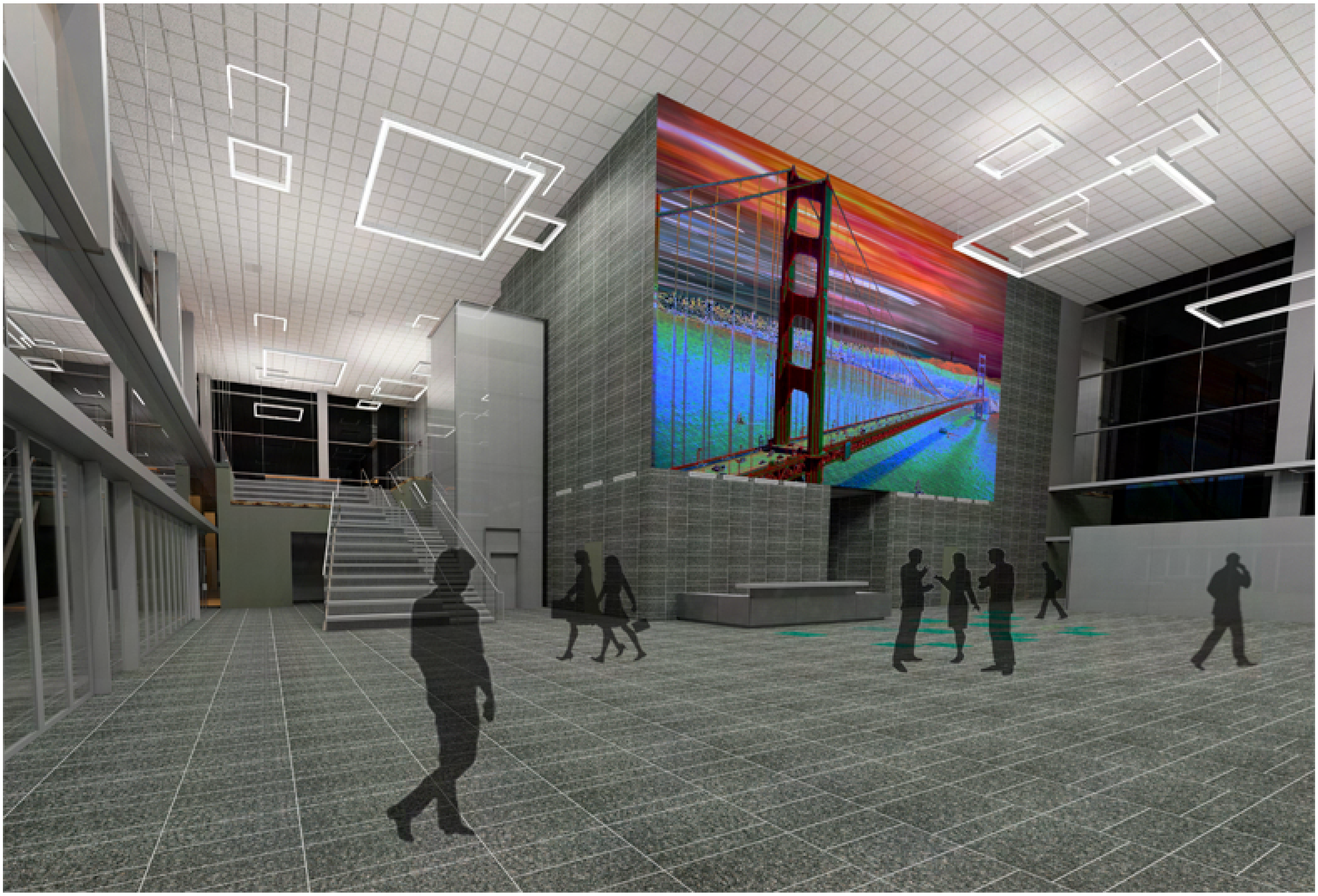
AEVITAS

UNENDING COMMITMENT TO INTEGRATED DESIGN



Taking an *integrated approach*, **AEVITAS** strives to *minimize environmental influences* by *engaging our community* with *sustainable* practices in energy conservation & emission reduction.

[ZERO**impact**]

ASCE Charles Pankow Foundation Annual Architectural Engineering Student Competition

Team Registration Number **03-2014**

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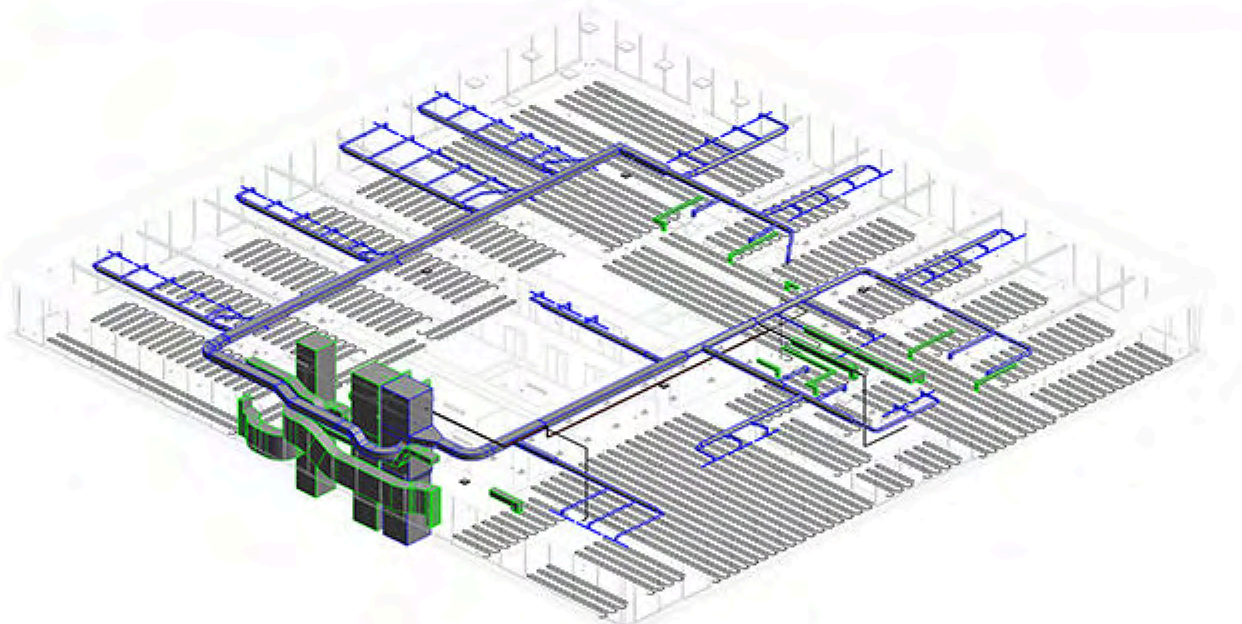

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MECHANICAL

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EXECUTIVE SUMMARY

The following report details the mechanical system design of 350 Mission, San Francisco.

With the end goal of designing a net-zero high-rise building in the heart of San Francisco, **AEVITAS** developed the overarching attitude of [ZERO**impact**], encompassing four design goals of [ZERO**interruption**], [ZERO**energy**], [ZERO**waste**], and [ZERO**emissions**]. Through integrated design analysis, **AEVITAS** achieves these goals through effective and efficient collaboration. **AEVITAS** is an integrated design team, composed of representatives from the construction, structural, electrical, and mechanical disciplines. Through a unified effort, 350 Mission's environmental impact has subsided. Information about the design of 350 Mission can be found in **AEVITAS**' reports as detailed in Table 1.

TABLE 1: SYSTEM OVERVIEW BREAKDOWN

ARCHITECTURAL	Floor Plan Changes, Vestibule Addition, Integrated Public Art Piece
FAÇADE	Natural Ventilation Louvers, Seismic Connections, Electrochromic Glazing
MECHANICAL	Radiant Floor System, Natural Ventilation Louvers, Dedicated Outdoor Air System
LIGHTING	LED Lighting, DALI Controls Responsive to Daylighting and Occupancy, Task Lighting
ENERGY GENERATION	Onsite Solar Array, Offsite Solar Array, Human Waste to Power Converter
ELECTRICAL	AC and DC Distribution, Natural Gas-Powered Fuel Cells, Dual Electrical Risers
STRUCTURAL	Steel Superstructure, Braced Frame Core, Composite Beams and Deck, Outrigger System, Concrete Substructure
CONSTRUCTION	Production Planning, Matrix Scheduling, Waste Management, BIM Execution Planning, Site Planning

350 Mission is located in the South of Market (SoMa) district of downtown San Francisco, a diverse neighborhood housing several prominent high rise buildings. The area is subject to microclimates and sub-microclimates due to the city's dynamic topography and marine layer.

Preliminary design identified energy efficient and sustainable mechanical systems and components that meet **AEVITAS**' objectives. Through energy conservation measures, life cycle cost (LCC) analyses, and energy performance, a mechanical system of primarily on slab radiant heating and cooling, dedicated outdoor air systems (DOAS), and natural ventilation proved energy efficient while integrating with the building design. This combination resulted in an 82% reduction of energy usage in comparison to the baseline building. The remaining energy usage is returned to the grid through a human-waste bioreactor, onsite solar collection, and offsite solar collection. The design offers a payback period of 10.6 years with a savings to investment ratio of 152%.

The indoor air quality analysis and acoustical analysis verify the positive contributions of the natural ventilation integration into the design. When open, the acoustical louvers have an NC-36 rating, slightly higher than the NC-35 standard. With regards to ASHRAE Standard 62.1 compliance, the office floors require 3500 CFM of outside air. Pressure differences draw the outside air into the space during natural ventilation conditions. Fire and smoke control, and robust design features provide analysis for limited building use and interruption in the case of emergency or seismic disturbance.

This approach allows successful reduction of the building's emissions, energy usage, waste, and interruption. Incorporating with the rest of the building, 350 Mission can achieve Platinum LEED accreditation. Balancing a net-zero design and an attainable life cycle cost results in an exceptionally energy efficient building, for both the owners and occupants.

TEAM DIRECTION: GOALS AND ATTITUDE

350 Mission is above all else, a collaboration. Through a joint effort, the concept of 'net-zero building' has grown to fully encompass the idea of green living and **AEVITAS** is on the forefront of this movement. In order to reach the infinite goals that are stemming from such sustainable building ideas, **AEVITAS** set out to define the way the team would approach 350 Mission. Provided with an established architectural design but a different set of owner goals, the team has been dedicated to making design decisions that reflect the new goals of the owner, as well as the community and future tenants. **AEVITAS** is a talented team comprised of eight individuals with varying educations and diverse experience including backgrounds in structural design, MEP systems design, and construction engineering and management.

For the *2014 ASCE Charles Pankow Foundation Annual Architectural Engineering Student Competition*, teams are challenged to embrace the "development and integration of innovative and original solutions to the design challenge." With an emphasis placed on "integration of the engineered systems and construction management plan for a high performance building."

When coming together as a unified design force, the team as a whole was adamant early on about developing something more than a set of goals, something that would enable our interconnected thought process throughout design – our over-arching attitude. This attitude would encompass all team-driven specifications, with the owner profile and competition goals providing direction. From these motives, [ZERO**impact**] was born. [ZERO**impact**] is the way the project team defines the sustainable practices that are driving design decisions and owner goal integration. Within this all-encompassing team attitude and a strong mission statement, there are four focus areas that the goals are derived from, as shown below in Figure 1.

Taking an *integrated approach*, **AEVITAS** strives to *minimize environmental influences* by *engaging our community* with *sustainable* practices in energy conservation and emission reduction.

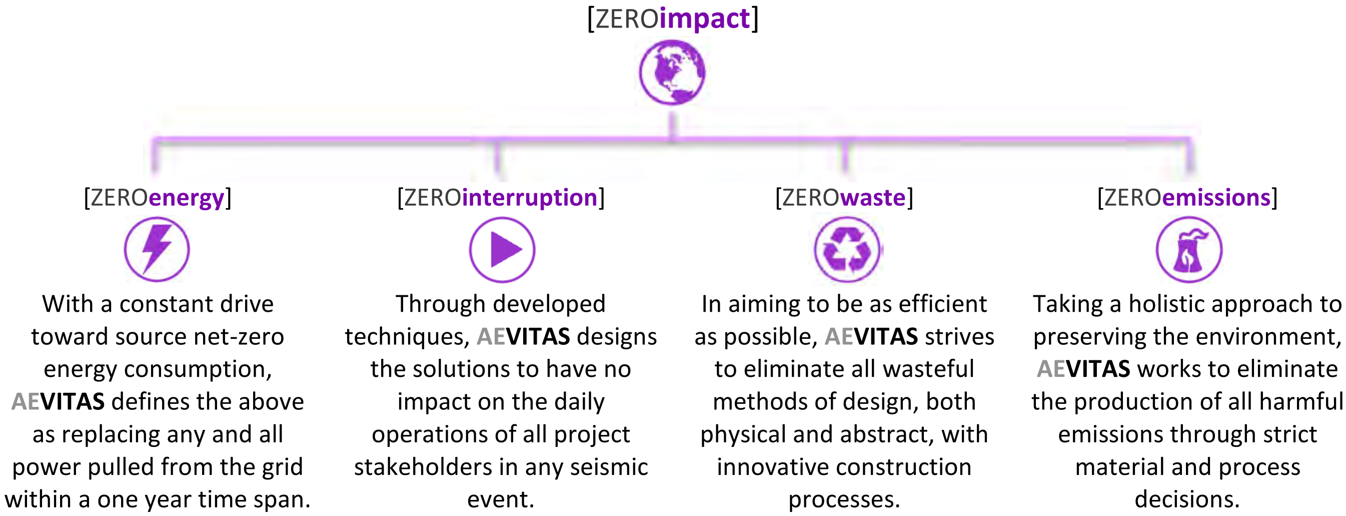


FIGURE 1: AEVITAS ATTITUDE WITH GOAL BREAKOUT

In the following report, **AEVITAS** has responded to the owner's goals to establish a building that is as close to having zero impact on all project stakeholders when possible. The symbols of the goals appear throughout the report to show the actions **AEVITAS** took to achieve these goals. As one cohesive team – with the project requirements established, the opinion of net-zero defined, mission statement created, and the attitude of [ZERO**impact**] applied – **AEVITAS** created the systems and solutions found in this report to achieve all goals of 350 Mission. Throughout all design and project decision making, application of the [ZERO**impact**] attitude was the ultimate driving force.

CODE ANALYSIS

350 Mission is designed to the following codes and standards found within the California Building Standards Code (California Title 24):

- 2010 California Mechanical Code and San Francisco Amendments
- 2010 California Plumbing Code and San Francisco Amendments
- 2010 California Energy Code and San Francisco Amendments
- 2010 California Fire Code and San Francisco Amendments
- California Green Building Standards Code (CALGreen)

California Title 24/California Energy Code is used in replace of AHSRAE Standard 90.1 for energy criteria. The California Green Building Standards Code (CALGreen) requires an additional 15% energy savings beyond the mandatory California Title 24 savings for green buildings.

ENVIRONMENTAL CONSIDERATIONS

San Francisco is located within California Building Climate Zone 3.[1] California Title 24 provides design conditions, taken from weather data 14 miles from 350 Mission at the San Francisco International Airport (SFO), as can be seen in Table 2. However, San Francisco is a city of microclimates due to its diverse topography and marine layer. Weather conditions taken from SFO can deviate from the actual conditions at 350 Mission. Actual Meteorological Year (AMY) wind data from the San Francisco Judiciary Building provides more accurate conditions, located only 0.2 miles from 350 Mission.

TABLE 2: SAN FRANCISCO DESIGN CONDITIONS

Season	*Warmest/Coldest Month*	*Design DB (0.2% Heating | 0.5% Cooling)*	*MCWB (0.5%)*
Heating	January	35° F	35° F
Cooling	July	83° F	64° F

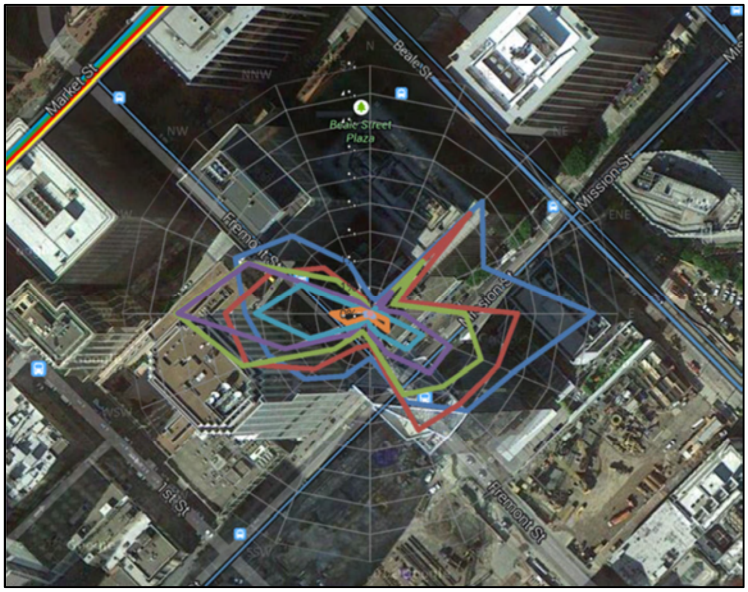


FIGURE 2: 350 MISSION WIND ROSE

Figure 2 provides graphical representation of wind direction and speed at the building site. The prevailing winds come from the East and West, while almost no wind is present in the North and South directions. Overlaid on an image of the site, the wind rose is used for preliminary analysis of wind power generation, natural ventilation, and façade design.

Figure 3 provides graphical representation of weather conditions at 350 Mission throughout the year. Weather conditions are comfortable in May through October, while the other six months require space heating. One-hundred percent outdoor air precooling can be optimized in May, June, and October, as cold nightly temperatures can precool the space before building occupancy during the day.

Diurnal temperature swings greater than nine degrees are present throughout the year. This provides opportunities to precool the building, thereby reducing energy usage and mechanical system operation.

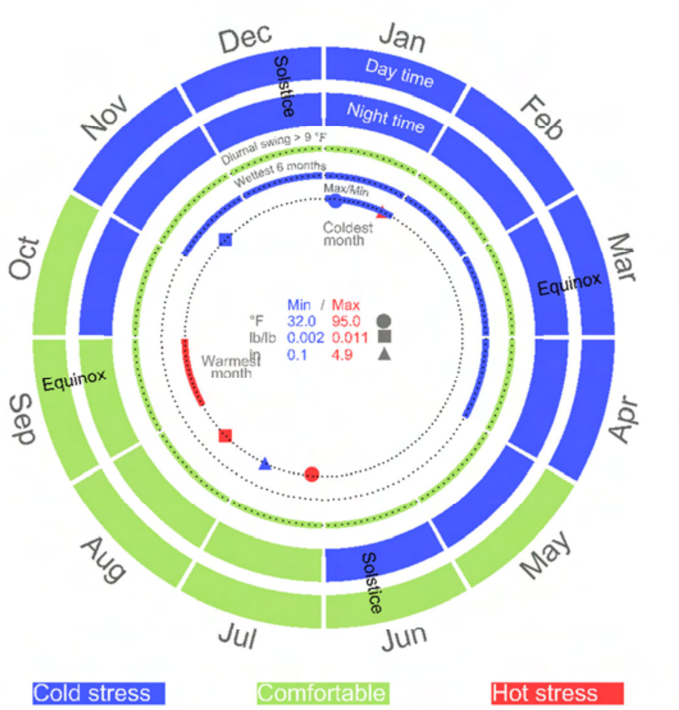


FIGURE 3: ANNUAL WEATHER CONDITIONS

ENERGY CONSERVATION MEASURES

Several sustainable, energy efficient initiatives were analyzed through Trane TRACE 700 paired with simple payback period analysis. In order to achieve a net-zero energy building, energy conservation measures were applied to the baseline model to lower the total energy usage. The energy conservation measures are additive, as each measure is applied in conjunction with the previous.

The energy usage of the baseline model is 19,410 MBtu/year, with a site Energy Use Intensity (EUI) of 48.3 kBtu/(sqft*year) and source EUI of 107.1 kBtu/(sqft*year). Through the first four energy conservation measures, the energy usage was reduced by 7,684 MBtu down to 11,726 MBtu. These measures result in a site EUI of 27 kBtu/(sqft*year) and source EUI of 77 kBtu/(sqft*year). The fifth energy conservation measure, the addition of a turbine to create cogeneration proves inefficient, as the energy required is exceedingly high. Therefore the first four measures are recommended, as they cumulatively lower the base model energy usage by 39.6%.

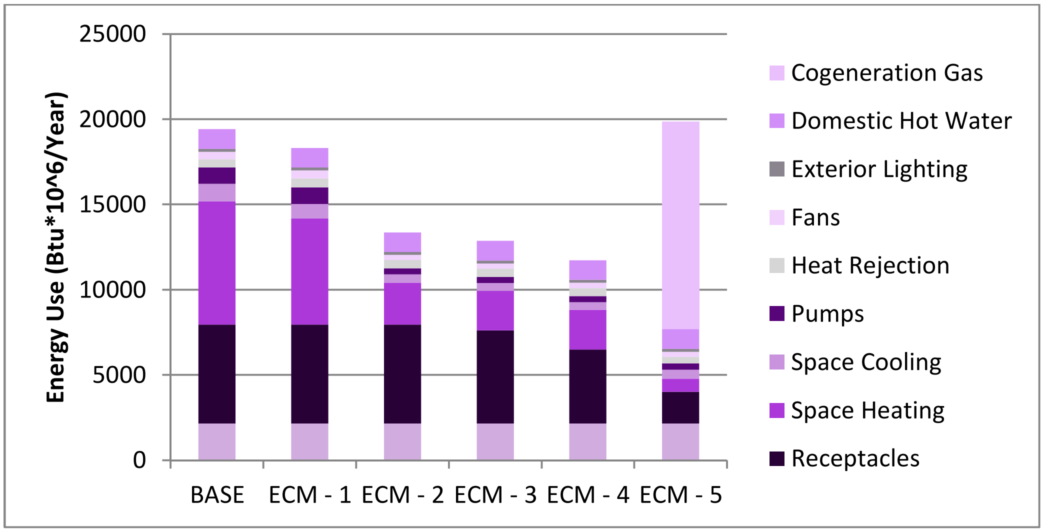


FIGURE 4: ENERGY CONSERVATION MEASURES

SIMPLE PAYBACK PERIOD

In addition to measuring the energy baseline savings, simple payback periods were used to provide feasibility analysis of the measures. This information can be seen in Table 3. The increased boiler efficiency, displacement UFAD + natural ventilation, and plug load control savings prove economically feasible, while the human waste converter has a payback period beyond the life span of the building; however, as an innovative component to meet the [ZERO**waste**] and [ZERO**emissions**] goals, alternative forms of the human waste converter have been pursued. For information about the human waste converter please refer to page 3 of the Electrical Report.

TABLE 3: ENERGY CONSERVATION MEASURES' SIMPLE PAYBACK PERIOD

	Energy Conservation Measure Description	Simple Payback Period
ECM - 1:	Increased Boiler Eff. (Condensing Boiler)	Payback: 5.15 years
ECM - 2:	Displacement UFAD + Natural Ventilation	Payback: Immediate
ECM - 3:	5-10% savings via Plug Load Controls	Payback: 3.56 years
ECM - 4:	8.8% savings via Human waste converter	Payback: 110.61 years
ECM - 5:	Cogeneration	Payback: Needs further investigation

MECHANICAL SYSTEM OVERVIEW

Based on the schematic design, UFAD displacement ventilation and natural ventilation systems were pursued. However, upon further analysis the energy savings were less than expected. To improve the situation, a dedicated outdoor air system coupled with natural ventilation is designed for required air distribution. The heating and cooling loads are accommodated through the use of a hydronic radiant system installed on top of the concrete floor slabs. These systems and the corresponding energy savings are detailed throughout the report.

ENERGY EFFICIENCY | ENERGY PRODUCTION

One of the major goals of this project is to develop a net-zero energy building. A key factor in achieving net-zero is limiting the energy use of the building by implementing a combination of high efficiency systems. These efficient systems include radiant heating and cooling, dedicated outdoor air supply, natural ventilation, improved glazing, condensing boilers, a human waste converter, a fuel cell, and on and off site photovoltaic panels. Through the use of all of these techniques, a source EUI of zero has been achieved. The energy use and production can be seen in Figure 5.

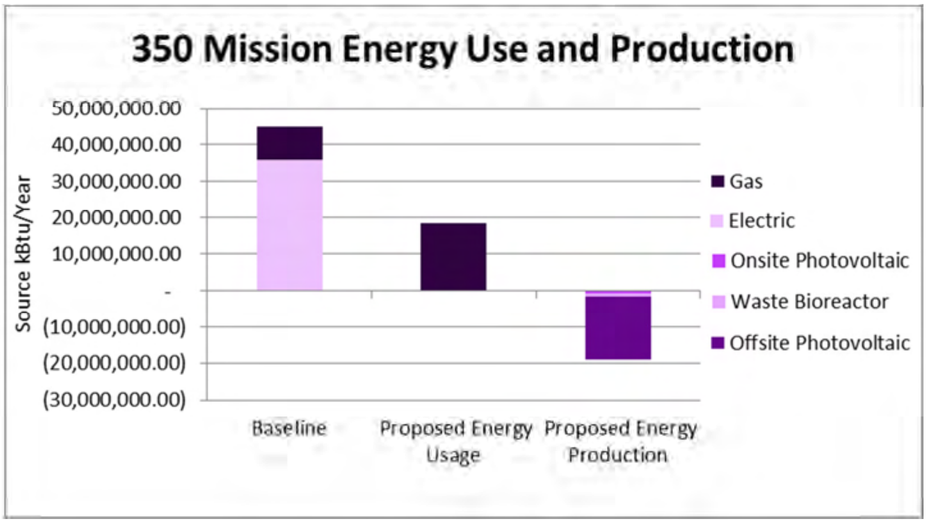


FIGURE 5: BASELINE AND PROPOSED ENERGY USE AND ENERGY PRODUCTION

A breakdown of the energy use by end-use can be seen on appendix page SD4 for both the baseline and proposed systems. For more information about the energy production measures employed please refer to page 11 of the Electrical Report.

LIFE-CYCLE-COST ANALYSIS

Not only does the design achieve a source EUI of zero, it achieves this major milestone while still offering the owner a competitive LCC. The proposed design utilizes an on-site natural gas and fuel cell combination to meet the buildings electrical and supplement the thermal loads. The use of natural gas is offset by the generation of electricity though the combination of the on-site and off-site methods. This important concept utilizes natural gas, which is less expensive than the generated electric sold to Pacific Gas and Electric (PGE) at a price of $0.10509/kWh maintained by California tariffs. Figure 6 shows energy use and production with regard to costs. A breakdown of the cost data, and assumptions can be found on appendix page SD5.

Based on the energy cost savings, government incentives, and PGE's tariff, a LCC was compiled. The results of the LCC analysis can be seen in Figure 7. The design offers a payback period ranging from 8.5 to 10.6 years depending on photovoltaic incentives, and offers a savings to investment ratio of 152%, when compared to the baseline building. This means that at the end of 20 years, 52% of a new mechanical system will already be paid for with the LCC savings.

TABLE 4: BASELINE AND PROPOSED ENERGY COSTS

		Baseline	Proposed
		Cost ($USD)	Cost ($Ud
Consumed (Supplied by PGE)	*Electric*	$ 588,389	-
	Gas	$ 79,260	$ 146,298
Produced On-Site	*Photovoltaic Panels*		$ (22,403)
	Waste Bioreactor		$ (30,542)
Produced Off-Site	*Photovoltaic Panels*		$ (531,670)
Total		**$ 667,650**	**$ (431,670)**
Savings Over Baseline		**--**	**$ 1,103,968**

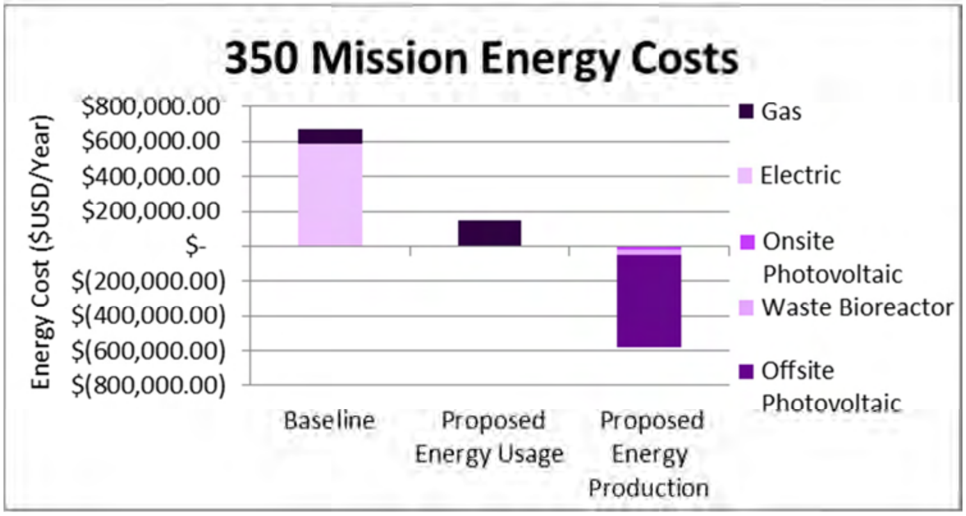


FIGURE 6: BASELINE AND PROPOSED ENERGY USE AND PRODUCTION COST COMPARISON

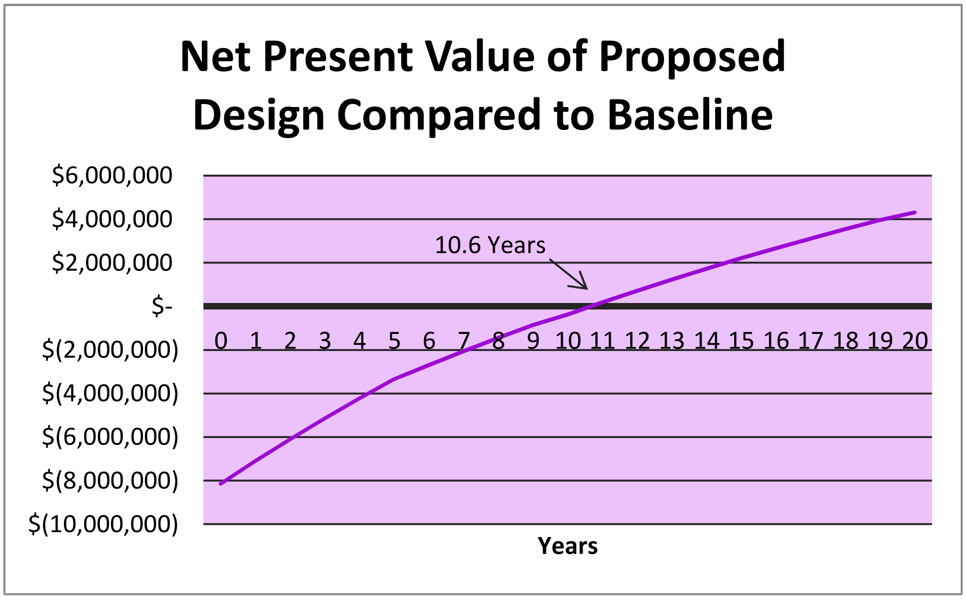


FIGURE 7: NET PRESENT VALUE OF PROPOSED DESIGN COMPARED TO BASELINE

COMFORT ANALYSIS

The use of occupancy controlled natural ventilation on the office floors offers great benefits with regard to energy savings; however, these benefits come with greater variance in ventilation airspeed, humidity, and temperature. **AEVITAS**' design controls these aspects, while delivering the required amount of ventilation air to the occupants.

The air velocity is directly related to the thermal comfort of the occupants. In order to achieve 3,500 CFM of ventilation, the exhaust system operates during the natural ventilation process, drawing outside air into the space through the louvers around the perimeter. Based on the ventilation air velocity required and the open area across the louvers, a face velocity was determined to be 12.3 FPM. According to ASHRAE Standard 55[2], this air velocity falls well within the "still air comfort zone," as seen in Figure 8, which meets the occupant comfort criteria. This is important because, while the correct quantity of air needs to enter the space, it cannot disrupt the occupants close to the louvers by creating drafts.

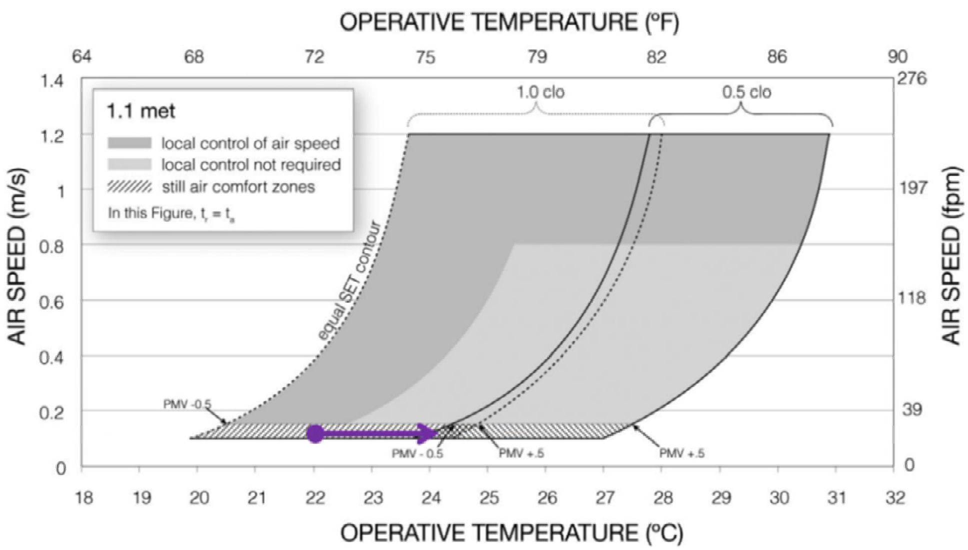


FIGURE 8: OPERATIVE TEMPERATURE AND AIR SPEED VERSE THERMAL COMFORT CHART

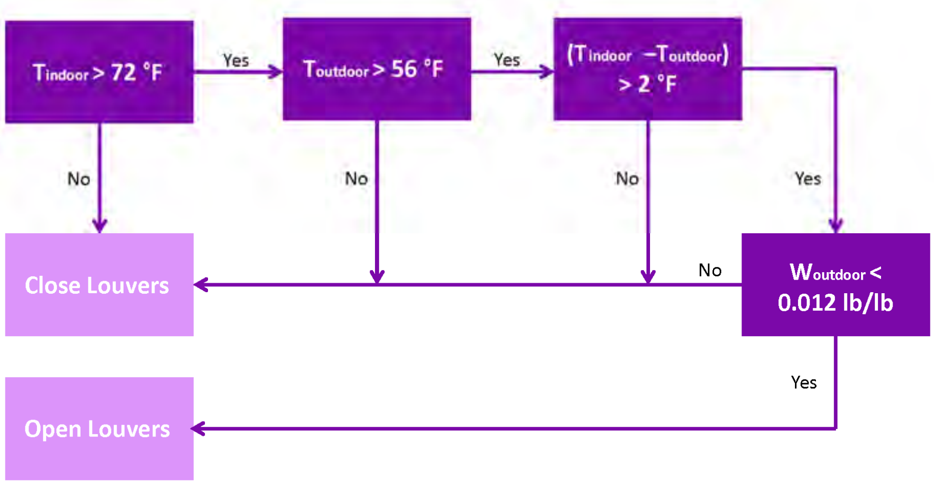


FIGURE 9: NATURAL VENTILATION LOUVER GOVERNING EQUATIONS

The natural ventilation process also must maintain appropriate temperature and indoor humidity to achieve a thermally comfortable environment. To successfully implement the natural ventilation scheme, a set of operating equations were written. They are highlighted in Figure 9.

The design does not use natural ventilation in the lobby due to the poor air quality at street level. A more conventional thermal comfort zone is implemented. The lobby is heated when the internal air temperature falls below 68° F and is cooled when the temperature rises above 75° F using on slab radiant heating and cooling.

INDOOR AIR QUALITY ANALYSIS

While indoor air quality is significant in all buildings, the presence of natural ventilation in 350 Mission creates a scenario that must be studied to ensure appropriate performance. LEED EQ Credit 2 requires a 30% increase in outdoor airflow over the ASHRAE Standard 62.1 ventilation rates. Ideally, this increase in natural ventilation frees the air of contaminates. But, given the urban location, this assumption cannot be assumed. Based on research, the air in San Francisco has been deemed acceptable for natural ventilation. However, further analysis was performed, and a model in CONTAM software was used to study the quality and quantity of outdoor air entering the building.

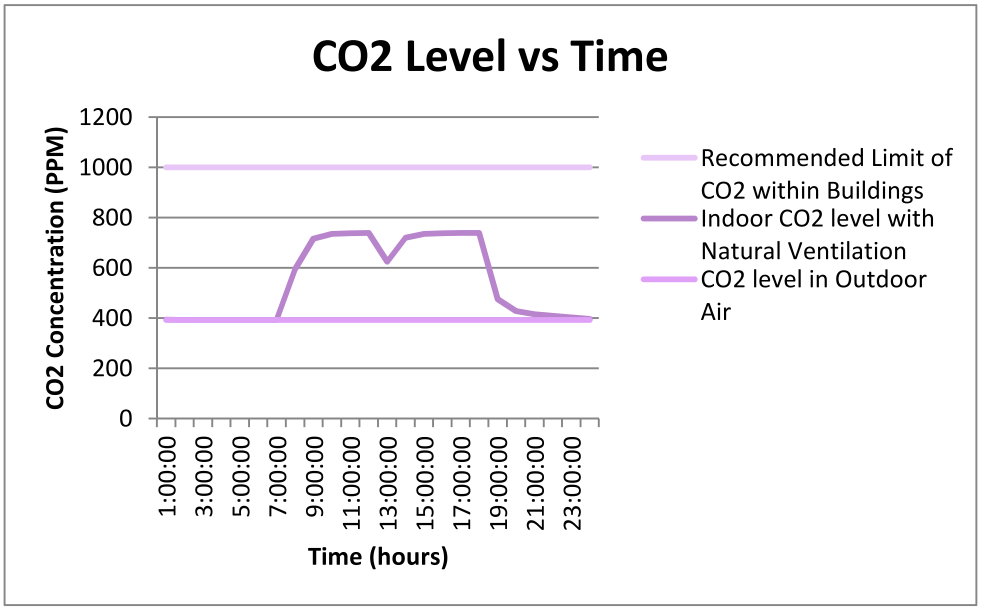


FIGURE 10: GRAPH OF CO2 LEVELS VERSE TIME WITH NATURAL VENTILATION IN EFFECT

Figure 10, depicts the CO_2 concentration within the open office during a typical business day. Based on the assumption of 392 parts per million (ppm) CO_2 in the outdoor air, the office space's CO_2 level does not exceed 739 ppm. This is well below the 1,000 ppm concentration that causes decreased work performance and productivity[3].

To ensure that the appropriate amount of outside air is drawn into the space during the natural ventilation cycle, an exhaust system needs to operate. This effectively creates a negative pressure within the space, drawing outside air through the dampers. Figure 11 depicts flow rates as modeled in CONTAM.

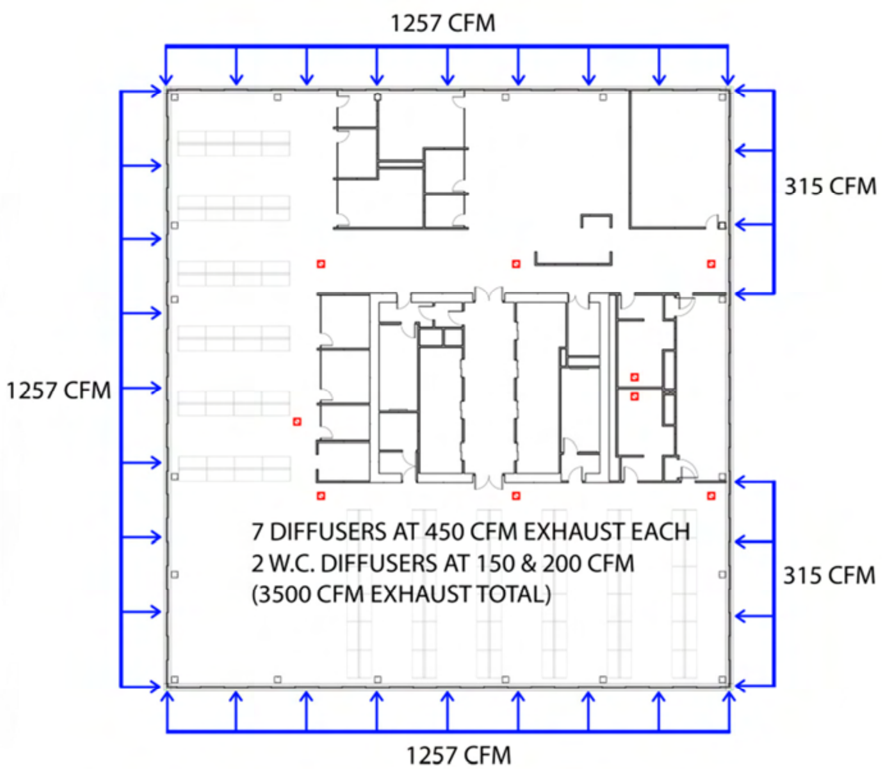


FIGURE 11: CONTAM RESULTS FOR NATURAL VENTILATION

ACOUSTICAL ANALYSIS

Another aspect of natural ventilation that must be taken into account is its effect on the indoor acoustical environment. While energy efficiency and thermal comfort are fundamental, acoustical comfort is of equal importance, despite an often overlooked aspect of design.

Incorporating natural ventilation into the mechanical system reduces energy use but raises acoustical issues. For instance, if the louvers are open, will traffic noise interfere with ongoing work? Further analysis, as seen below, was needed to answer this question.

Based on average traffic noise in business/commercial areas during daylight hours coupled with an emergency siren at 4000 Hz and knowing the distance from the street to the closest operable openings, the worst case average sound pressure level experienced within the space is calculated. Figure 12, located below, shows the results of this study.

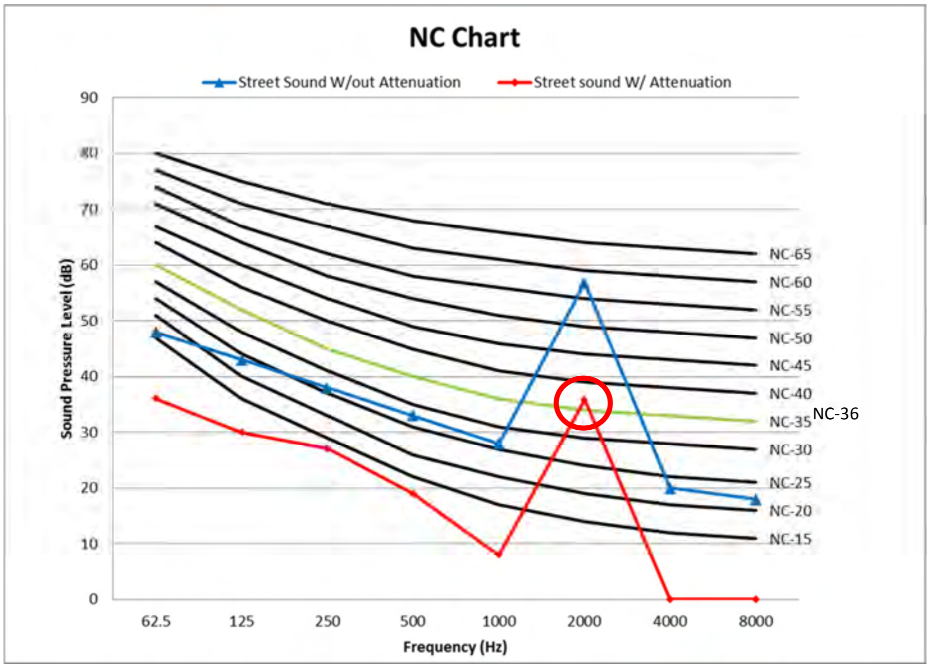


FIGURE 12: NOISE CRITERIA CHART SHOWING THE NC LEVELS WITH AND WITHOUT THE ACOUSTICAL LOUVERS

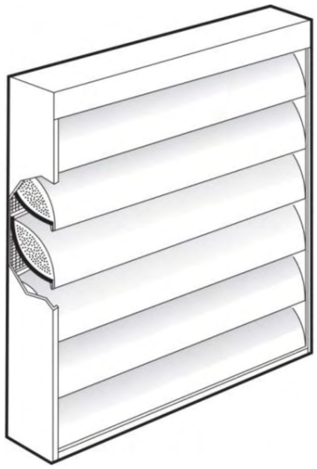


FIGURE 13: ACOUSTICAL LOUVERS WITH POROUS BACKING AND FILL[4]

The sound pressure levels at various frequencies should not exceed the Noise Criterion (NC) 35 curve. However, the 2000 Hz frequency level exceeds the NC-35 curve by nearly 25 dB. Therefore the space without attenuation is unacceptable.

To solve unacceptably high noise within the space, 6-inch acoustic louvers, as seen in Figure 13 are used. Table 5 shows the louvers attenuation at different frequencies. Through the use of the acoustic louvers, a NC-36 is achieved. This is slightly above the desired NC-35; however, it meets the occupant's expectations for a space that is directly open to the exterior environment.

TABLE 5: ACOUSTIC DATA FOR LOUVERS

Noise Reduction (dB re: 20µPa)						
125 Hz	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**	**8000 Hz**
12.0	13.0	11.0	14.0	20.0	21.0	22.0

FIRE AND SMOKE CONTROL

When dealing with high-rise buildings, smoke control becomes a very important factor in regards to occupant safety. To achieve and maintain a safe environment, multiple methods of smoke control design are implemented. The first of which is a "pressure-method" smoke control procedure.

Upon the sounding of the fire-alert system all external opens close and all mechanical systems utilizing outside air cease operation. This prevents smoke that is venting from the building from reentering the building at a different location. Per the California Building Code, 0.05 inches w.c. must be maintained between the fire origin site and all fire barriers. This pressure difference results in a low pressure fire site in relation to adjacent floors, preventing smoke from seeping through crack areas and contaminating other floors. This can be visualized in Figure 14.

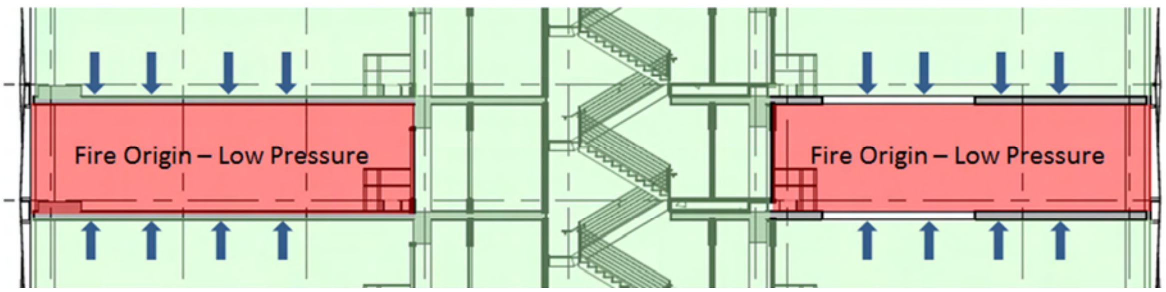


FIGURE 14: TOWER SMOKE CONTROL

Based on the crack-area of each office floor, 50,000 cubic feet per minute (CFM) must be exhausted from the fire-origin floor to maintain a 0.05 inch w.c. pressure difference. To achieve this, one duct rises from level 5 to the roof, where a smoke exhaust fan is located. This exhaust system maintains the 0.05 inch w.c. pressure difference, causes air to migrate from the non-fire zone to the fire zone, as illustrated in Figure 14.

The lobby, a 54 foot tall space, must be controlled through other methods. The California Building Code allows for large spaces to be controlled via "exhaust-method," when approved by a fire code official. **AEVITAS** believes this space qualifies as a "large enclosed volume, such as in atriums," and a code official would deem this application of the exhaust method appropriate.

TABLE 6: EXHAUST METHOD CALCULATION OUTPUT

Exhaust-Method Smoke Control		
Smoke Height	24	Ft
Steady State Heat Release Rate	1,500	Btu/Sec
Average Plume Temperature	161.2	^{0}F
Temperature of Smoke	116.6	^{0}F
Mass Flow Rate of Smoke	49.1	Lb./Sec
Smoke Exhaust Volume	42,800	CFM
Make-Up Air Volume	34,250	CFM

Based on the equations provided by the National Fire Protection Association's (NFPA) Standard 92B, a smoke-exhaust rate and make-up air rate are calculated. Table 6 summarizes the results of these calculations.

To maintain a smoke height of 24 feet above the floor 42,800 CFM must be exhausted from the lobby. There must also be 34,250 CFM of make-up air introduced into the space below the smoke height of 24 feet, and the make-up air cannot travel faster than 200 FPM. This is achieved through the 4 sets of double operable doors providing entrance to the lobby space.

Through the use of the pressure method on office levels and exhaust method in the lobby, 350 Mission appropriately accommodates a fire or smoke situation to ensure occupant safety and continuity of operation.

COMBINED HEAT AND POWER

Combined heat and power (CH&P) has been around for decades. If used correctly and under the right conditions it can reduce the source energy required by a building. As it pertains to 350 Mission, a CH&P system was considered in the early design phases. However, a more detailed analysis needed to be performed to validate its effectiveness.

Plausibility Analysis

To ensure that the use of CH&P in 350 Mission results in a tangible energy savings, and to determine the appropriate combustion process, an analysis was performed based on energy modeling output from IES Virtual Environment.

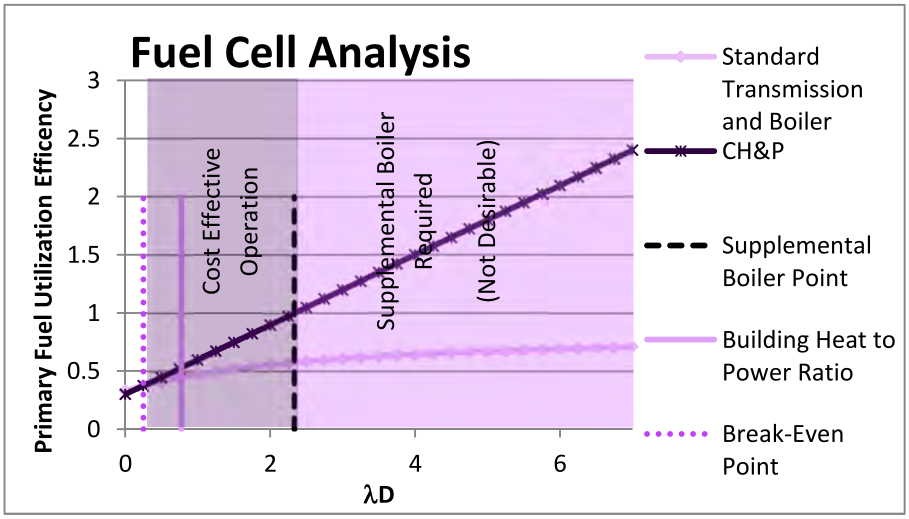


FIGURE 15: CH&P ANALYSIS SHOWING PRIMARY FUEL UTILIZATION EFFICENCY

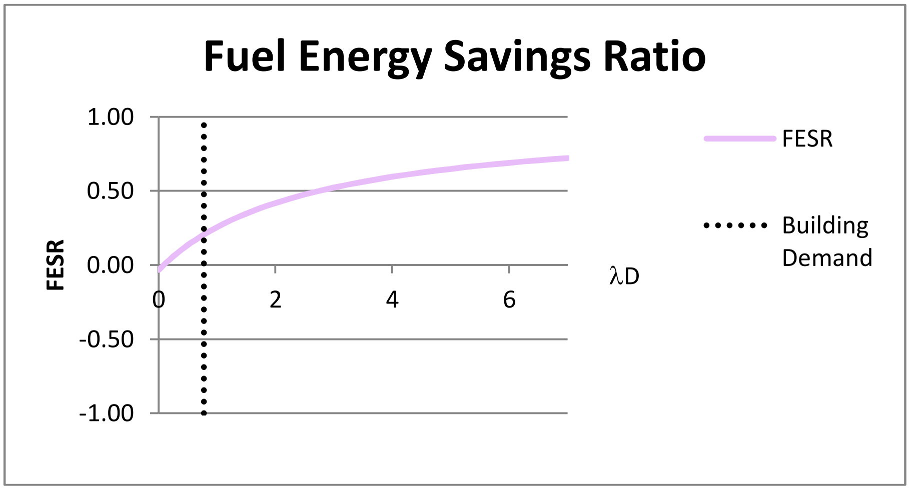


FIGURE 16: CH&P ANALYSIS SHOWING PRIMARY FUEL SAVINGS

350 Mission has an electrical demand on the order of 4,050 MBH and a heating demand of 3,160 MBH. From this information a heat to power ratio (λ_D) of 0.77 is determined for the buildings electrical and heat profile. Based on typical electrical grid efficiency of 31% and typical boiler efficiency of 80%[5], the primary fuel utilization efficiency for standard power distribution can be graphed with respect to λ_D. Additionally, assuming a typical efficiency for the combustion devices, a CH&P primary fuel utilization efficiency can also be graphed. The location at which these two lines cross is the "break-even point." The CH&P system must operate to the right of this intersection to save energy. Seen in Figure 15, the heat ratio is well within the desirable cost effective region.

Based on the analysis, the most suitable combustion process utilized by the 350 Mission CH&P system is a fuel cell, which provides the building with a 20% reduction in fuel energy required. This can be seen in Figure 16. Other prime movers were investigated; however, a fuel cell meets the building's thermal and electrical needs while also remaining in line with **AEVITAS**' goals of [ZERO**emissions**].

LAYOUT: TYPICAL OFFICE FLOOR

The offices' mechanical system is composed of two distinct components, thermal and ventilation. The thermal component encompasses the hydronic radiant heating and cooling loop located on top of the floor. The ventilation component includes both mechanical and natural ventilation. The thermostat control zones vary throughout the floor; enclosed spaces are controlled separately from the open office, as detailed on appendix page D5.

Thermal Component

Through energy modeling with IES Virtual Environment, it was determined that a radiant system offers the greatest energy savings over the baseline model. There are two types of radiant systems, ceiling mounted and floor mounted.

The ceiling mounted set-up has a few substantial drawbacks; the first being the weight. Since 350 Mission is located within a highly seismic area, it is unwise to increase the load above the occupied spaces. Secondly, there can be condensation issues with a radiant ceiling and natural ventilation operating at the same time in close proximity, due to San Francisco's humid climate. This phenomenon could cause the ceiling panels to drip on the occupants and equipment located within the space below.

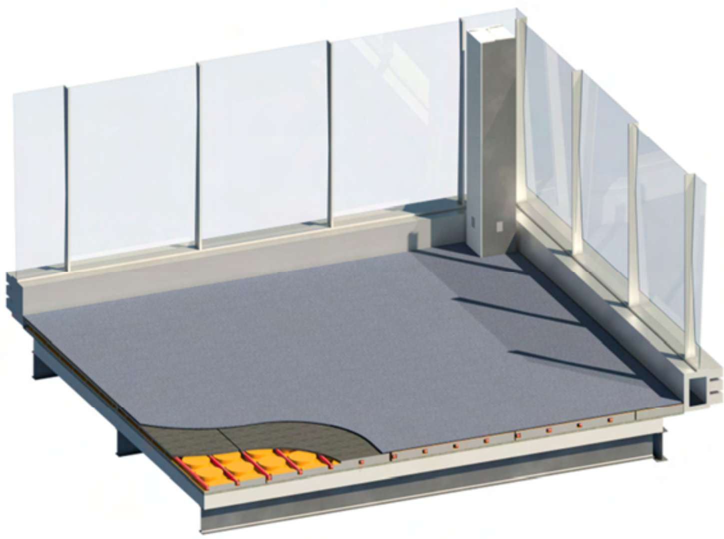


FIGURE 17: CUTAWAY SECTION OF RADIANT FLOORING

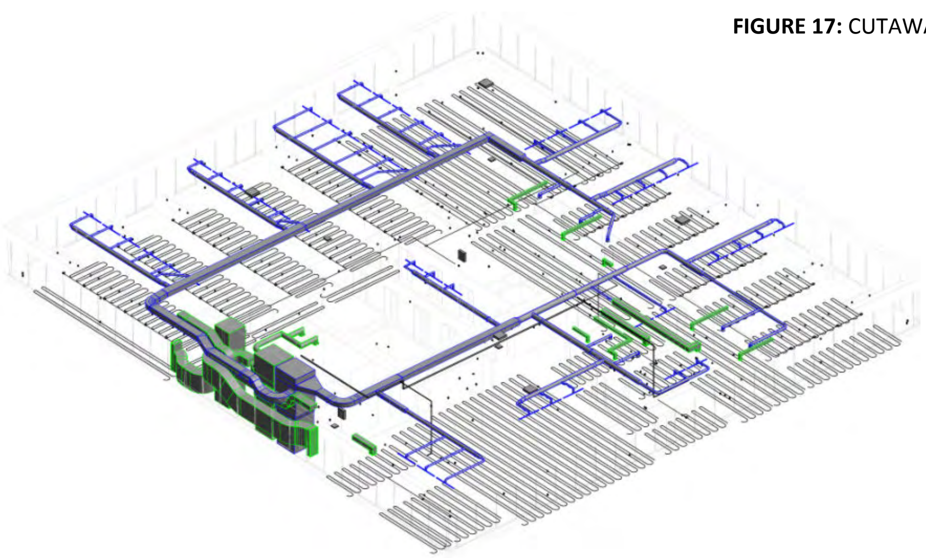


FIGURE 18: TYPICAL OFFICE MECHANICAL LAYOUT

The implementation of a hydronic radiant floor system, with changeover, utilizes less piping. Meeting a majority of the heating and cooling demand through the radiant system requires less overhead ductwork than a traditional system, thus reducing plenum space, materials, and cost. Additionally, from a constructability standpoint, a prefabricated radiant system allows for rapid installation of piping. The "sandwich" radiant floor construction is built on top of the poured concrete slab. See Figure 17 for a cutaway section of the system. Raised grid insulated panels create paths for the radiant tubing and a simple subfloor is placed on top. This system is more versatile than an embedded radiant system and allows for changes to the open office floor design.

Façade

The façade design utilizes electrochromic glass which changes throughout the day depending on incident solar radiation. This creates a very dynamic façade, and also influences the heating and cooling loads. However, since the heating equipment is sized at night on the coldest day of the year, and the cooling equipment is sized with a visible light transmittance of 64% (the peak transmittance allowed by the electrochromic glass) the heating and cooling plant are not under sized. The electrochromic glass is expected to lower the building's cooling load during the warmer months.

Ventilation Component

The second component of the offices' mechanical design is ventilation. This is done through two different media, mechanical and natural ventilation.

Mechanical Ventilation

The offices' require 3,500 CFM of outdoor air to maintain compliance with ASHRAE Standard 62.1. This outdoor air is brought into the building through two shafts. One shaft enters at the 3rd floor mechanical space and serves office floors 5-17. The second shaft enters through the roof and serves floors 18-30. The exhaust shafts for the office floors run in similar fashion. From the office floors' mechanical room the supply duct splits into two directions. This allows the use of smaller ducts while achieving the same amount of airflow. As seen in Figure 18, the exhaust for the floor is done through a plenum return.

Natural Ventilation

A section view of the design for the natural ventilation louvers can be seen in Figure 19. The louvered section of the wall is comprised of three pieces. The three outside components are the acoustic louvers, which are detailed in the "Acoustical Analysis" section of the report. The middle of the section includes actuators and adjustable louvers. Finally, a screen on the inside of the section offers a visually appealing finish to the system while adequately supplying air to the space.

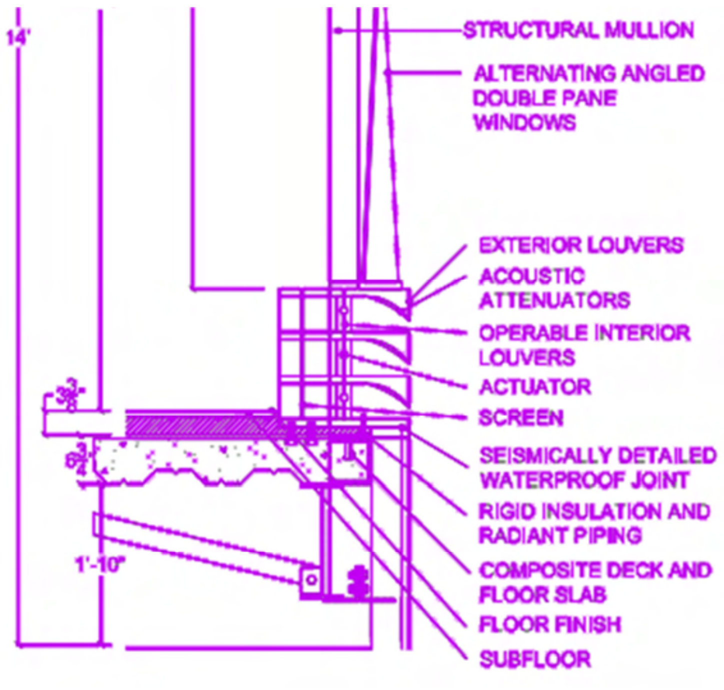


FIGURE 19: NATURAL VENTILATION SYSTEM SECTION

The natural ventilation louvers operate when weather permits, to supply outdoor air to rooms directly along the façade. Interior spaces are supplied through the DOAS mechanical system. Louvers open and close based on control sequences to allow outdoor air to enter directly into the space. This design reduces fan runtime, and energy consumption with respect to a typical mechanically ventilated system. A diagram of the control zones can be seen on appendix page D5.

LAYOUT: LOBBY

Similar to the office space, the lobby design is also comprised of radiant flooring. However, due to the unpredictable quality of the air at street level, natural ventilation is not used within the lobby level.

Radiant Flooring

The radiant floor design resulted in a slight energy reduction when compared to underfloor air distribution, and a very large energy reduction when compared to the baseline variable air volume system. The strongest benefit of the radiant system is that the heating and cooling occurs close to the occupants. This is especially important in tall spaces that have large volumes of air located above the occupied zone.

Mechanical Ventilation

The lobby ventilation air is drawn into a DOAS unit located in the 3rd floor mechanical room from the 5th floor roof. This roof is also where the lobby and loading dock exhaust exits the building, however, care was taken to minimize the possibility of crossover to the supply inlet. From the DOAS unit, the ventilation air takes two different paths to the lobby. One path serves the upper lobby, and the other serves the lower lobby and sales spaces. The ductwork in the lower lobby takes a unique path, through a specially designed plenum on the outskirts of the core. The diffusers connected to this duct can be seen in Figure 20. Running the duct at a low height on the wall breaks down the lobby to human scale and provides the fresh air directly to the occupied space.

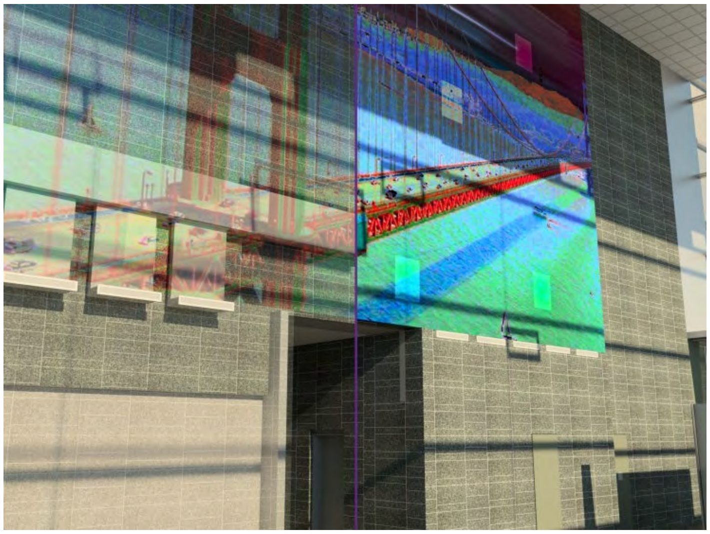


FIGURE 20: LOWER LOBBY DUCT SYSTEM WITH LOW SUPPLY DIFFUSERS

ROBUST DESIGN

In the case of a seismic event or natural disaster, 350 Mission will return to near immediate occupancy through robust mechanical design and [ZERO**interruption**] features. The mechanical heating and cooling plants are located in the mechanical penthouse, maximizing leasable space value as well as preventing possible flood and water damage. A 4800 gallon potable water storage tank is also located in the mechanical penthouse to allow for gravity based distribution throughout the building in case of power failure to the domestic water pumps, as shown in Figure 21 on the following page. The heating plant, consisting of 3 boilers, is sized such that two boilers produce 67% of the building's peak heating. The cooling plant, consisting of 3 chillers, is sized similarly, being able to produce 67% of the building's peak cooling load. The building rarely operates at full load, creating a scenario of redundancy. In regards to robust design, on slab radiant heating and cooling was chosen for occupant safety and durability. Overhead radiant ceiling panels and active chilled beams pose a potential collapse liability in the case of a seismic event and require additional structural support. Radiant floor heating and cooling grids are located on top of the structural slab, posing little risk to the occupants.

WATER CONSERVATION

Storm water collection, water use reductions, and recycled wastewater are integrated cohesively to meet the goal of [ZERO**waste**]. Through this three pronged approach, 350 Mission uses 65% less water than the California Building Code baseline. This reduction can be seen in Table 7 on the following page. Through the use of vacuum toilets and waterless urinals, water usage has decreased dramatically when compared to the baseline.

The vacuum toilets save 1.1 gallon per flush, and the waterless urinals save one gallon per flush[6]. The second prong of **AEVITAS**' water conservation design is the reuse of water already within the building systems. The proposed design incorporates unique showers that filter, clean and then recycle the water. This innovative feature offers both energy savings and water savings on the order of 80% and 90% respectively[7].

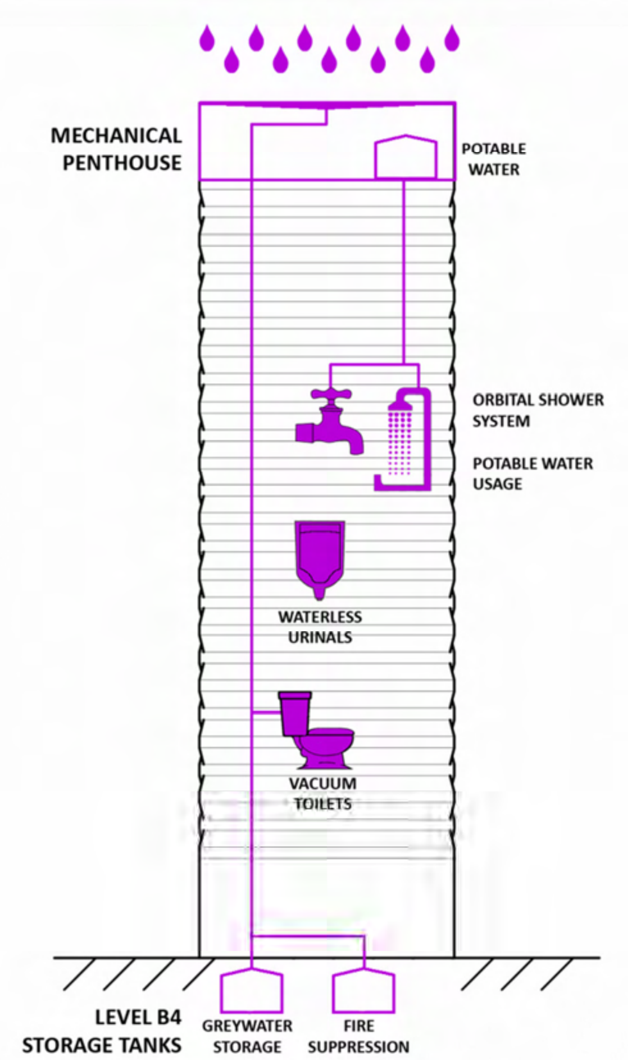


FIGURE 21: WATER CONSERVATION MEASURES

Per San Francisco code, 350 Mission is a zero runoff site, collecting one-hundred percent of the rainwater from the roof and feed it into grey water and fire suppression tanks, both stored on the B4 level. The fire suppression tanks are first filled to ensure adequate sprinkler water supply. Then grey water storage tank supplements the water needed for the vacuum toilets. San Francisco averages 23.63 inches of rain per year, with the majority of rainy days occurring during the winter season. Given the footprint of the 350 Mission, 646 US gallons of water will be collected on average per day. The vacuum toilets require 2,000 gallons per day, thus utilize both grey water and public utilities water. The grey water storage tanks can hold over 26,000 gallons of water, based on a 12 hour – 10 year storm.

TABLE 7: WATER CONSERVATION

Baseline	
Total	**19550 gallon/day**
Proposed	
Grey Water Total	2000 gallon/day
Potable Water Total	4800 gallon/day
Total	**6800 gallon/day**
Percent Savings	**65%**

Designing for [ZERO**interruption**], a 9,600 gallon potable water tank is located in the mechanical penthouse, supplying enough potable water for a two day period. In case of emergency, such as a seismic event, the storage tank supplies potable water throughout the building through a gravity-based system. A further breakdown of the water consumption, tank sizing, and rainwater collection can be found on appendix page SD12.

LEED ANALYSIS

Under the LEED 2009 for New Construction and Major Renovations Checklist, 350 Mission can achieve LEED Platinum Accreditation, accumulating 93 points out of a possible 110 points.

LEED accreditation is an acceptable method of determining high performance buildings. Energy cost analysis, combining onsite renewable energy and fuel cell energy generation results in a 84% energy cost reduction in comparison to the baseline model; 19 of 19 points can be achieved through the Energy and Atmosphere | Credit 1: Optimize Energy Performance, the largest singular LEED credit. Innovative water use technologies, including storm water collection and grey water usage can achieve 10 of 10 possible LEED points associated with Water Efficiency. In addition, Innovative waste water technologies and water use reduction are regional priorities in San Francisco, thus are worth two additional LEED credits. Increased ventilation, indoor air quality management, and thermal comfort also contribute to mechanical associated LEED credits. Pilot credits for LEED v4 are applied for Innovation and Design Process points, including acoustical analysis, and sustainable wastewater management plans. Further breakdown of 350 Mission's LEED points can be seen on appendix page SD18.

CONCLUSION

The underlying attitude of [ZERO**impact**] has guided the approach of the project through the four design goals of [ZERO**energy**], [ZERO**interruption**], [ZERO**waste**], and [ZERO**emissions**]. In conjunction with other building systems, the mechanical system selection and design effectively contributes to all four design goals while remaining economically feasible. The approach has culminated in a design that is beneficial to the environment, building occupants, and owner.

The system integration of radiant heating and cooling, dedicated outdoor air systems, natural ventilation and combined heat and power, results in an energy cost reduction of 84% in comparison to the baseline building. The remaining energy consumed is returned to the grid through both onsite and offsite green energy production including on-site and off-site solar collection, and the human waste to energy converter.

350 Mission operates with a source energy usage intensity of zero, saving 20,299,688 kBTU/year compared to the baseline building. This energy savings results in cost savings on the order of $1.1 million/year. The design surpasses California Building Standards Code (California Title 24) and is capable of achieving a LEED Platinum accreditation. These goals are met, without losing sight of the bottom line. Through the use of a LCC analysis a payback period of 10.6 years was determined, when compared to the code-minimum baseline building.

Indoor air quality analysis shows the effectiveness of the natural ventilation design, while also allowing for the incorporation of a 30% increase over the base ASHRAE Standard 62.1 ventilation requirements. The acoustical analysis further cemented the natural ventilation integration into the design, showing an achievement of NC-36 with the acoustical louvers open, and an achievement of the [ZERO**interruption**] goal. This NC value is only slightly higher than the suggested NC rating of NC-35; however, the difference is generally unperceivable.

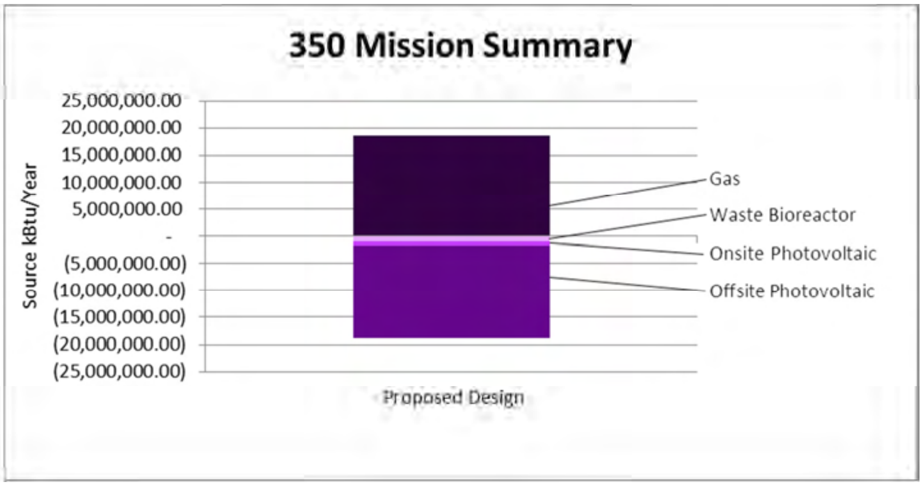


FIGURE 22: HOW NET-ZERO ENERGY IS REACHED

Water conservation measures and component selection has substantially reduced 350 Mission's water impact by 65% of the baseline consumption. This contributes to the design goal of [ZERO**waste**]. Grey water collection from captured rainwater further reduces the potable water use of the building to 4,800 gallons per day in comparison to the 19,550 gallons per day of the baseline water usage. Locating a potable water storage tank in the mechanical penthouse allows for a gravity based system in the event of a system failure, adding to the robust design goal of [ZERO**interruption**].

AEVITAS' design successfully achieves the design goals for 350 Mission. Through the implementation of efficient and effective system selection, design, team coordinate, and integration, the design balances energy efficiency and green practices with LCC, making 350 Mission a net-zero high-rise.

DESIGN TOOLS

Throughout the mechanical design process, a plethora of software was used. The following information with highlight the programs and detail their uses through the design process.

Trane Trace700:

Trane was used early on in the process determine simple payback periods and to perform quick investigations on different systems.

IES Virtual Environment:

After basic systems were selected, IES VE was used to further hone-in the design and determine a fine energy use for the building. It was also used in CFD modeling of the spaces to ensure proper temperature stratification within the room.

AIM Dynasonics Software:

This program was used to ensure the noise from natural ventilation and mechanical equipment will not interfere with ongoing work within the space.

AutoDesk REVIT 2014:

This program was used to layout piping, ductwork, and equipment. It was also used for clash detection between mechanical and structural systems.

eQuest:

After a comprehensive load and energy analysis in IES, eQuest was used to ensure code compliance with Title 24. eQuest is one of two accepted energy modeling programs in California (the other being Energy Pro).

Taco HVAC Design Solutions:

This program was used for hydronic system sizing and the creation of visuals.

Greenheck CAPS:

CAPS was used for selecting fans for the smoke control system.

SOM Environment Analysis Tool

This program was used to compare carbon emissions of the building through its life, with the baseline carbon emissions.

MECHANICAL POINT SYSTEM

		ZERO IMPACT GOALS				OWNER DRIVEN EVALUATION CRITERIA														
	SYSTEM DESCRIPTION	ENERGY	INTERRUPTION	WASTE	EMISSIONS	ENERGY QUANTITY	COST	SUSTAINABILITY	PHASEABILITY	INNOVATION	COMPLEXITY	SPACE NEEDED	MAINTENANCE	INTEGRATION	SITE/CLIMATE ISSUES	TEACHING	PRACTICALITY	LIFECYCLE	EFFECTIVENESS	RECOMMENDED?
Heating/Cooling	Radiant Slabs - Heating/Cooling Plant Located on Roof	++	+	0	+	0	+	+	+	+	--	0	-	+	-	0	++	+	++	YES
Heating/Cooling	Under Floor Air Distribution	+	0	0	+	0	-	+	+	+	-	-	0	0	0	0	+	+	+	NO
Ventilation	Natural Ventilation	++	+	++	++	0	-	++	+	0	-	0	-	+	-	+	++	+	++	YES
Ventilation	Dedicated Outdoor Air System	+	0	0	+	0	+	+	+	0	+	+	0	0	0	0	++	+	+	YES
Energy	Trigeneration	-	0	++	0	++	--	+	--	+	--	-	--	+	--	+	--	--	--	No
Energy	Cogeneration	-	0	+	0	++	--	+	--	+	--	-	--	+	--	+	--	--	--	No
Misc.	Improved Façade	+	0	0	+	0	--	+	0	+	0	0	0	++	-	0	+	0	+	YES
Misc.	Modular Equipment	0	0	0	0	0	++	0	++	-	+	+	++	+	0	0	+	+	0	YES
Misc.	Rain-Water Collection, Gavity Fed Graywater	0	+	++	+	0	0	++	+	-	+	--	0	+	+	+	+	+	+	YES

ALTERNATIVE MECHANICAL SYSTEMS MATRIX

Alternative Mechanical Component	Reason(s) for Rejection	Details
Trigeneration (Combined heat, cooling, and power)	Cost, energy consumption, issue of scale	Similar to cogeneration, the required turbine energy exceeds the baseline model's energy usage and will not pay off. 350 Mission does not generate excess heat to provide an absorption chiller.
Under floor air distribution (UFAD)	Feasibility	With an end goal of net-zero, through energy simulations, under floor air distribution did not lower energy usage in the building compared to radiant heating/cooling.
Chilled beams	Seismic concern	Active chilled beams in the ceiling with both heating and cooling coils require additional structural connections in case of a seismic event, increasing cost and construction coordination.
Geothermal wells	Cost, feasibility, seismic consideration	Geothermal wells require high installation costs and for 350 Mission's heating/cooling load, geothermal wells covering the building's footprint are not sufficient in energy generation. Drilling in a highly seismic region also risks induced seismic events.
Green roof	Cost, building site, issue of scale	While green roofs can reduce heat island effect and absorb rainwater, the size of 350 Mission's roof proves ineffective for green roofs in comparison to the use of photovoltaic energy generation. The higher initial investment and regular maintenance prove disadvantageous also.
Double skin façade	Cost, structural weight, daylighting limitations	A double skin façade provides additional thermal insulation and comfort but come at the significantly additional cost in construction, operation, and maintenance. The added weight to the building's structure increases stress on the columns and connections. The double skin decreases transmittance, complicating daylighting analysis and use of electrochromic glass on the façade. Energy model result accuracy with double skin facades varies as well.

Alternative Mechanical Component	Reason(s) for Rejection	Details
Solar thermal	Building site	Solar thermal arrays have been successfully implemented to preheat domestic water and other applications in buildings however, photovoltaic energy generation is more liable, effective, and efficient for 350 Mission.
Radiant Ceiling Panels	Condensation concern, seismic consideration	Integrating with natural ventilation, radiant ceiling panels pose condensation concerns, given San Francisco’s high humidity. Occupants may experience water dripping due to condensate collection on overhead panels. Due to seismic considerations, overhead mechanical components weighing 20 lbs or greater require additional structural support, adding to costs and construction time.

ENERGY USE BY END-USE

Through IES modeling, we were able to quantify the energy use for both the baseline and proposed systems. Below is a graphical representation of the energy uses, as well as components models.

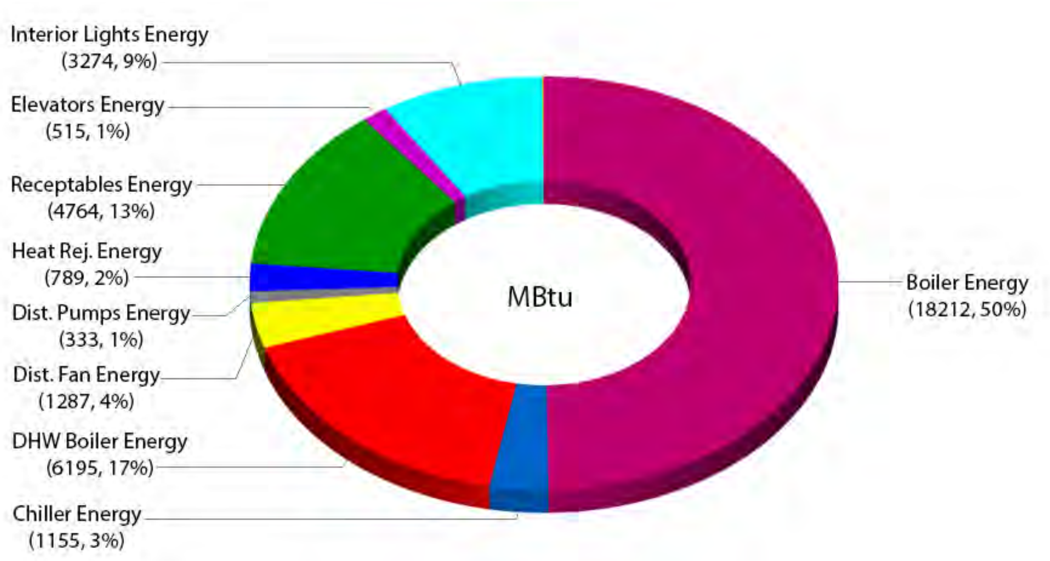


FIGURE 1: BASELINE ENERGY PER YEAR BY ENDUSE

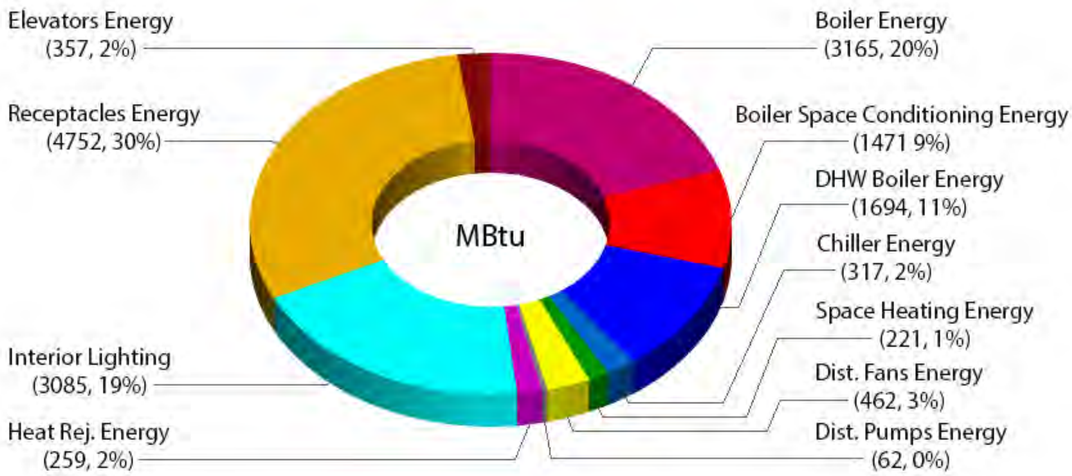


Figure 2: PROPOSED ENERGY PER YEAR BY ENDUSE

ENERGY SAVINGS | ENERGY PRODUCTION VS. COST

Based on our proposed design, 350 Mission will achieve a source EUI of 0. Below is the breakdown of energy use and energy generation as well as the baseline and proposed source and site EUI.

	Baseline		**Proposed**	
	Energy (kbtu)	cost ($)	Energy (kbtu)	cost ($)
Energy Used Onsite				
Electric	11,956,470	$ 588,389.96	-	$ -
Gas	8,343,218	$ 79,260.57	16,895,173	$ 146,297.23
Electric Produced Onsite				
Photovoltaic Panels			(662,423)	$ (20,402.70)
Waste Bioreactor			(991,613)	$ (30,541.78)
Total Energy Used From Grid	20,299,688	$ 667,650.53	15,241,137	$ 95,352.75
Electric Produced Offsite			(17,261,943)	$ (531,669.86)
Energy Use Deficit	20,299,688	$ 667,650.53	(2,020,805)	$ (436,317.11)
Site EUI	48.33		40.23	
Source EUI	107.08		(0.789)	

Source EUI Calculation	**Baseline**	**Proposed**
Electric Used (kbtu/ year)	11,956,470/.334	0
Gas Used (kbtu/ year)	8,343,218*1.1	16,895,173*1.1
Electric Produced (kbtu/ year)	0	(18,915,977)
Subtotal (kbtu/year)	44,975,353	(331,288)
Gross SQFT	÷ 420000	÷ 420000
Source EUI (kbtu/SQFT-year)	107.08	(0.79)

LIFE-CYCLE-COST DATA

The following data was the basis for our LCC analysis. Given that some of the proposed technology is new, cost data was difficult to find. In these instances, a conservative allowance was used.

Item	Cost	Source
Baseline Maintenance Cost	$0.446/sf	ASHRAE Maintenance Cost Data
Proposed Maintenance Cost	$0.74/sf	Allowance
Building Maintenance Cost	$0.512/sf	ASHRAE Maintenance Cost Data
Fuel Cell Maintenance Cost	$0.032/kWh	U.S. EPA Combined Heat and Power Partnership: Catalog of CHP Technologies
Photovoltaic batteries	$0.239/kWh-10 year	Solarbuzz.com
Baseline Mechanical System		
Boiler	$90789.00 ea.	RS Means Assembly
Cooling Tower	$262408.00 ea.	RS Means Assembly
Chiller	$225014.40 ea.	RS Means Assembly
VAV AHU	$145141.40 ea.	RS Means Assembly
VAV Terminal W/ Reheat 2000 CFM	$20690.30 ea.	RS Means Assembly
VAV Terminal W/ Reheat 400 CFM	$ 7100.80 ea.	RS Means Assembly
Proposed Mechanical System		
Boiler	$48048.40 ea.	RS Means Assembly
Cooling Tower	$262408.00 ea.	RS Means Assembly
Chiller	$225014.4 ea.	RS Means Assembly
CAV AHU	$111679.80 ea.	RS Means Assembly
Radiant System	$12000000.00	Allowance
Fuel Cell	$7000000.00 (6mil. Incentive)	See Electrical Report
Photovoltaic	$5,475,000.00 (30% Incentive)	See Electrical Report
Human Waste To Power Converter	$1000000.00	Allowance

Rate	Percent (%)	Source
Discount	8.00	NISTIR 85
Electricity	3.75	NISTIR 85
Natural Gas	5.00	NISTIR 85
Maint. And Labor	1.73	NISTIR 85
Materials	1.73	NISTIR 85

Based on the Pacific Gas and Electric Tariff data, we were able to determine a rate at which electricity can be sold back to the grid. This information can be found in the figure below.

ELECTRIC SCHEDULE E-SRG Sheet 3
SMALL RENEWABLE GENERATOR PPA

SPECIAL CONDTIONS: (cont'd)

6. The Market Price Referent (MPR) is stated in the table below, which the Commission approved in Resolution E-4442, effective December 6, 2011. (T) (T)

Adopted 2011 Market Price Referents (N)
(Nominal - dollars/kWh)

Resource Type	10-Year	15-Year	20-Year
2012 Baseload MPR	0.07688	0.08352	0.08956
2013 Baseload MPR	0.08103	0.08775	0.09375
2014 Baseload MPR	0.08454	0.09151	0.09756
2015 Baseload MPR	0.08804	0.09520	0.10132
2016 Baseload MPR	0.09156	0.09883	0.10509
2017 Baseload MPR	0.09488	0.10223	0.10859
2018 Baseload MPR	0.09831	0.10570	0.11218
2019 Baseload MPR	0.10186	0.10928	0.11587
2020 Baseload MPR	0.10550	0.11296	0.11965
2021 Baseload MPR	0.10916	0.11675	0.12354
2022 Baseload MPR	0.11299	0.12067	0.12752
2023 Baseload MPR	0.11691	0.12469	0.13160

(N)

LIFE CYCLE COST DATA (CONT)

Life Cycle Cost Analysis	Project Information	
Options Comparison	Building	350 Mission St.
Input Table	Project Name	AEVITAS Thesis
Date January 15, 2014	Project Type (lighting, heating, etc)	HVAC system

Costs

	BASELINE				Proposed			
Initial Costs								
	Total Cost	$ 10,989,149			Total Cost	$ 26,779,952		
	Incentives	$ -			Incentives	$ 7,642,500		
	Net Costs	**$ 10,989,149**			**Net Costs**	**$ 19,137,452**		
Replacement Costs								
	Expected Life (Years)	20			Expected Life (Years)	20		
	Replacement Cost	$ 10,989,149			Replacement Cost	$ 26,779,952		
One Time Operating Costs								
		Materials	Labor	Total		Materials	Labor	Total
FY14	Year 1	$ 178,400	$ 250,000	$ 428,400	Year 1	$ -	$ 400,000	$ 400,000
FY15	Year 2	$ 178,400	$ 250,000	$ 428,400	Year 2	$ -	$ 400,000	$ 400,000
FY16	Year 3	$ 178,400	$ 250,000	$ 428,400	Year 3	$ -	$ 400,000	$ 400,000
FY17	Year 4	$ 178,400	$ 250,000	$ 428,400	Year 4	$ -	$ 400,000	$ 400,000
FY18	Year 5	$ 178,400	$ 250,000	$ 428,400	Year 5	$ -	$ 400,000	$ 400,000
FY19	Year 6	$ 178,400	$ 250,000	$ 428,400	Year 6	$ 294,400	$ 400,000	$ 694,400
FY20	Year 7	$ 178,400	$ 250,000	$ 428,400	Year 7	$ 294,400	$ 400,000	$ 694,400
FY21	Year 8	$ 178,400	$ 250,000	$ 428,400	Year 8	$ 294,400	$ 400,000	$ 694,400
FY22	Year 9	$ 178,400	$ 250,000	$ 428,400	Year 9	$ 294,400	$ 400,000	$ 694,400
FY23	Year 10	$ 178,400	$ 250,000	$ 428,400	Year 10	$ 480,820	$ 400,000	$ 880,820
FY24	Year 11	$ 178,400	$ 250,000	$ 428,400	Year 11	$ 294,400	$ 400,000	$ 694,400
FY25	Year 12	$ 178,400	$ 250,000	$ 428,400	Year 12	$ 294,400	$ 400,000	$ 694,400
FY26	Year 13	$ 178,400	$ 250,000	$ 428,400	Year 13	$ 294,400	$ 400,000	$ 694,400
FY27	Year 14	$ 178,400	$ 250,000	$ 428,400	Year 14	$ 294,400	$ 400,000	$ 694,400
FY28	Year 15	$ 178,400	$ 250,000	$ 428,400	Year 15	$ 294,400	$ 400,000	$ 694,400
FY29	Year 16	$ 178,400	$ 250,000	$ 428,400	Year 16	$ 294,400	$ 400,000	$ 694,400
FY30	Year 17	$ 178,400	$ 250,000	$ 428,400	Year 17	$ 294,400	$ 400,000	$ 694,400
FY31	Year 18	$ 178,400	$ 250,000	$ 428,400	Year 18	$ 294,400	$ 400,000	$ 694,400
FY32	Year 19	$ 178,400	$ 250,000	$ 428,400	Year 19	$ 294,400	$ 400,000	$ 694,400
FY33	Year 20	$ 178,400	$ 250,000	$ 428,400	Year 20	$ 480,820	$ 400,000	$ 880,820
	Totals	**$ 3,568,000**	**$ 5,000,000**	**$ 8,568,000**	**Totals**	**$ 4,788,840**	**$ 8,000,000**	**$ 12,788,840**
	Yr 20 Remaining Equip. Value			**$ -**	**Yr 20 Remaining Equip. Value**			**$ -**

Annual Consumption

	BASELINE		Proposed	
	Annual Consumption	Cost ($)	Annual Consumption	Cost ($)
Electricity	3,504,241	$ 588,390	-5,543,956	$ (582,614.34)
Natural Gas	83,432	$ 79,260.57	168,952	$ 146,297.23
	TOTALS	**$ 667,651**	**TOTALS**	**$ (436,317)**

Assumptions

Discount Rate	Escalation Rates				
	Electricity	Natural Gas	Materials	Maint. and Labor	Study Period
8.00%	3.75%	5.00%	**1.73%**	**1.73%**	**20**

LIFE CYCLE COST DATA (CONT)

Life Cycle Cost Analysis	**Project Information**	
Options Comparison	**Building**	350 Mission St.
Results Table	**Project Name**	AEVITAS Thesis
Date January 15, 2014	**Project Type (lighting, heating, etc)**	HVAC system

Baseline 20 Year Total Cost of Ownership (TCO)	**Cost to Own**
	$ 24,350,582

Proposed Design

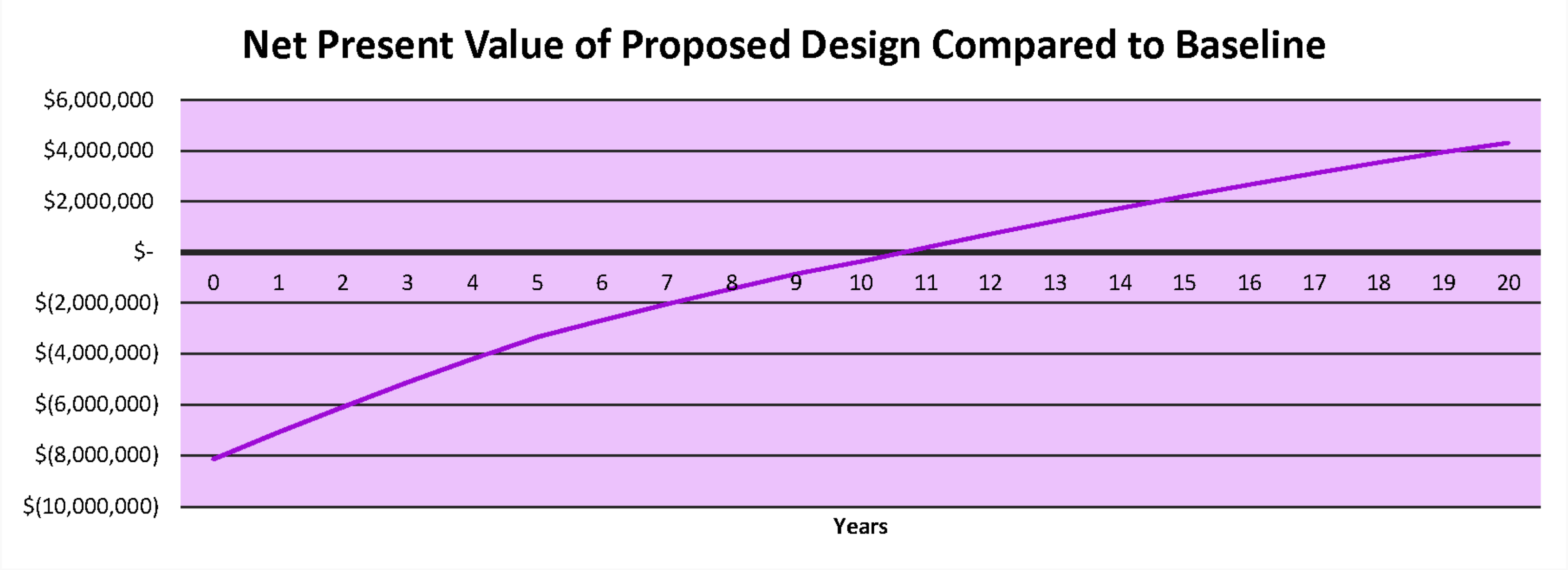
	Cost/Savings Variable Cost Only
20 Yr Total Cost of Ownership	**$ 20,040,069**
20 Yr Net Present Value (NPV)	**$ 4,310,513**

Simple Payback Analysis

	Cost/Savings Variable Cost Only
First Year Utility Savings (FY14 rates)	$1,103,968
Simple Payback Period (Years)	7.38
First Year Return on Investment	13.5%

Life Cycle Cost Metrics

	Cost/Savings Variable Cost Only
20 Year Savings to Investment Ratio	1.52
Discounted Payback Period (Years)	See Graph
Adjusted Internal Rate of Return	14.0%



VENTILATION CALCULATIONS

Building:	VAV - Lobby Area
System Tag/Name:	AHU-1
Operating Condition Description:	100% Open
Units (select from pull-down list)	IP

Inputs for System	**Name**	**Units**	**System** (w/o diversity)		**Diversity**	**System** (w/ diversity)
Floor area served by system	**As**	sf	13730			
Population of area served by system	***Ps***	P	935	D	100%	935
Design primary supply fan airflow rate	**Vpsd**	cfm	7,455	D	100%	7,455
OA req'd per unit area for system (Weighted average)	**Ras**	cfm/sf	0.10			
OA req'd per person for system area (Weighted average)	**Rps**	cfm/p	5.8			
Outdoor air intake provided for system	OA	cfm				

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

	Name	Units	Note	Potentially Critical Zones									
Zone Name				**Electical Room**	**Exit Passageway**	**Service Lobby**	**Lobby**	**Retail**	**Office**	**Corridor**	**Mechanical Room**	**Lobby**	***Restaurant***
Zone Tag				**105**	**107**	**103**	**101**	**113**	**110**	**208**	**206**	**215**	**209**
Occupancy Category			Select from pull-down list:	**Electrical equipment rooms**	**Corridors**	**Lobbies**	**Lobbies**	**Sales**	**Office space**	**Corridors**	**Electrical equipment rooms**	**Lobbies**	**Restaurant dining rooms**
Floor Area of zone	*Az*	sf		109	428	89	5,351	655	85	457	225	2,107	4,224
Design population of zone	*Pz*	P	(default value listed; may be overridden)	0	0	13.35	300	9.825	0.425	0	0	316.05	295.68
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm		6	33	200	1,518	127	50	50	325	1,423	3,723
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A:										
Frac. of local recirc. air that is representative of system RA	*Er*			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Inputs for Operating Condition Analyzed	Name	Units	System										
Percent of total design airflow rate at conditioned analyzed	**Ds**	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list:		FSCR LV	CSCRH	CSCRH	FSCR LV	FSCR LV	CSCRH	FSCR LV	CSCRH	FSCR LV	CSCRH
Zone air distribution effectiveness at conditioned analyzed	*Ez*			1.20	0.80	0.80	1.20	1.20	0.80	1.20	0.80	1.20	0.80
Primary air fraction of supply air at conditioned analyzed	*Ep*												

Results of Minimum ASHRAE 62.1 Ventilation Rate Procedure (EQp1)			
System Ventilation Efficiency	*Ev*		**0.91**
Outdoor air intake required for system (EQp1)	*Vot*	cfm	**7,454**
Outdoor air per unit floor area	*Vot* /As	cfm/sf	**0.54**
Outdoor air per person served by system (including diversity)	*Vot* /Ps	cfm/p	**8.0**
Outdoor air as a % of design primary supply air	Ypd	%	**100%**

Results of 30% Increase beyond ASHRAE 62.1 Ventilation Rate Procedure (EQc2)				
System Ventilation Efficiency with 30% increase (EQc2)	*Evz30*		**0.89**	Critical zone needs more ventilation
Outdoor air intake required for system with 30% increase (EQc2)	*Vot30*	cfm	**>100%**	**More than 100% outside air is required based on conditions provided**
Outdoor air per unit floor area for system with 30% increase (EQc2)	*Vot30* /As	cfm/sf		
Outdoor air per person served by system (including diversity) (EQc2)	*Vot30* /Ps	cfm/p		
Outdoor air as a % of design primary supply air (EQc2)	Ypd30	%		

VENTILATION CALCULATIONS (CONT,)

Building:	DOAS for Typical Office Floor
System Tag/Name:	AHU-5 to 30
Operating Condition Description:	100%
Units (select from pull-down list)	IP

Inputs for System	Name	Units	w/o diversity System		Diversity	w/ diversity System
Floor area served by system	As	sf	13243			
Population of area served by system	Ps	P	233	D	100%	233
Design primary supply fan airflow rate	Vpsd	cfm	3,435	D	100%	3,435
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.06			
OA req'd per person for system area (Weighted average)	Rps	cfm/p	5.0			
Outdoor air intake provided for system	OA	cfm	3,350			

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

Potentially Critical Zones

	Name	Units	Stair 1 Vestibule	Storage Room	Electrical Room	*Elevator Lobby*	Service Lobby	Stair 2 Vestibule	Mechanical Room	Office	Office	Office	Office	Office
Zone Name			Stair 1 Vestibule	Storage Room	Electrical Room	*Elevator Lobby*	Service Lobby	Stair 2 Vestibule	Mechanical Room	Office	Office	Office	Office	Office
Zone Tag														
Occupancy Category		Select from pull-down list:	Corridors	Storage rooms	Electrical equipment rooms	Lobbies	Lobbies	Corridors	Electrical equipment rooms	Office space	Office space	Office space	Office space	Office space
Floor Area of zone	Az	sf	90	47	69	413	97	48	518	623	67	72	87	80
Design population of zone	Pz	P (default value listed; may be overridden)	0	0	0	12.4	2.9	0	0	3.115	1	1	1	1
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	10	10	10	115	30	10	50	75	25	25	25	25
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A:												
Frac. of local recirc. air that is representative of system RA	Er													

	Office	Office	Office	Office	Office	Office	Office	Break Room	Conference Room	Conference Room	Office	Office
Occupancy Category	Office space	Office space	Office space	Office space	Office space	Office space	Office space	Break rooms	Conference/meeting	Conference/meeting	Office space	Office space
Floor Area of zone (Az, sf)	113	77	133	128	132	98	9,553	88	246	267	100	98
Design population of zone (Pz, P)	1	1	1	1	1	1	175	2.2	12.25	13.35	1	1
Design total supply to zone (Vdzd, cfm)	25	25	25	25	25	25	2,500	25	150	150	25	25

Inputs for Operating Condition Analyzed

	Name	Units	System	All 24 zones
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100% (each zone)
Air distribution type at conditioned analyzed		Select from pull-down list:		FSCR (each zone)
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00 (each zone)
Primary air fraction of supply air at conditioned analyzed	Ep			1.00 (each zone)

Inputs for Systems with Outdoor Air Economizers	Name	Units		All 24 zones
Outdoor air Temperature	Toa	Deg F		1.00 (each zone)
Supply Air Temperature	Tp	Deg F		
Return Air Temperature	Tr	Deg F		
Supply Fan Heat Gain	dTsf	Deg F		
Return Fan Heat Gain	dTrf	Deg F		

Results of Minimum ASHRAE 62.1 Ventilation Rate Procedure (EQp1)

	Name	Units	Value
System Ventilation Efficiency	Ev		0.82
Outdoor air intake required for system (EQp1)	Vot	cfm	**2,403**
Outdoor air per unit floor area	Vot /As	cfm/sf	0.18
Outdoor air per person served by system (including diversity)	Vot /Ps	cfm/p	10.3
Outdoor air as a % of design primary supply air	Ypd	%	70%

Results of 30% Increase beyond ASHRAE 62.1 Ventilation Rate Procedure (EQc2)

	Name	Units	Value
System Ventilation Efficiency with 30% increase (EQc2)	Evz30		0.76
Outdoor air intake required for system with 30% increase (EQc2)	Vot30	cfm	**3,349**
Outdoor air per unit floor area for system with 30% increase (EQc2)	Vot30/As	cfm/sf	0.25
Outdoor air per person served by system (including diversity) (EQc2)	Vot30/Ps	cfm/p	14.4
Outdoor air as a % of design primary supply air (EQc2)	Ypd30	%	98%

Detailed Calculations

Initial Calculations for the System as a whole

	Name	Units	Formula		Value
System primary supply air flow at conditioned analyzed	Vps	cfm	= Vpsd Ds	=	3435
Uncorrected OA intake flow req'd for system	Vou	cfm	= Rps Ps + Ras As	=	1963
30% increase Uncorrected OA intake flow req'd for system (EAc2)	Vou30	cfm	= (Rps Ps + Ras As)*1.3	=	2553
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.57
30% increase Uncorrected OA req'd as a fraction of primary SA	Xs30		= Vou30 / Vps	=	0.74

Initial Calculations for individual zones

	Name	Units	Formula	Stair 1 Vestibule	Storage Room	Electrical Room	Elevator Lobby	Service Lobby	Stair 2 Vestibule	Mechanical Room	Office	Office	Office	Office	Office
Area outdoor air rate	Ra	cfm/sf		0.06	0.12	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
People outdoor air rate	Rp	cfm/p		0.00	0.00	0.00	5.00	5.00	0.00	0.00	5.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	Vdzd Ds	10	10	10	115	30	10	50	75	25	25	25	25
Primary airflow to zone (at condition being analyzed)	Vpz	cfm	= Vdz Ep =	10	10	10	115	30	10	50	75	25	25	25	25
Breathing zone outdoor airflow	Vbz	cfm	= Rp Pz + Ra Az =	5	6	4	87	20	3	31	53	9	9	10	10
Breathing zone outdoor airflow with 30% increase (EAc2)	Vbz30	cfm	= (Rp Pz + Ra Az)*1.3 =	7	7	5	113	26	4	40	69	12	12	13	13
Zone outdoor airflow	Voz	cfm	= Vbz / Ez =	5	6	4	87	20	3	31	53	9	9	10	10
Zone outdoor airflow with 30% increase (EAc2)	Voz30	cfm	= Vbz30/Ez =	7	7	5	113	26	4	40	69	12	12	13	13
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep) Er =	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OA fraction required in the supply air to the zone	Zd		= Voz / Vdz =	0.54	0.56	0.41	0.75	0.68	0.29	0.62	0.71	0.36	0.37	0.41	0.39
OA fraction required in the primary air to the zone	Zpz		= Voz / Vpz =	0.54	0.56	0.41	0.75	0.68	0.29	0.62	0.71	0.36	0.37	0.41	0.39
OA fraction required in the supply air to the zone for EAc2	Zd30		= Voz30 / Vdz =	0.70	0.73	0.54	0.98	0.88	0.37	0.81	0.92	0.47	0.48	0.53	0.51
OA fraction required in the primary air to the zone for EAc2	Zpz30		= Voz30/ Vpz =	0.70	0.73	0.54	0.98	0.88	0.37	0.81	0.92	0.47	0.48	0.53	0.51
System Ventilation Efficiency															
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa+FbXs-FcZpzEp)/Fa =	1.03	1.01	1.16	0.82	0.89	1.28	0.95	0.87	1.21	1.20	1.16	1.18
Zone Ventilation Efficiency with 30% increase (EAc2) (App A)	Evz30		= (Fa+FbXs-FcZpz30Ep)/Fa =	1.04	1.01	1.20	0.76	0.86	1.37	0.94	0.83	1.27	1.26	1.21	1.23

	Office	Office	Office	Office	Office	Office	Office	Break Room	Conference Room	Conference Room	Office	Office
Ra	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Rp	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vdz	25	25	25	25	25	25	2500	25	150	150	25	25
Vpz	25	25	25	25	25	25	2500	25	150	150	25	25
Vbz	10	12	10	13	13	13	11	1448	16	76	83	11	11
Vbz30	13	15	13	17	16	17	14	1883	21	99	108	14	14
Voz	10	12	10	13	13	13	11	1448	16	76	83	11	11
Voz30	13	15	13	17	16	17	14	1883	21	99	108	14	14
Fa	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fb	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Zd	0.47	0.38	0.52	0.51	0.52	0.44	0.58	0.65	0.51	0.55	0.44	0.44
Zpz	0.47	0.38	0.52	0.51	0.52	0.44	0.58	0.65	0.51	0.55	0.44	0.44
Zd30	0.61	0.50	0.67	0.66	0.67	0.57	0.75	0.85	0.66	0.72	0.57	0.57
Zpz30	0.61	0.50	0.67	0.66	0.67	0.57	0.75	0.85	0.66	0.72	0.57	0.57
Evz	1.10	1.19	1.05	1.06	1.05	1.14	0.99	0.92	1.07	1.02	1.13	1.14
Evz30	1.13	1.24	1.07	1.08	1.07	1.18	0.99	0.90	1.08	1.03	1.17	1.18

	Name	Units	Formula		Value
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.82
System Ventilation Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	n/a
System Ventilation Efficiency w/ 30% increase (EAc2) (App A)	Ev30		= min (Evz30)	=	0.76
System Ventilation Efficiency w/ 30% increase (EAc2) (Table 6.3)	Ev30		= Value from Table 6.3	=	n/a
Minimum outdoor air intake airflow (EQp1)					
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	2403
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.70
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	n/a
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	n/a
Time-averaging					
Time period with high occupancy	Th	min			
Room height	h	ft	=		9
Time period over which averaging can take place	T	min	= 3 v / Vbz	=	450
Error - sum of all values above will show error					617
Error flag					FALSE FALSE
30% increase beyond Minimum Outdoor air intake airflow (EQc2)					
Outdoor Air Intake Flow required to System	Vot30	cfm	= Vou / Ev	=	3349
OA intake req'd as a fraction of primary SA	Y30		= Vot / Vps	=	0.98
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot30	cfm	= Vou / Ev	=	n/a
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y30		= Vot / Vps	=	n/a
OA Temp at which Min OA provides all cooling					
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf)}/Y	=	48

RADIANT SIZING

	Room Name	Floor Area (ft2)	Cooling Sensible Load with Oversizing factor* (Btu/h)	Heating Sensible Load with Oversizing factor* (Btu/h)	Radiant Ceiling (BTU/hr/SF)	Cooling Radiant Floor (%Area)	Heating Radiant Floor (%Area)	Cooling and Heating Floor Covering (%)	Does this meet load?
Typical Office Floor	Large Conference	604	17,579	2,734	38	77%	12%	**77%**	Yes
	Office 1	60	1,746	272	38	77%	12%	**77%**	Yes
	Video Conference	88	1,825	280	38	55%	8%	**55%**	Yes
	Office 2	121	1,770	266	38	38%	6%	**38%**	Yes
	Office 3	135	1,442	202	38	28%	4%	**28%**	Yes
	Interview Room	60	1,909	279	38	84%	12%	**84%**	Yes
	Office 4	88	1,420	197	38	42%	6%	**42%**	Yes
	Office 5	62	1,643	228	38	70%	10%	**70%**	Yes
	Open Office	10,326	308,129	62,605	38	79%	16%	**79%**	Yes
	Small Conference 1	214	7,360	717	38	91%	9%	**91%**	Yes
	Small Conference 2	214	7,360	693	38	91%	9%	**91%**	Yes
Lobby	Lower Lobby	5,351	186,000	125,000	38	91%	61%	**91%**	Yes
	Loading Dock Office	83	700	800	38	22%	25%	**25%**	Yes
	Retail Space	655	24,000	22,000	38	96%	88%	**96%**	Yes
	Upper Lobby	2,108	71,600	48,000	38	89%	60%	**89%**	Yes
	Restaurant	4,224	127,500	88,500	38	79%	55%	**79%**	Yes

WATER SAVINGS AND WATER TANK SIZING

Water Consumption

Baseline						
Fixture Type	**Flow Rate**	**Duration**	**Daily Uses**	**Occupants**	**Total**	
Showerheads	2.5 gpm	8 min.	1	300	6000	gallon/day
Lavatory Faucets	0.5 gpm	0.25 min.	3	2000	750	gallon/day
Kitchen Faucets	2.2 gpm	4 min.	1	500	4400	gallon/day
Flushometer Tank Water Closets	1.6 gpm	1 flush	1 male + 3 female	2000	6400	gallon/day
Urinals	1.0 gpm	1 flush	2 male	1000	2000	gallon/day
Total					**19550**	**gallon/day**

Proposed						
Fixture Type	**Flow Rate**	**Duration**	**Daily Uses**	**Occupants**	**Total**	
Showerheads*	0 gpm	8 min.	1	300	0	gallon/day
Lavatory Faucets	0.4 gpm	0.25 min.	3	2000	600	gallon/day
Kitchen Faucets	1.8 gpm	4 min.	1	500	3600	gallon/day
Vacuum Toilets	0.5 gpm	1 flush	1 male + 3 female	2000	2000	gallon/day
Waterless Urinals	0.0 gpm	1 flush	2 male	1000	0	gallon/day
Total					**6800**	**gallon/day**
Grey Water Total					**2000**	**gallon/day**
Potable Water Total					**4800**	**gallon/day**

Percent Savings:	**65%**

Water Tank Sizing

Potable Water Storage Tank	Size	Dimensions	Weight (lbs.)
1 Day Storage	4800 gallon/day	8.5'D x 13'H	39978
2 Day Storage	9600 gallon/day	12'D x 10'H	79955

Greywater Storage Tank	Cubic Feet	Length (10' D)	Length (8' D)	Weight (lbs.)
10 Year Storm	3534	45	70	220144
1 Year Storm	2240	29	45	139563

Rainwater Collection

Month	Monthly Rainfall	Rainy Days
Jan.	4.5	11.7
Feb.	4.45	11.1
Mar.	3.25	11
Apr.	1.46	6.5
May	0.7	3.8
June	0.16	1.5
Jul.	0	0.3
Aug.	0.06	1
Sept.	0.21	1.7
Oct.	1.12	3.9
Nov.	3.16	8.9
Dec.	4.56	11.6
Total	**23.63**	**73**

San Francisco Rainfall	23.63	inches/year
Roof Area	16000	square feet
Total Yearly	235685	US gal/year
Rainwater Collection	**646**	**US gal/day**

Percent Greywater Use	**32%**

12 Hour - 10 Year Storm	2.65	inches/12 hours
Roof Area	16000	square feet
Total Rainfall	**26431**	**US gal/12 hours**

12 Hour - 1 Year Storm	1.68	inches/12 hours
Green Roof Area	16000	square feet
Total Rainfall	**16756**	**US gal/12 hours**

CONTAMINANTS ANALYSIS

This data was found on www.stateoftheair.org. It states that our location, at 350 Mission, has outdoor air quality that is suitable for natural ventilation without filtration.

If you live in San Francisco County, the air you breathe needs your support.

Ozone	Particle Pollution 24-hour	Particle Pollution Annual
A	C	Pass

You can make a difference in the air that you breathe.

Take Action for Healthier Air

Tell us why having healthy air matters to you.

Tell your friends about the air where you live.

High Ozone Days		Learn More
Ozone Grade:	A	How is my grade calculated?
Weighted Average:	0.0	Change Since 1996: 0 fewer days this year
View Orange, Red, and Purple Ozone Days		
Particle Pollution - 24 Hour		Learn More
Grade:	C	How is my grade calculated?
Weighted Average:	2.0	Change Since 2000: 13 fewer days this year
View Orange, Red, and Purple Particle Pollution Days		
Particle Pollution - Annual		Learn More
Grade:	Pass	How is my grade calculated?
Design Value	9.9	Change Since 2000: -2.1 µg/m^3
Groups At Risk		Learn More
Total Population:	812,826	Risks to the population
Pediatric Asthma:	7,834	Risks to people with Asthma
Adult Asthma:	59,153	Risks to people with Asthma
COPD:	30,993	Risks to people with COPD
Cardiovascular Disease:	205,566	Risks to people with Cardiovascular Disease
Diabetes:	54,461	Risks to people with Diabetes
Children Under 18:	109,429	Risks to children and teens
Adults 65 & Over:	111,905	Risks to older adults
Poverty Estimate:	110,260	Risks to people with low incomes

SMOKE CONTROL CALCULATIONS

The smoke control design for that building is in compliance with the California Building Code. The office tower will be controlled via the "pressurization method" and the lobby will be controlled through the "exhaust method." The supporting equations for air quantity will be detailed on this page.

Typical Office Smoke Control

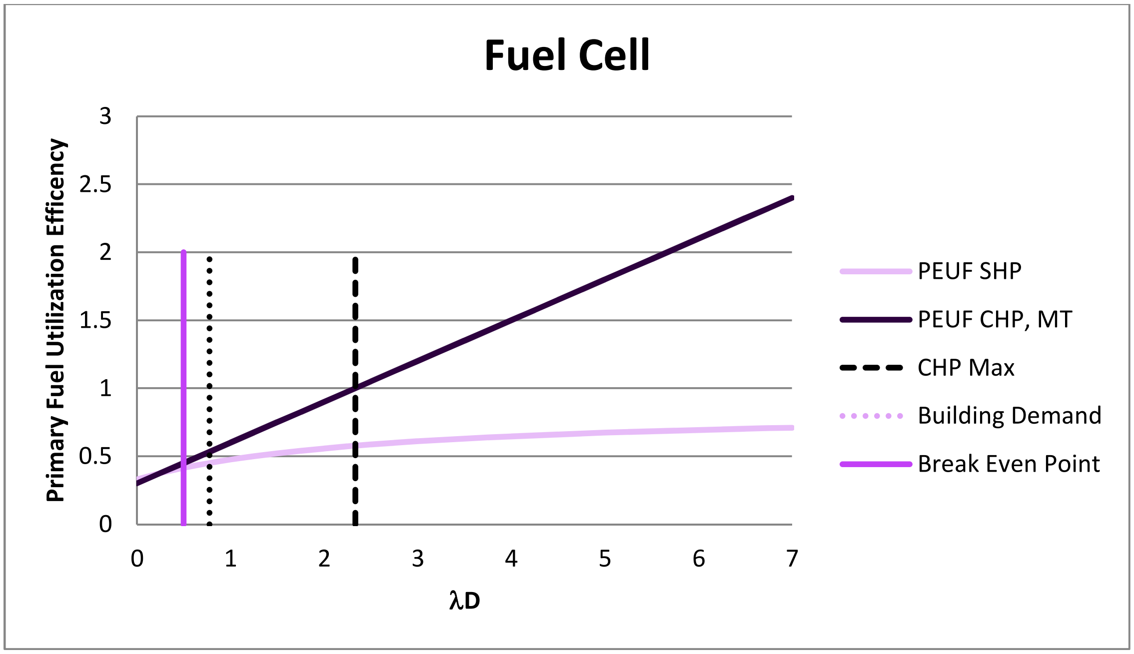
Floor Area	**=**	**15258.00**	**ft^2**		**(Area of floor calculated.)**
Roof Area	=	15258.00	ft^2		(Area of roof calculated.)
Wall Area	=	6930.00	ft^2		(Area of wall calculated - Perimeter area.)
Exit Enclosure Area	=	300.00	ft^2		(Area of exits or stair walls calculated.)
Other Shaft Area	=	644.00	ft^2		(Area of other shafts calculated.)
Other Openings	=	0.00	ft^2		(Area of any other opening.)
Number of Doors:(1)					
36" doors	=	2	0.42	ft^2	
42" doors	=	0	0	ft^2	
48" doors	=	0	0	ft^2	
Pressure Difference	=	0.05	w.c.		(Minimum pressure difference required.)
Total Leakage Area	=	85.36			Calculated with IBC Equation 9-2
Exhaust Rate	=	49814.93			

Lobby Smoke Control

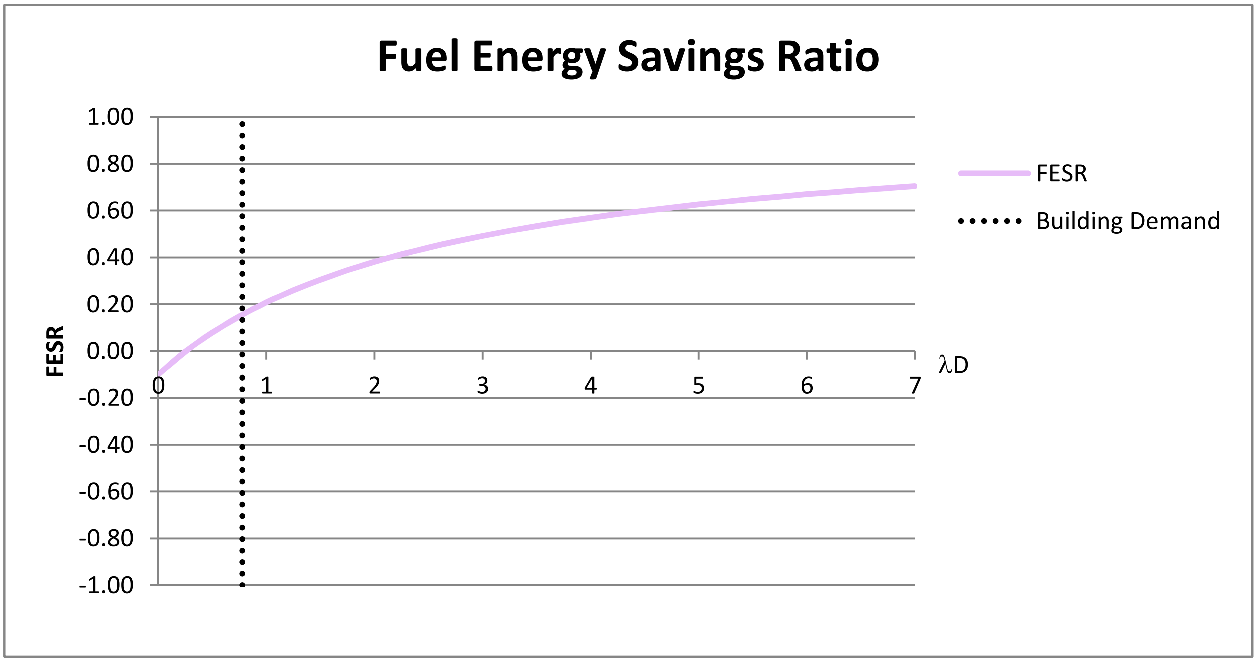
Z	**=**	**24.0**	**ft**	**(Height of the smoke layer above fire.)**
Q	=	1,500	Btu/s	(Steady state heat release rate.)
Qc	=	1,050	Btu/s	(Convective portion of heat release rate, estimated as 0.7 X Q.)
zl	=	8.6	ft	(Limiting elevation.)
T_0	=	72.0	^0F	(Ambient temperature.)
T_p	=	161.2	^0F	(Average Plume Temperature)
T_s	=	116.6	^0F	(Temperature of smoke)
p_{atm}	=	14.69	psi	(Density of smoke/air at 68 ^0F.)
r	=	0.069	lb/ft^3	(Density of smoke.)
$m_{,z>zl}$	=	49.1	lb/s	(Mass flow rate of smoke production above the limiting elevation.)
V	=	42,788.6	ft^3/min	(Volumetric rate of smoke production. Exhaust CFM required)

COMBINE HEAT AND POWER ANALYSIS

Based on the anticipated power and electrical demand on 350 Mission, it is a viable candidate for the use of Fuel Cell technology. For a more detailed report on the fuel cell, please refer to the lighting and electrical report.

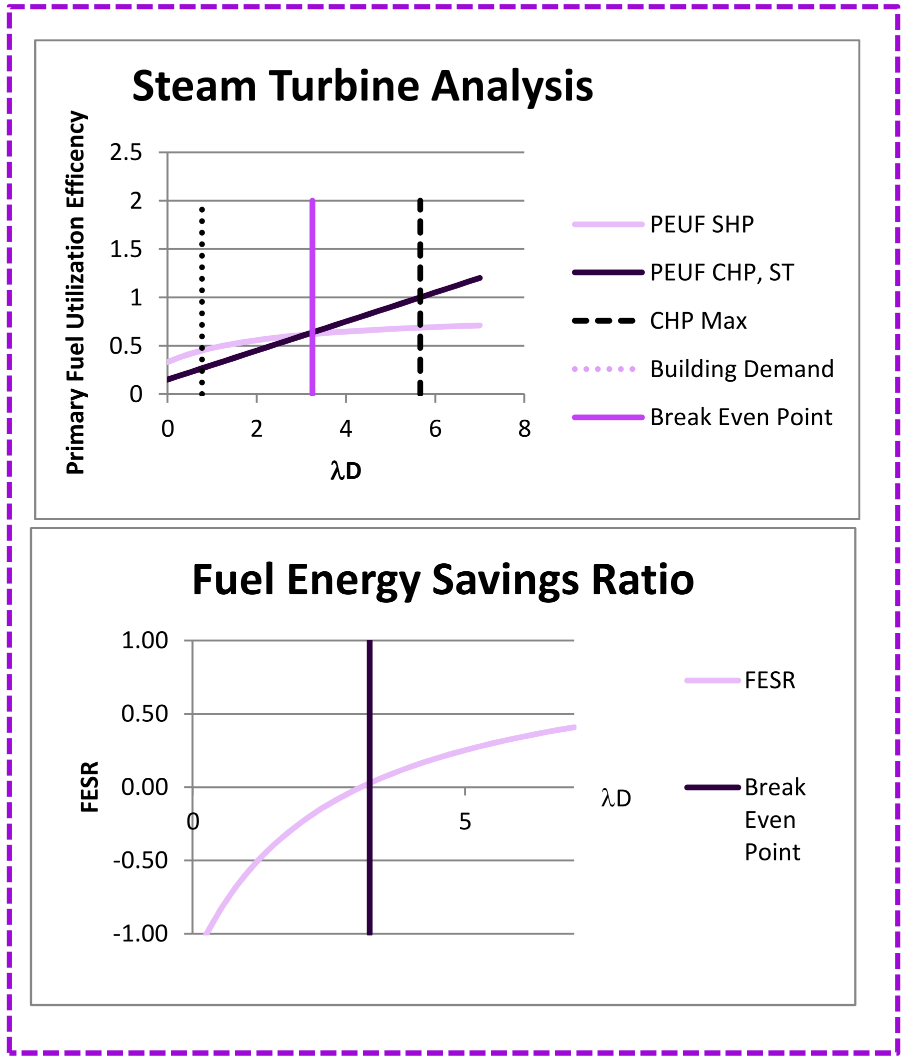


Based on our analysis using a fuel cell for both heat and power will reduce our primary energy use by 17%. These calculations assumed a 31% electrical grid and an 80% efficient onsite boiler. The following page will detail other prime mover analyses.

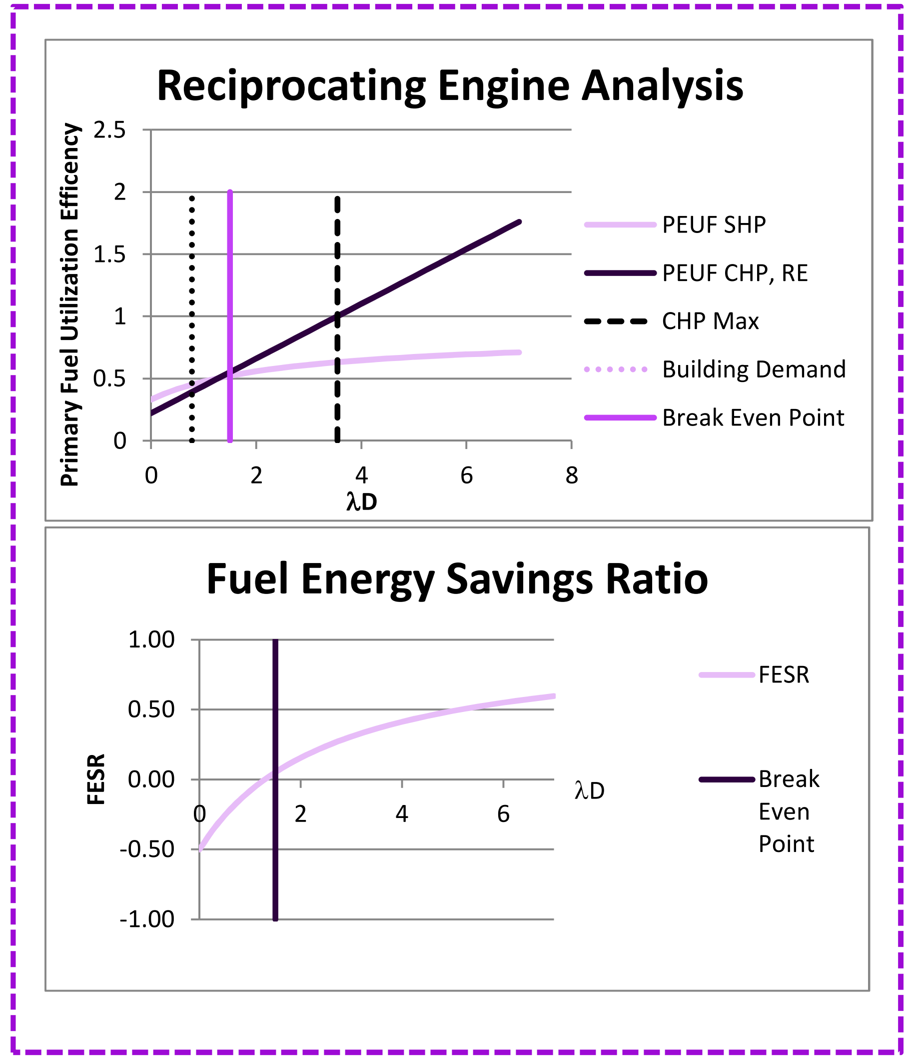


COMBINED HEAT AND POWER ANALYSIS (CONT)

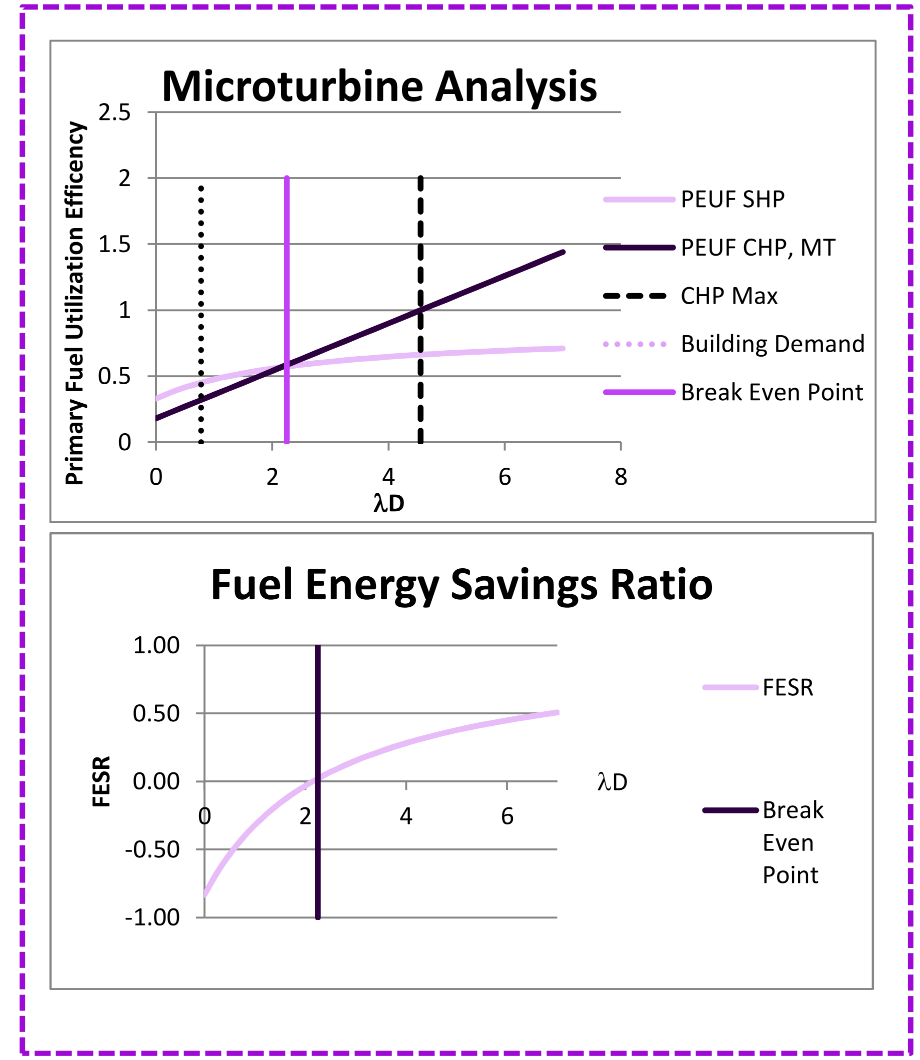
STEAM TURBINE



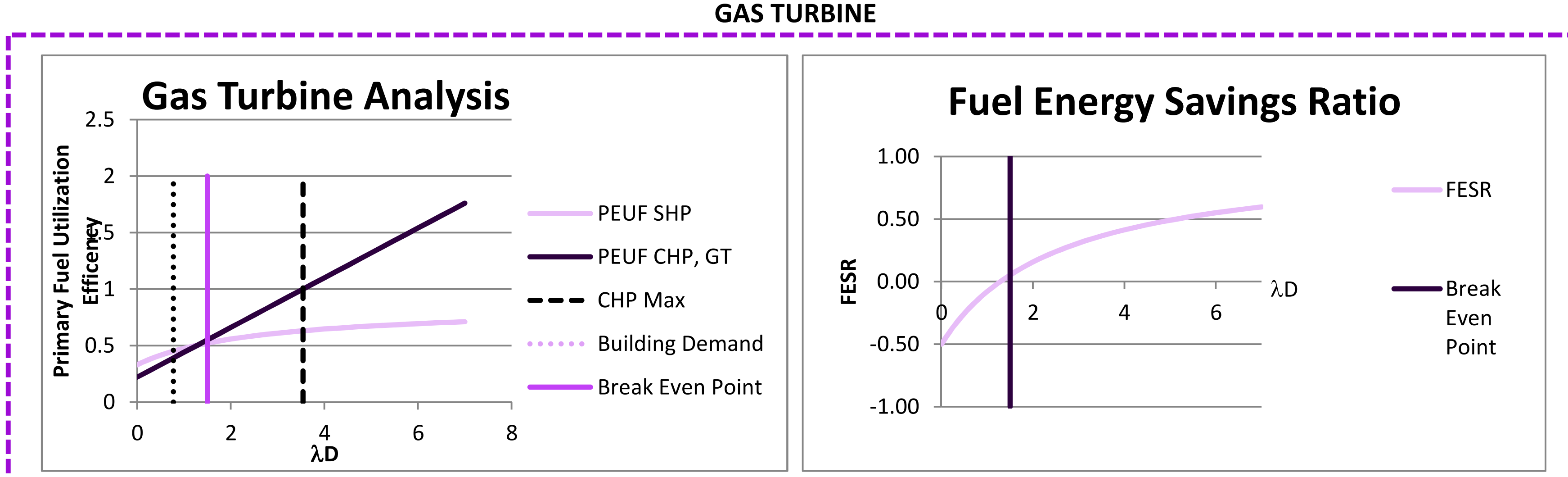
RECIPROCATING ENGINE



MICROTURBINE



GAS TURBINE



LEED CHECKLIST

Under the LEED 2009 for New Construction and Major Renovations Checklist, 350 Mission can achieve LEED Platinum Accreditation, accumulating 93 points out of a possible110 points.

Sustainable Sites (21/26 Points)

Prereq 1	Construction Activity Pollution Prevention	
Credit 1	Site Selection	1 Point
Credit 2	Development Density and Community Connectivity	5 Points
Credit 4.1	Alternative Transportation – Public Transportation Access	6 Points
Credit 4.2	Alternative Transportation – Bicycle Storage and Changing Rooms	1 Point
Credit 4.3	Alternative Transportation – Low-Emitting and Fuel-Efficient Vehicles	3 Points
Credit 4.4	Alternative Transportation – Parking Capacity	2 Points
Credit 6.1	Stormwater Design – Quantity Control	1 Point
Credit 7.1	Heat Island Effect – Non-roof	1 Point
Credit 8	Light Pollution Reduction	1 Point

Water Efficiency (10/10 Points)

Prereq 1	Water Use Reduction – 20% Reduction	
Credit 1	Water Efficient Landscaping | No Potable Water Use or Irrigation	4 Points
Credit 2	Innovative Wastewater Technologies	2 Points
Credit 3	Water Use Reduction | Reduce by 40%	4 Points

Energy and Atmosphere (31/35 Points)

Prereq 1	Fundamental Commissioning of Building Energy Systems	
Prereq 2	Minimum Energy Performance	
Prereq 3	Fundamental Refrigerant Management	
Credit 1	Optimize Energy Performance| Improve by 48%+ for New Buildings	19 Points
Credit 2	On-Site Renewable Energy | 7% Renewable Energy	7 Points
Credit 3	Enhanced Commissioning	2 Points
Credit 5	Measurement and Verification	3 Points

Materials and Resources (9/14 Points)

Prereq 1	Storage and Collection of Recyclables	
Credit 2	Construction Waste Management | 75% Recycled or Salvaged	2 Points
Credit 3	Materials Reuse | Reuse 10%	2 Points
Credit 4	Recycled Content | 20% of Materials	2 Points
Credit 5	Regional Materials	2 Points
Credit 7	Certified Wood	1 Point

Indoor Environmental Quality (14/15 Points)

Prereq 1	Minimum Indoor Air Quality Performance	1 Point
Prereq 2	Environmental Tobacco Smoke (ETS) Control	1 Point
Credit 1	Outdoor Air Delivery Monitoring	1 Point
Credit 2	Increased Ventilation	1 Point
Credit 3.1	Construction IAQ Management Plan – During Construction	1 Point
Credit 3.2	Construction IAQ Management Plan – Before Occupancy	1 Point
Credit 4.1	Low-Emitting Materials – Adhesives and Sealants	1 Point
Credit 4.2	Low-Emitting Materials – Paints and Coatings	1 Point
Credit 4.3	Low-Emitting Materials – Flooring Systems	1 Point
Credit 4.4	Low-Emitting Materials – Composite Wood and Agrifiber Products	1 Point
Credit 5	Indoor Chemical and Pollutant Source Control	1 Point
Credit 6.1	Controllability of Systems – Lighting	1 Point
Credit 6.2	Controllability of Systems – Thermal Comfort	1 Point
Credit 7.1	Thermal Comfort – Design	1 Point
Credit 7.2	Thermal Comfort – Verification	1 Point
Credit 8.2	Daylight and Views - Views	1 Point

Innovation and Design Process (4/6 Points)

Credit 1.1	Innovation in Design: Acoustics Pilot Credit	1 Point
Credit 1.2	Innovation in Design: Interior Lighting – Quality Pilot Credit	1 Point
Credit 1.3	Innovation in Design: Sustainable Wastewater Management Pilot Credit	1 Point
Credit 2	LEED Accredited Professional	1 Point

Regional Priority Credits (4/4 Points)

Credit 1.1	Regional Priority: On-site Renewable Energy	1 Point
Credit 1.2	Regional Priority: Daylight & Views - Daylight	1 Point
Credit 1.3	Regional Priority: Innovative wastewater technologies	1 Point
Credit 1.4	Regional Priority: Water use reduction	1 Point

Total LEED Points 93/110

References

People

Adam Bernardo, JBA Consulting Engineers
Andy Paxton, Southland Industries
Andy Rhodes, Southland Industries
Brian Ault, Scheeser Buckley Mayfield Consulting Engineers
David Kaneda, Integral Group
Leighton Deer, HGA Architects and Engineers
Mark McKinley, AECOM

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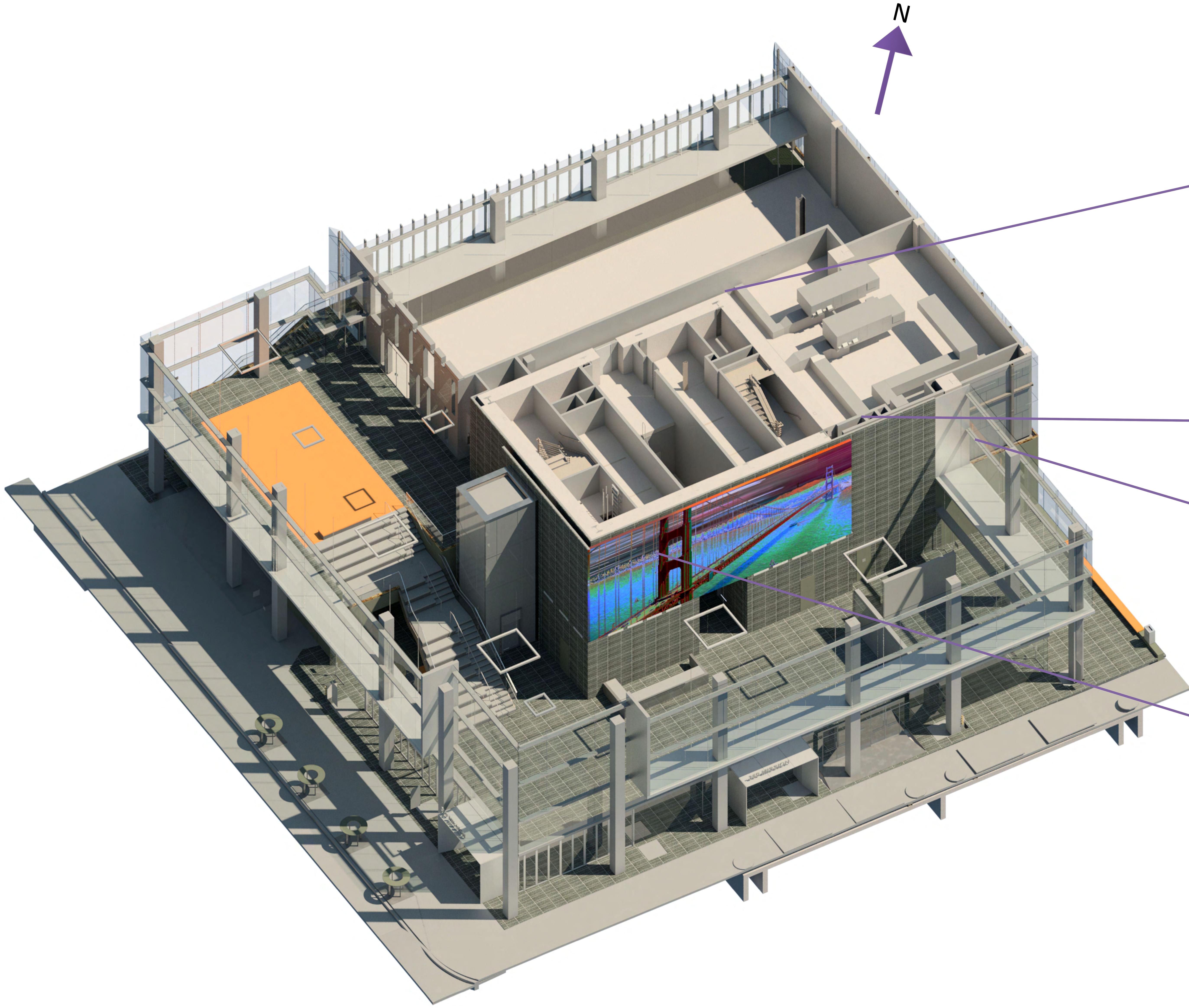
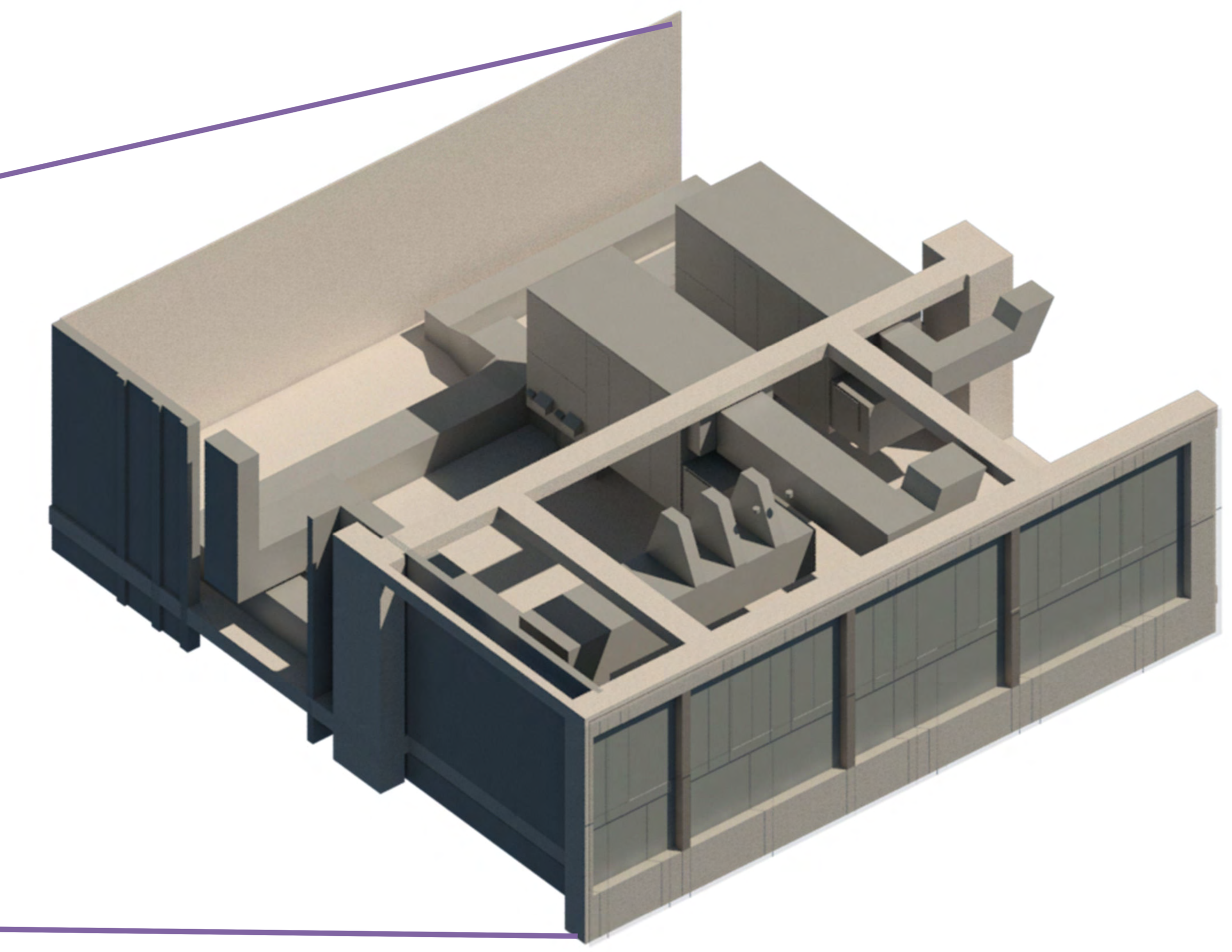
[5] Catalog of CHP technologies. Washington, D.C.?: U.S. Environmental Protection Agency, Combined Heat and Power Partnership, 2002.

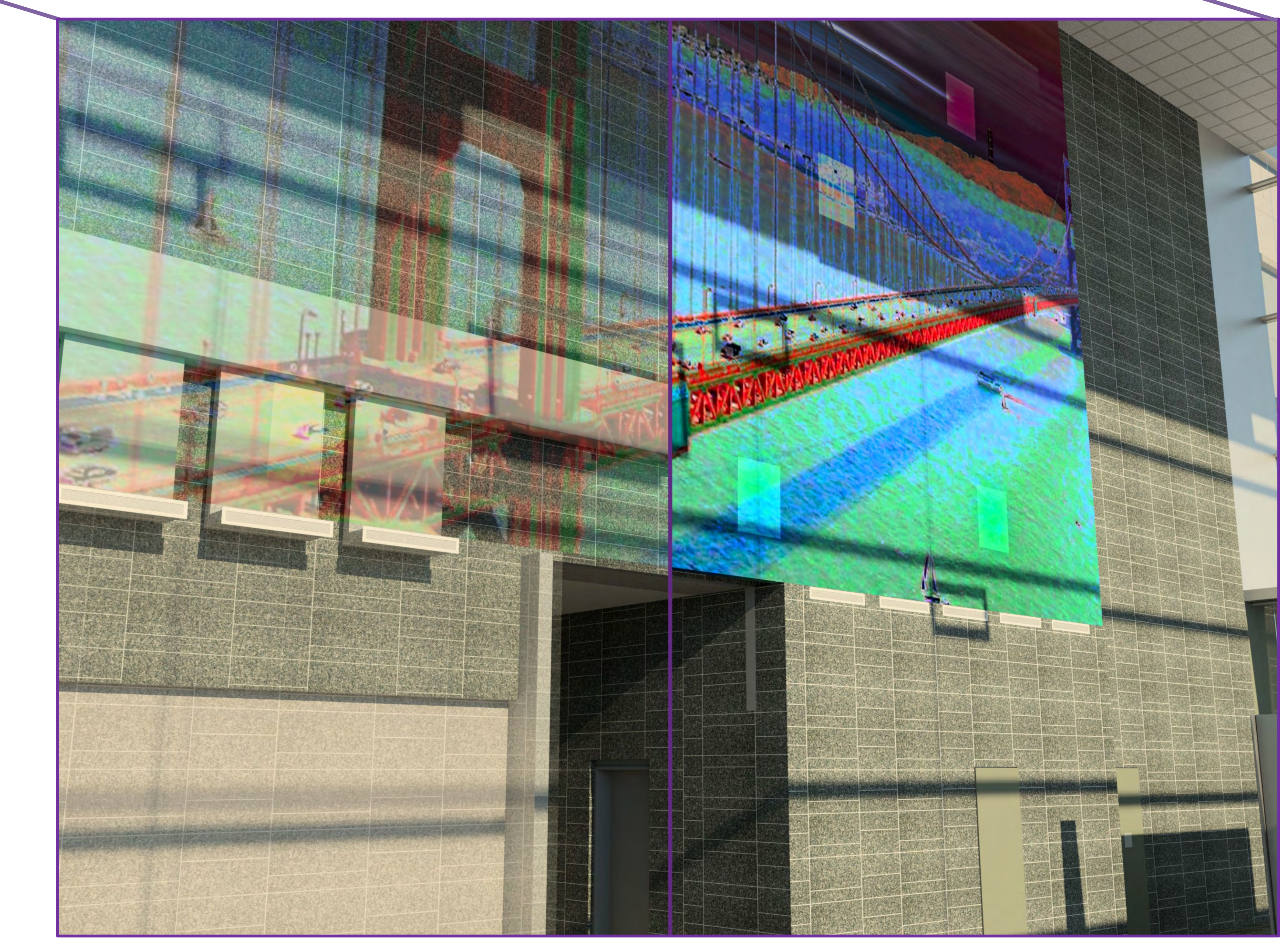
[2] Heating, Refrigerating and Air. ASHRAE standard: thermal environmental conditions for human occupancy. Atlanta, Ga.: ASHRAE, 2010.





3rd FLOOR MECHANICAL SPACE

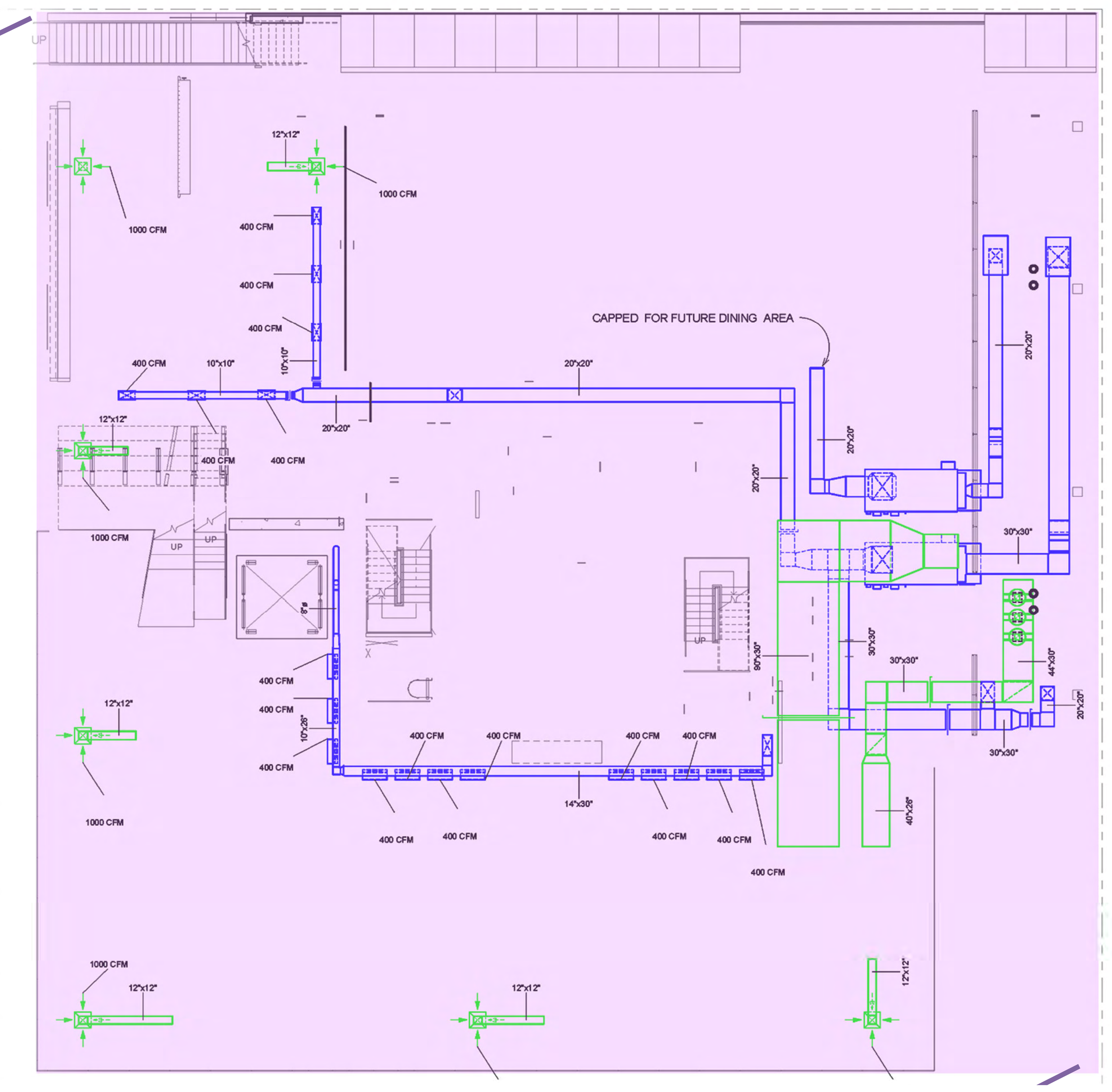
This rendering shows the coordination of structure with 3rd floor mechanical room. The mechanical room houses two DOAS air handling units. One unit serves the lower half of the office floors, the other unit is capped for the future dining area.



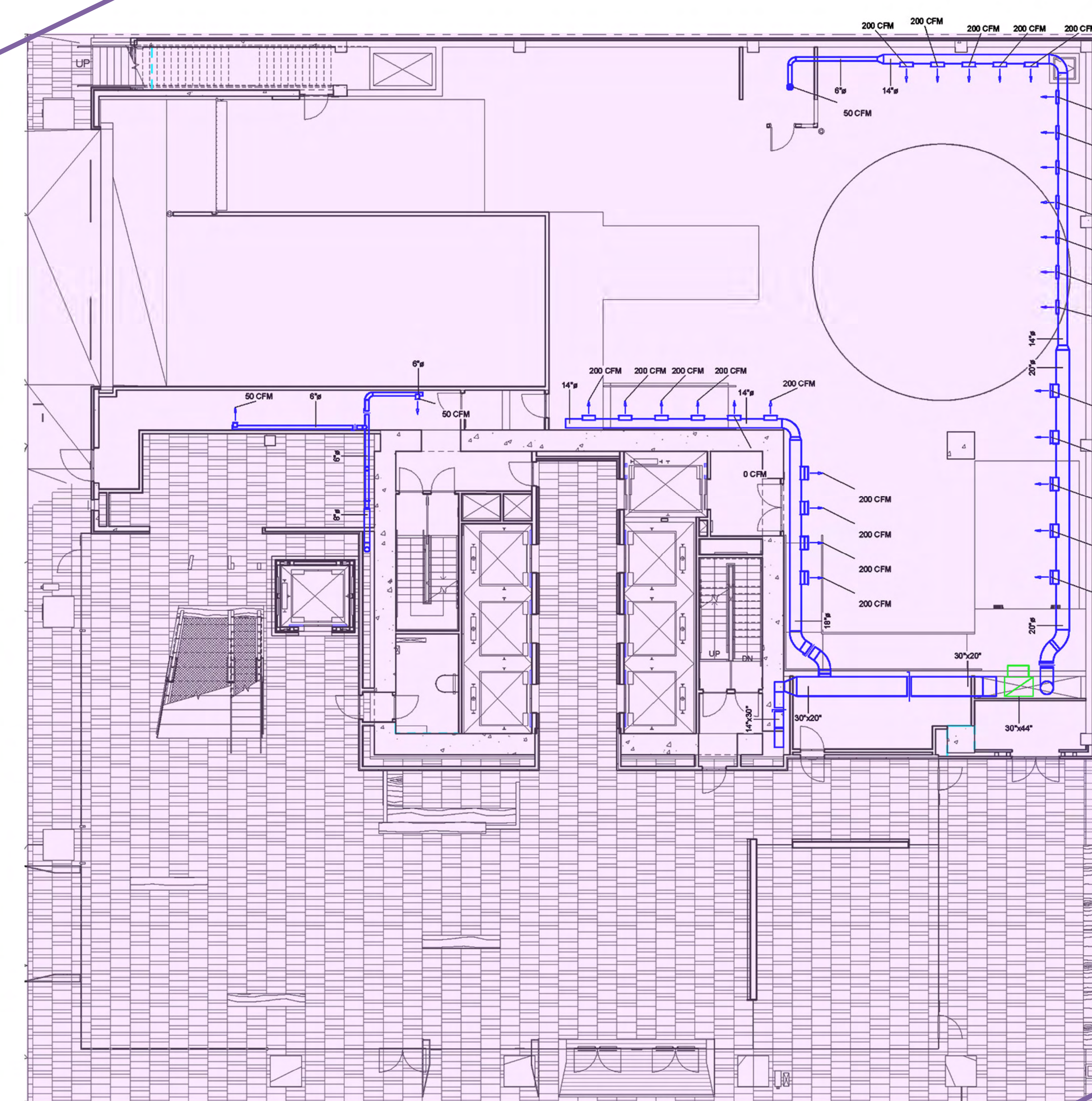
LOWER LOBBY SUPPLY PLENUM

LOBBY RENDERINGS

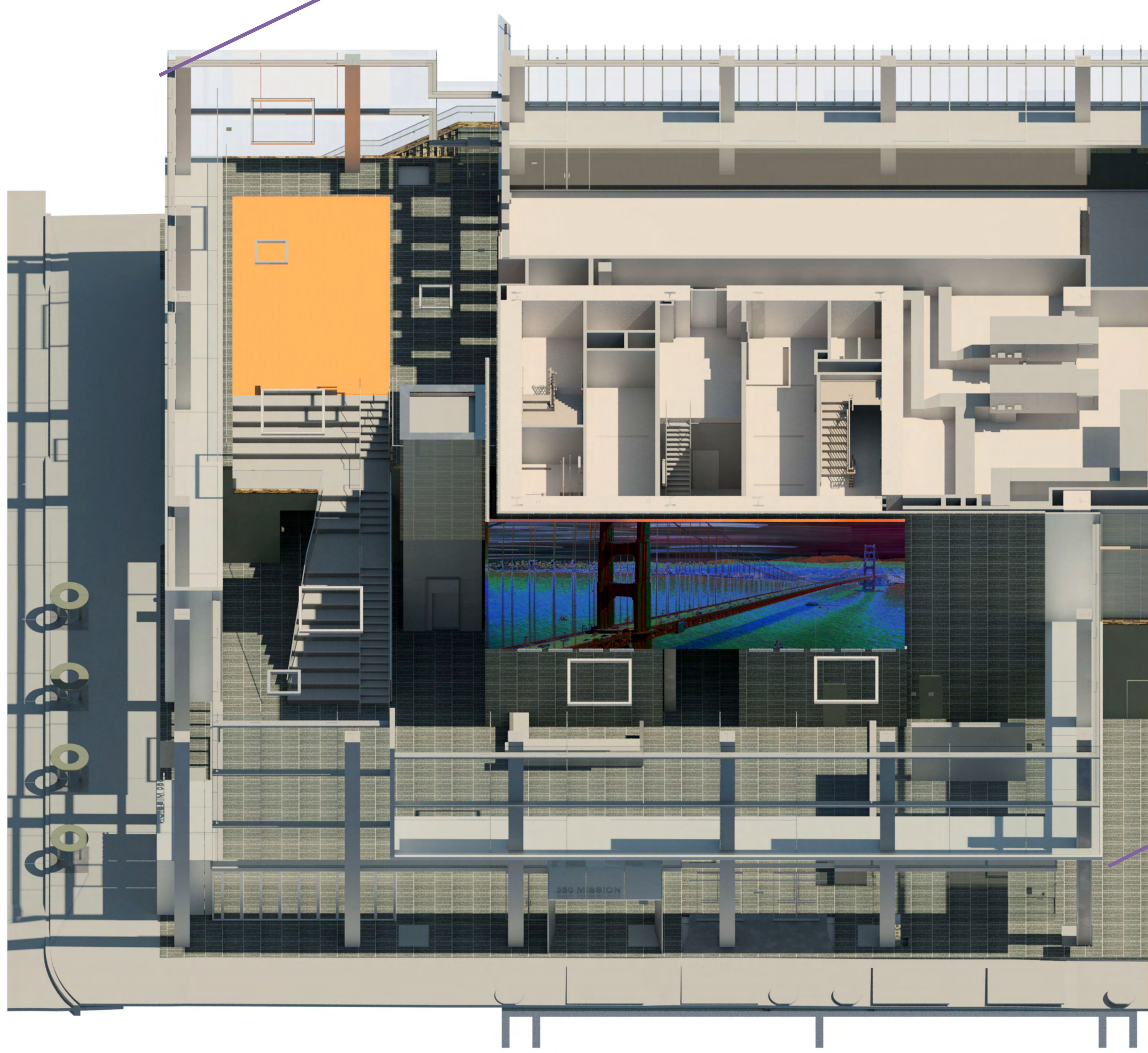
The mechanical system integrates with the architecture design, structure, and lighting components to effectively serve the space. The 3rd floor mechanical space houses the DOAS-2 AHU, kitchen exhaust fan, and the bathroom fan with variable frequency drive. The lower lobby supply plenum delivers conditioned outdoor air directly to the occupied space. The diagram on the right illustrates the integration of the duct work with the public art feature. The left half image reveals the duct work path along the core, while the right half image is the actual depiction of the space.



UPPER LOBBY MECHANICAL

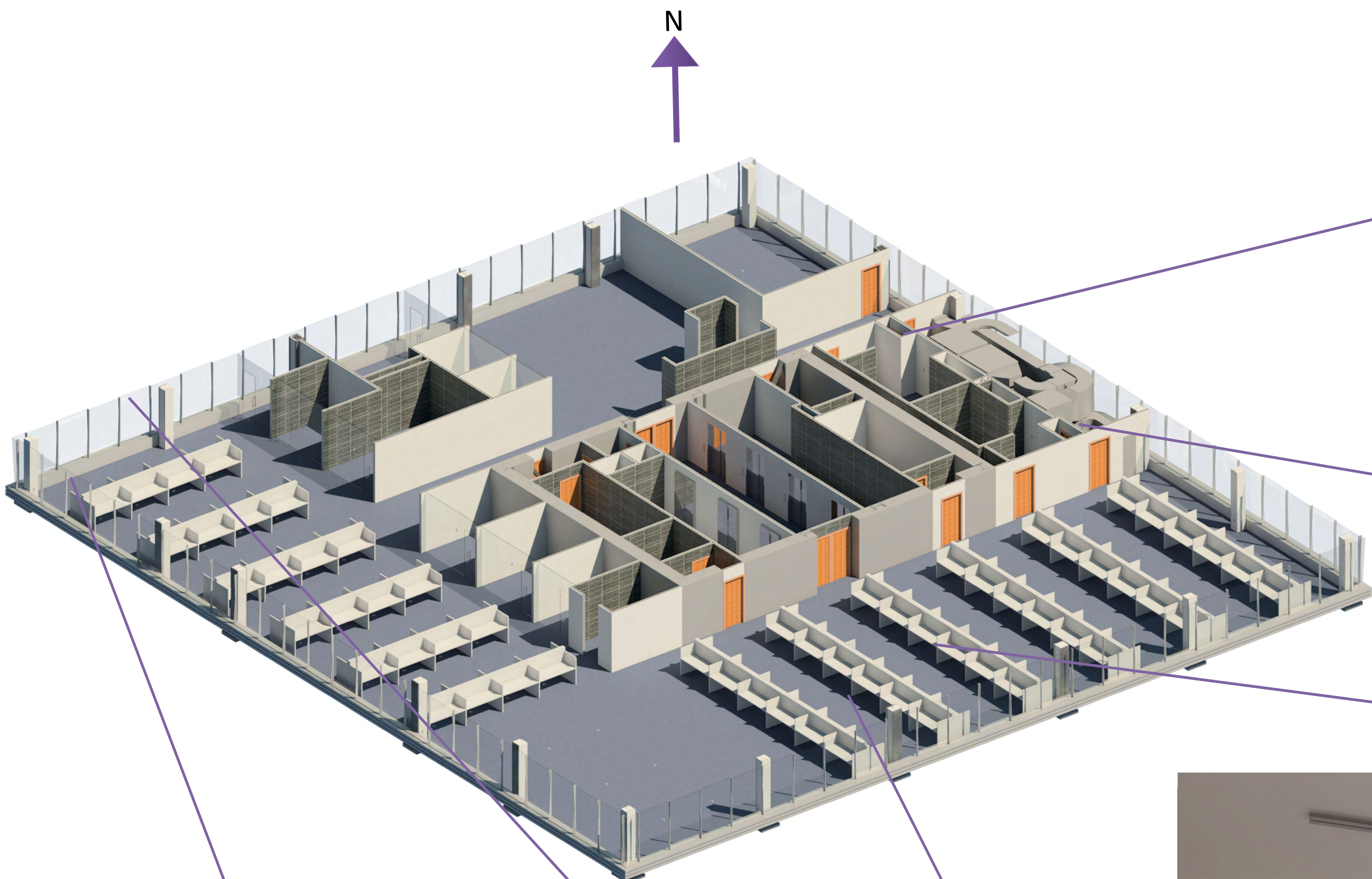


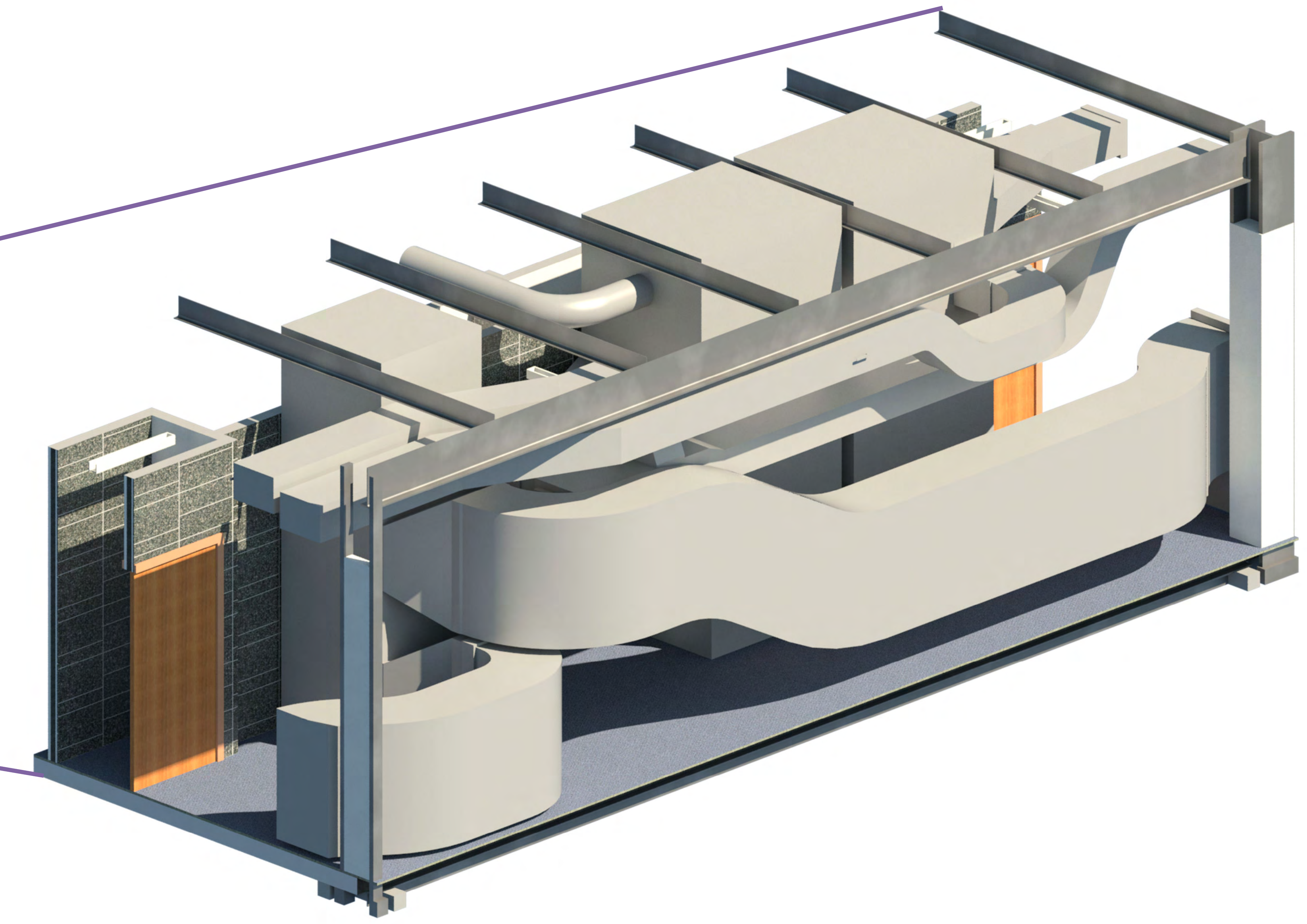
LOWER LOBBY MECHANICAL



LOBBY MECHANICAL LAYOUT

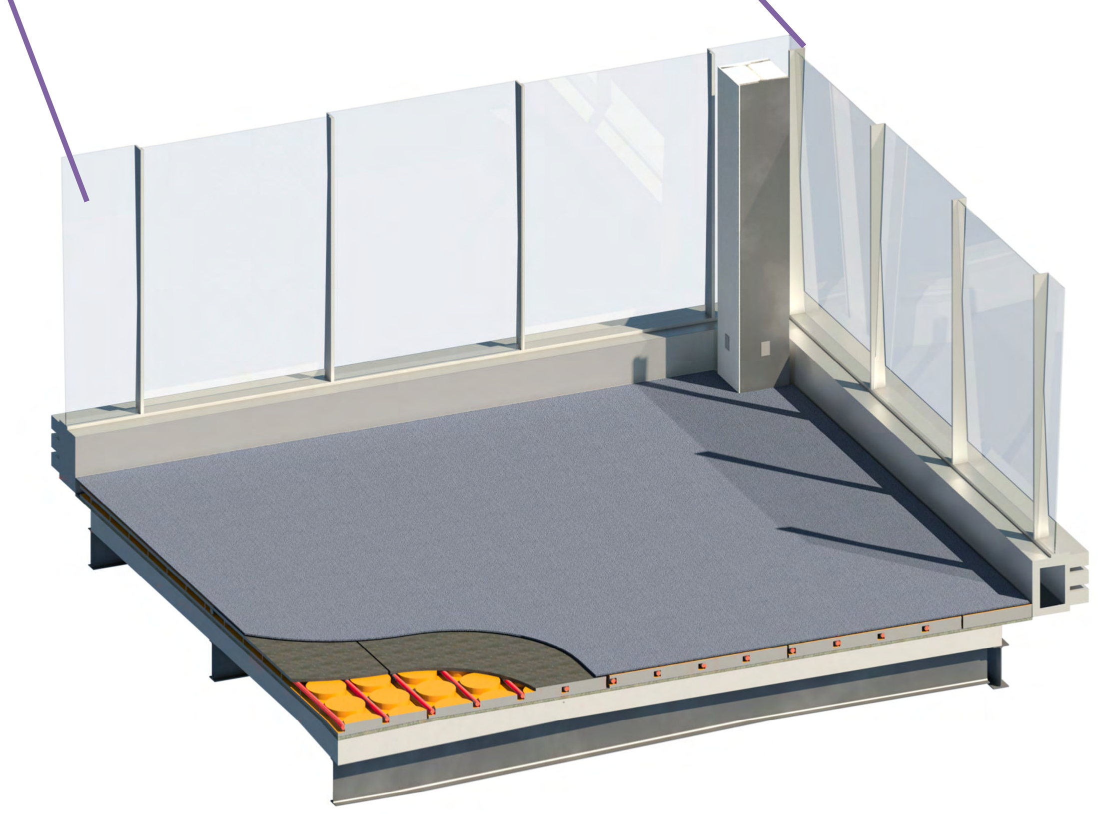
The lobby mechanical system operates along the inside building perimeter and core to meet the ventilation requirements. The lower lobby mechanical floor plan depicts mechanical ductwork below 14'. DOAS-2 supplies the loading dock with fresh air along the building perimeter. The upper lobby mechanical floor plan depicts mechanical ductwork above 14'. The lobby supply diffusers are at a height of 14' to service the occupants directly. The return air is through the plenum space at a height of 47'.





30th FLOOR MECHANICAL ROOM

The mechanical room efficiently encloses the mechanical components to maximize occupiable floor space.



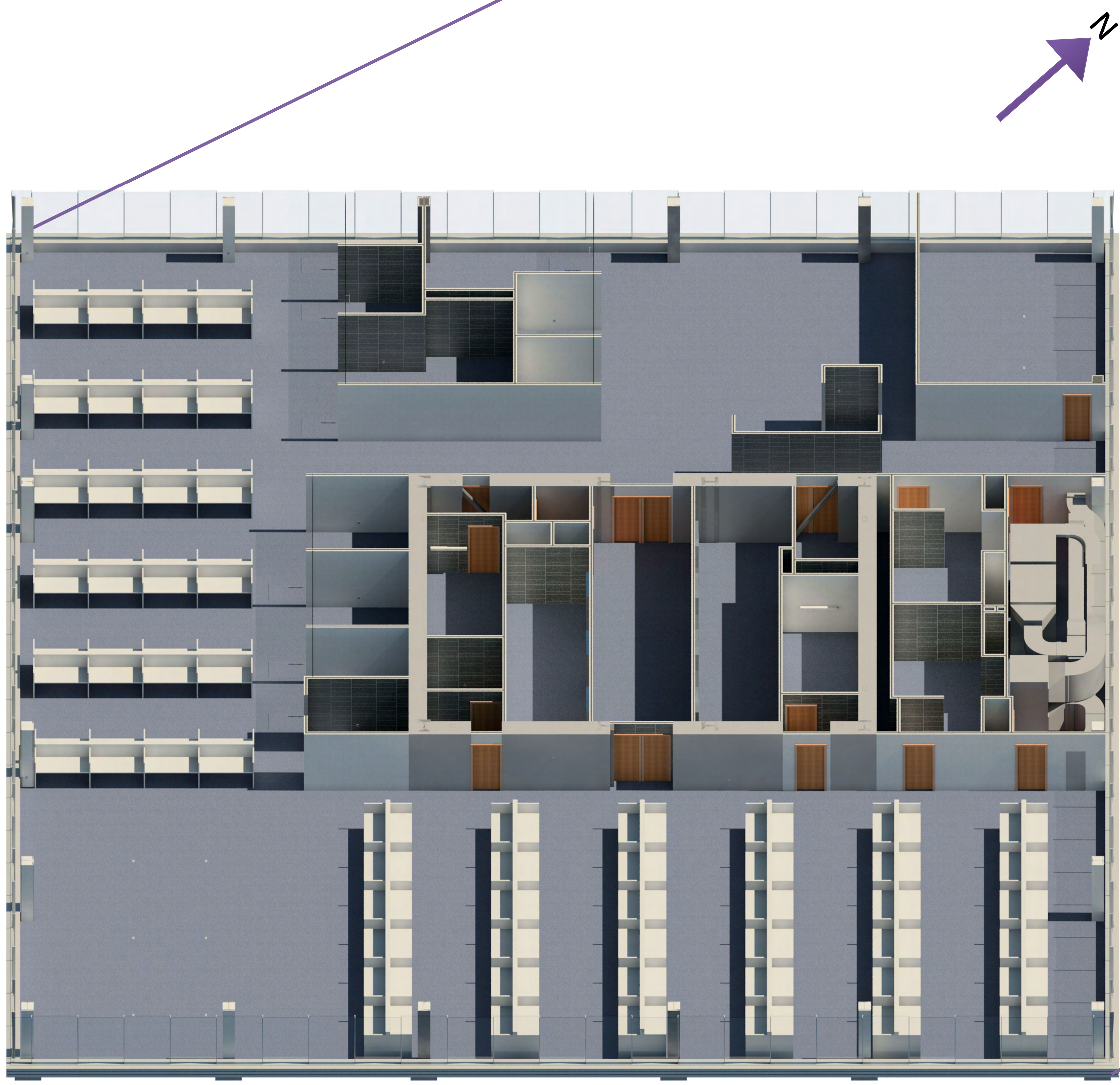
ON SLAB RADIANT

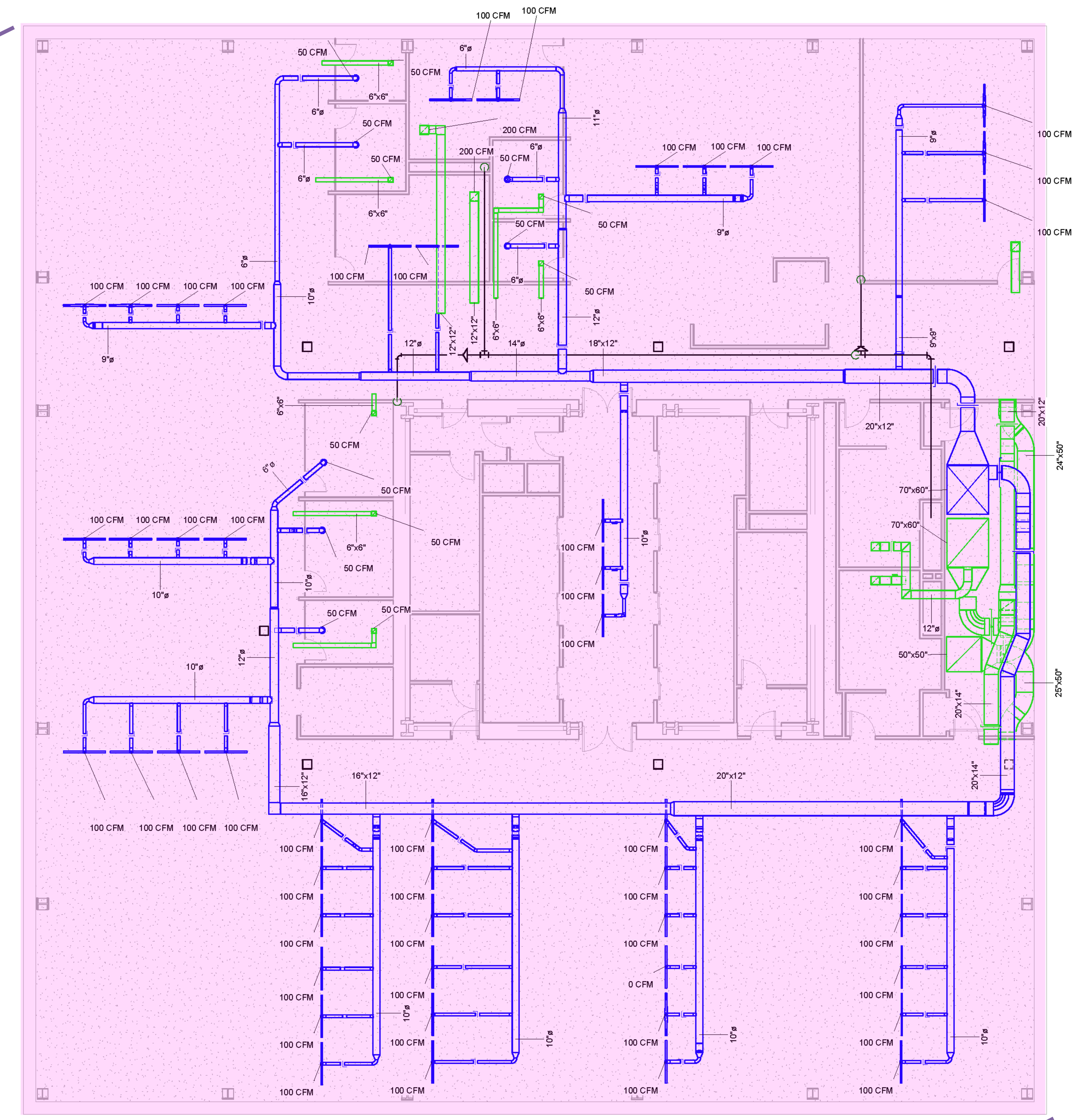
The on slab radiant system includes a prefab mesh for easy installation, zoning, and alterations.

OPEN PLAN OFFICE

The typical office floor combines both natural ventilation and overhead linear diffusers to supply air to the space. Overhead linear diffusers mimic the lighting design to avoid visual clutter.

AEVITAS | Office Mechanical Layout

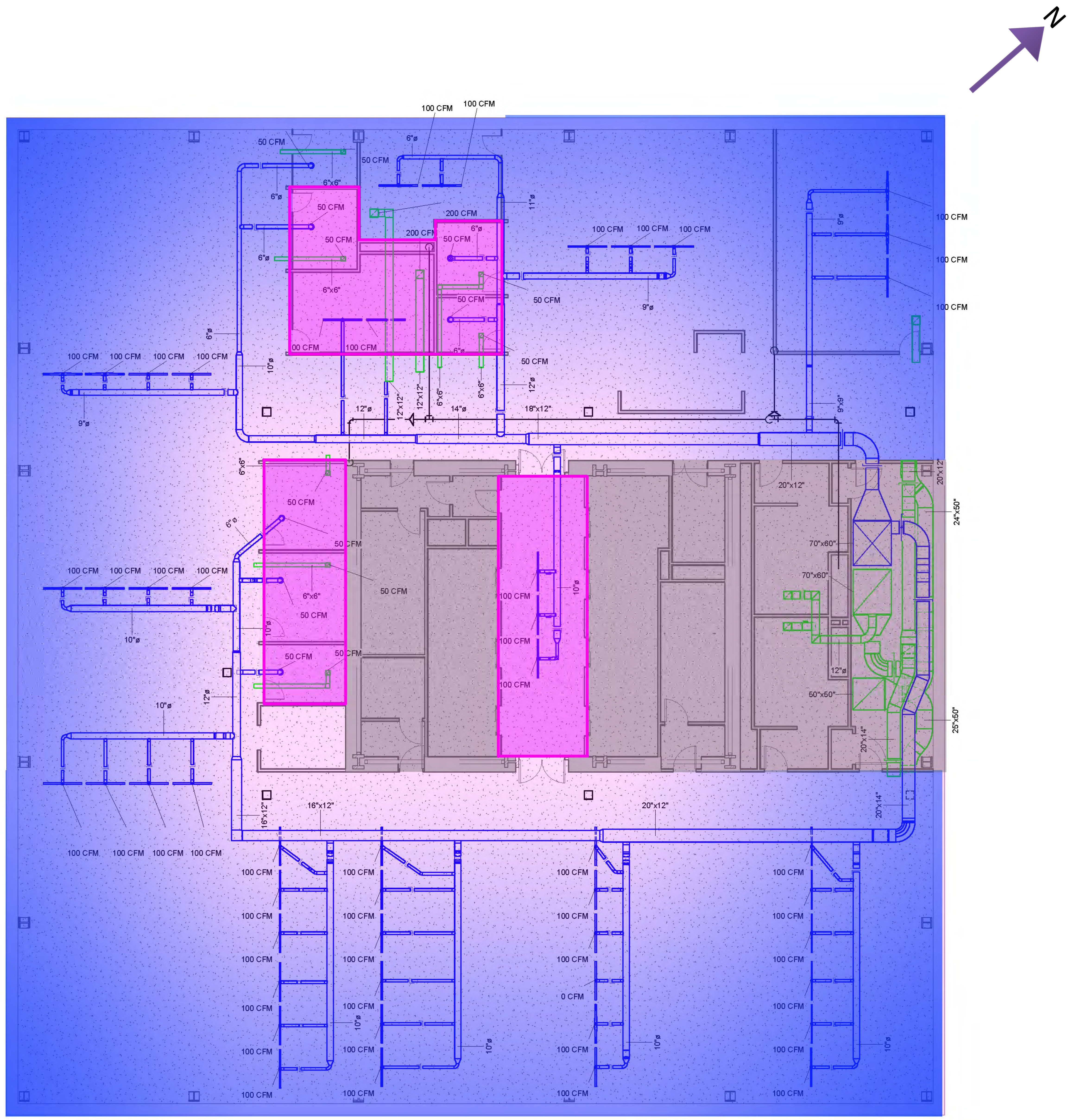


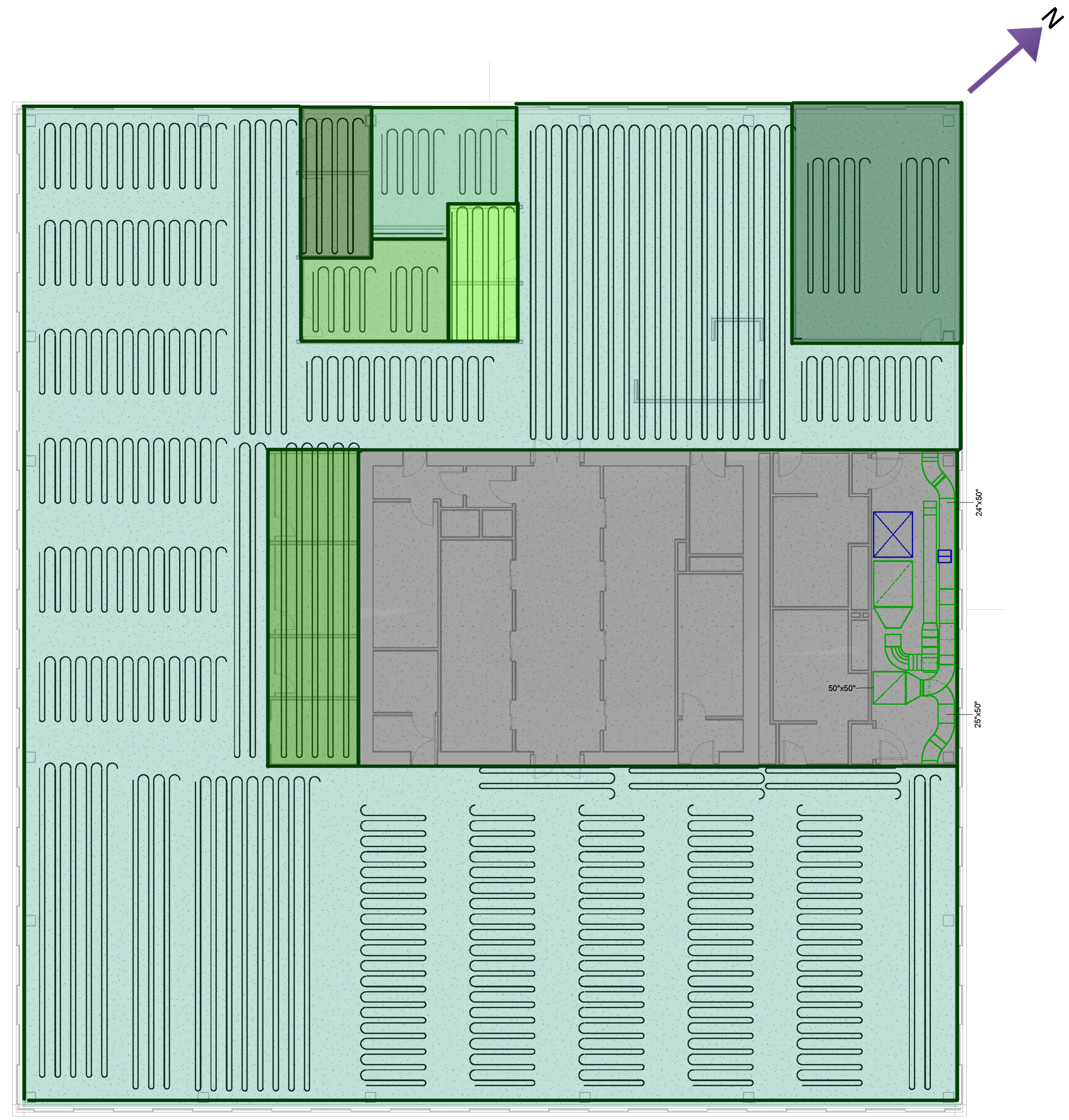


TYPICAL OFFICE MECHANICAL

OFFICE MECHANICAL LAYOUT

A typical office floor integrates the natural ventilation louvers and overhead ductwork with dampers, as shown in blue. The return air exhausts to the plenum space, as shown in green, with an exhaust fan located in the mechanical room.





NATURAL VENTILATION ZONING

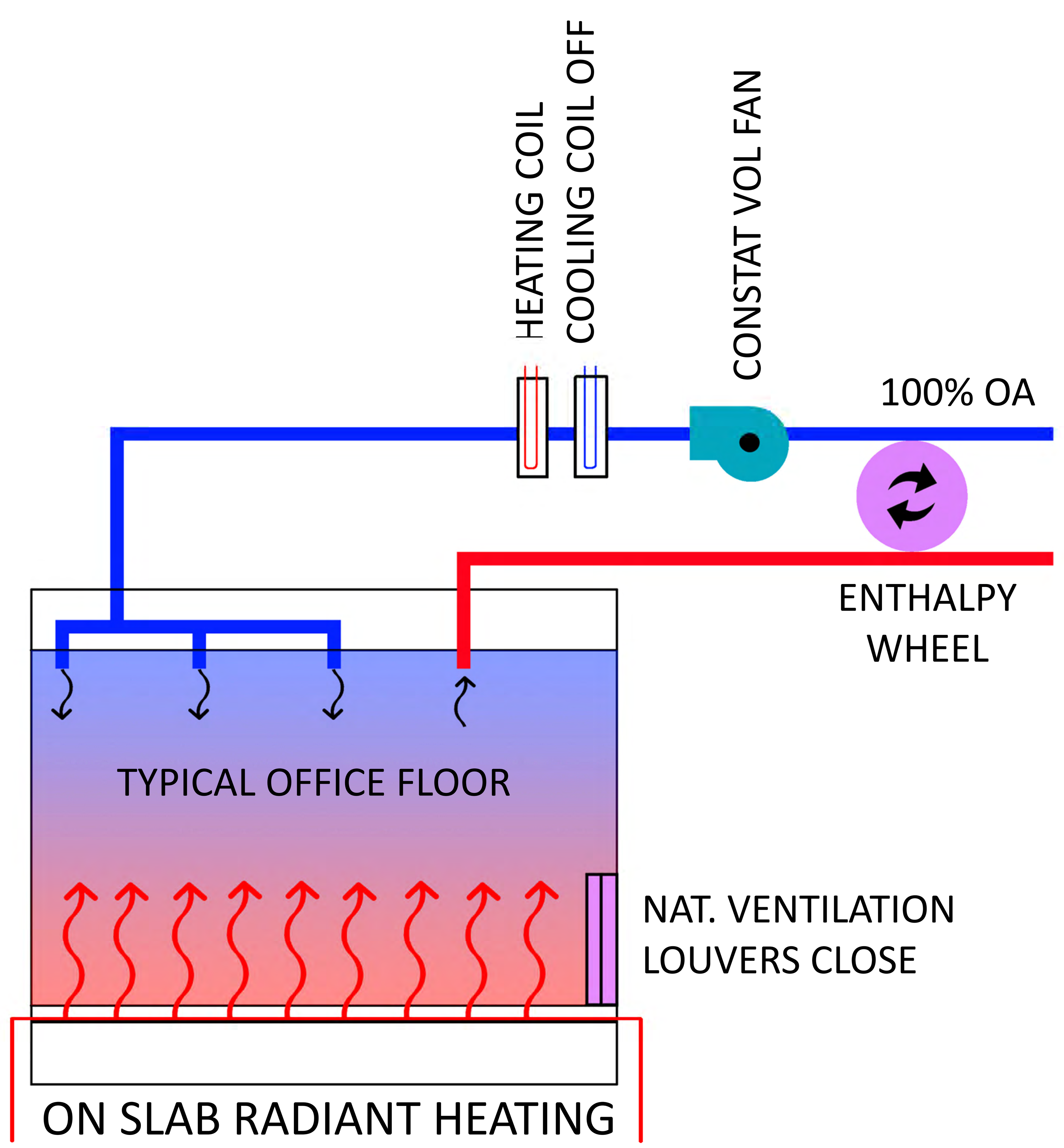
When weather permits, the natural ventilation louvers open along the perimeter. Exhaust fans create a pressure change, drawing the outdoor air into the space. Dampers controlling the distribution of mechanical ventilation close in the spaces directly adjacent to the louvers, as shown in blue. The purple shading depicts enclosed spaces, in which mechanical ventilation supply is maintained.

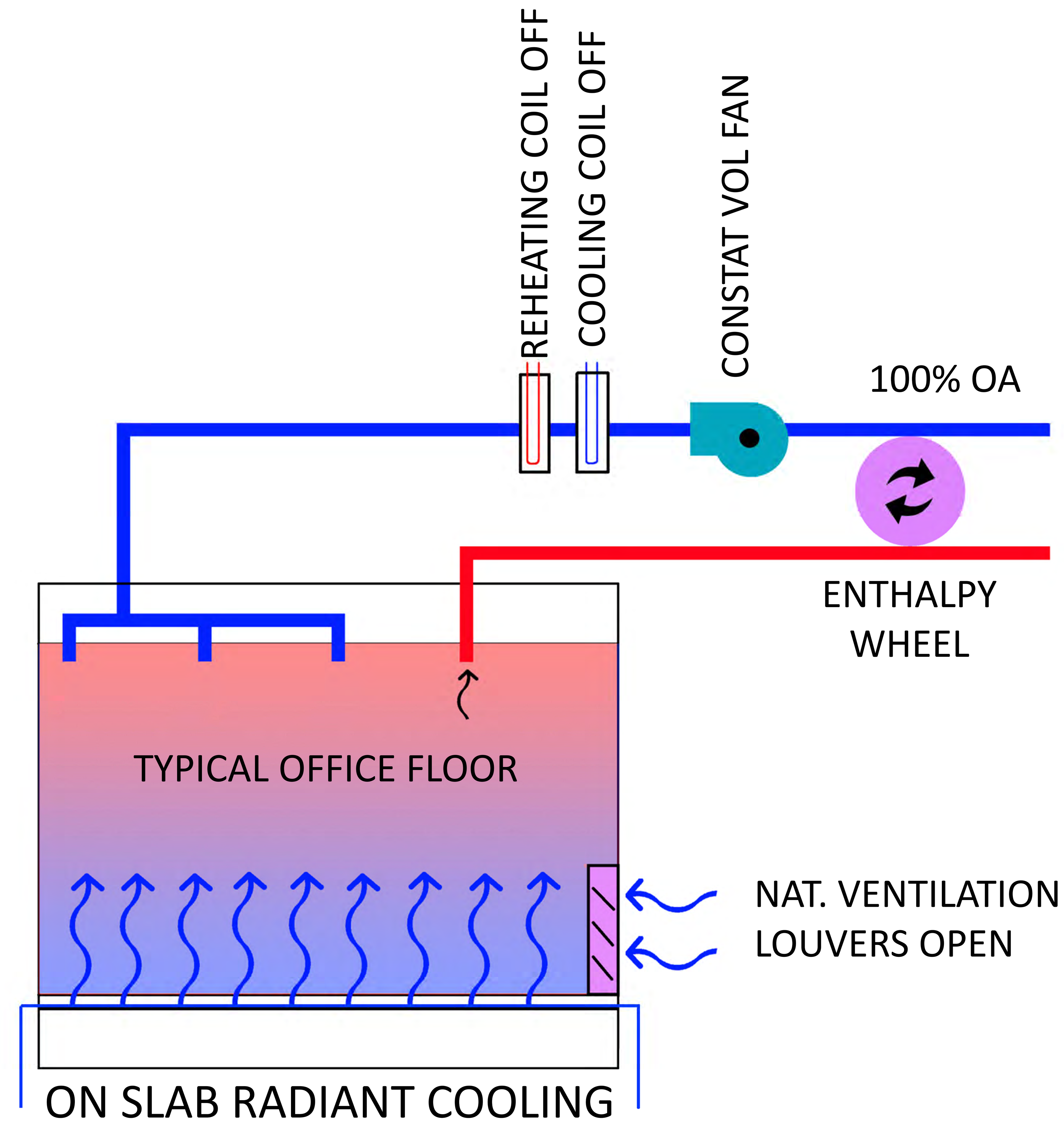
ABOVE SLAB RADIANT ZONING

The radiant system zoning will allow enclosed spaces to operate on a different schedule than the open office area. This will enable the occupants to control their thermal environment, and better ensure occupant comfort. The different shades of green depict the different zones.. The grey space indicates areas without an on slab radiant system.

TYPICAL OFFICE FLOOR SECTION

E-W LOBBY SECTION



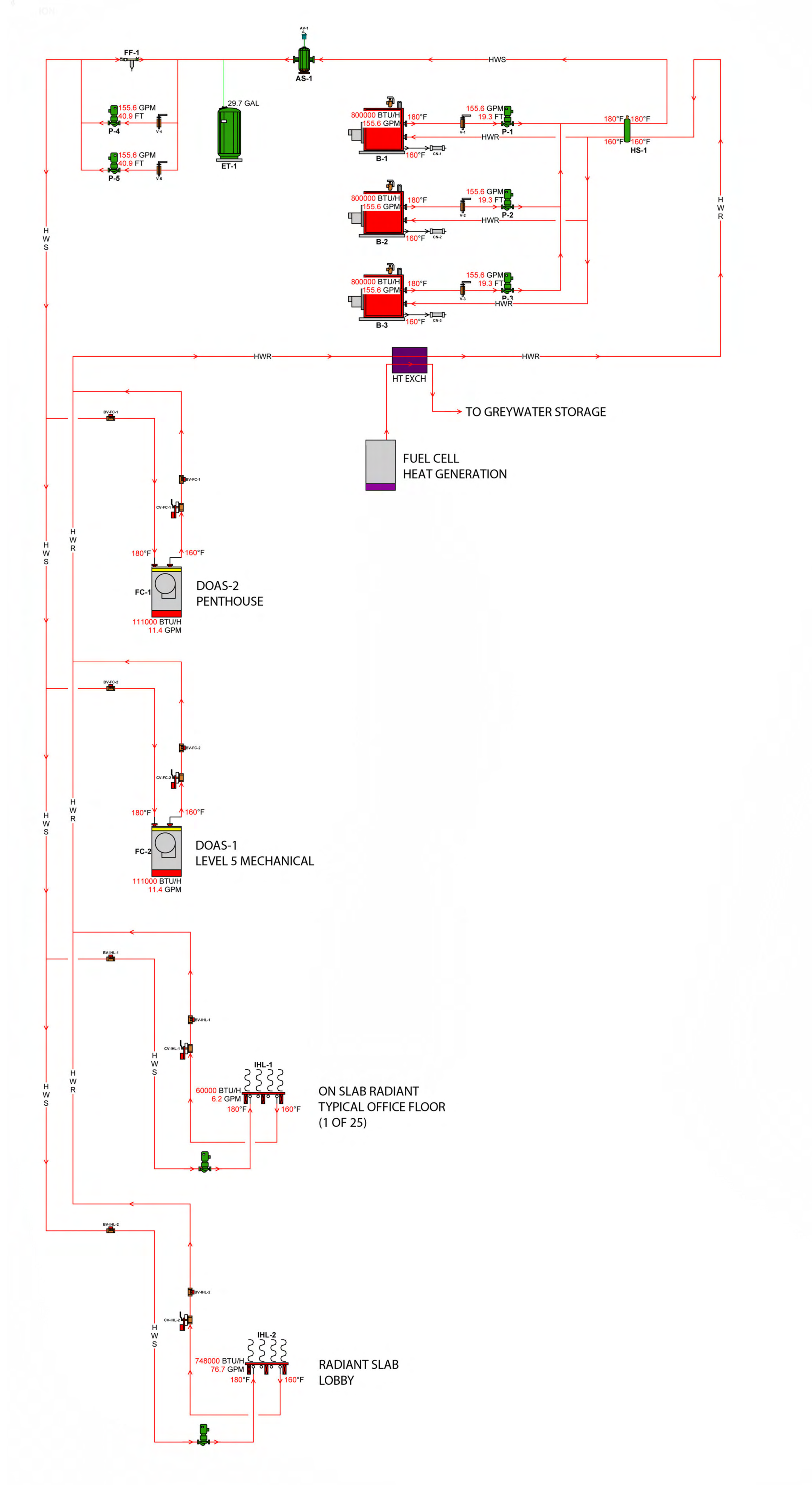


HEATING MODE

The mechanical system enters heating mode when the internal air temperature drops below 68F. The radiant slab enters heating mode, radiating heat from the concrete floor slab. The dedicated outdoor air system (DOAS) supplies 100% outside air to the space, while an enthalpy wheel operates for heat recovery. Return air returns through the plenum above the office floor. The natural ventilation louvers remain close, given unfavorable environmental conditions.

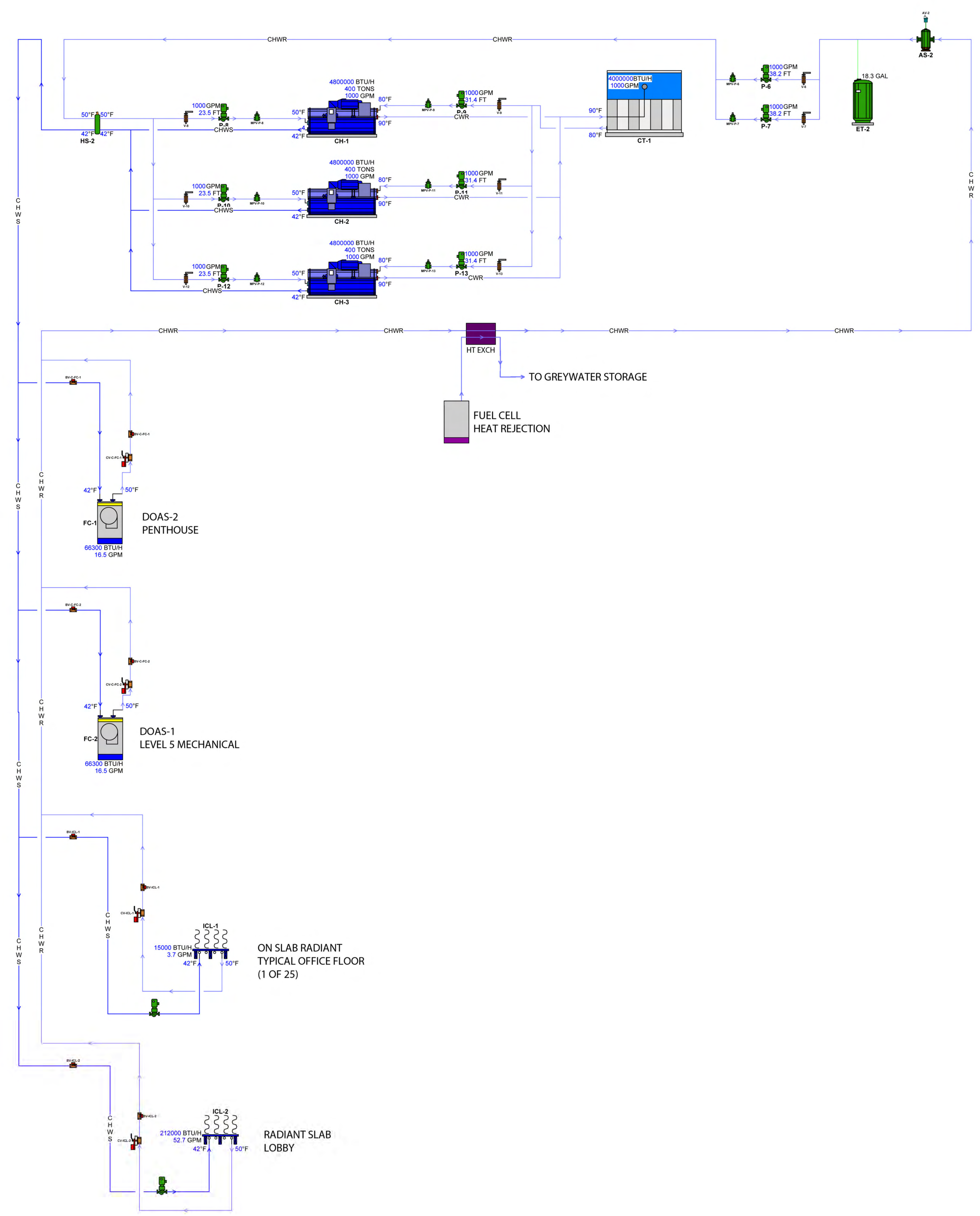
COOLING MODE WITH OPEN LOUVERS

The mechanical system enters cooling mode when the internal air temperature reaches above 75F. The on slab radiant enters cooling mode, acting as a sink to draw heat from the occupied spaces. The natural ventilation louvers operate based on the governing equations outlined in Table 4 of the mechanical narrative, providing both cooling and increased ventilation to the occupants. Exhaust air returns through the plenum above the office floor. When necessary, the dedicated outdoor air system (DOAS) supplies 100% outside air to the space, while an enthalpy wheel operates for heat recovery.



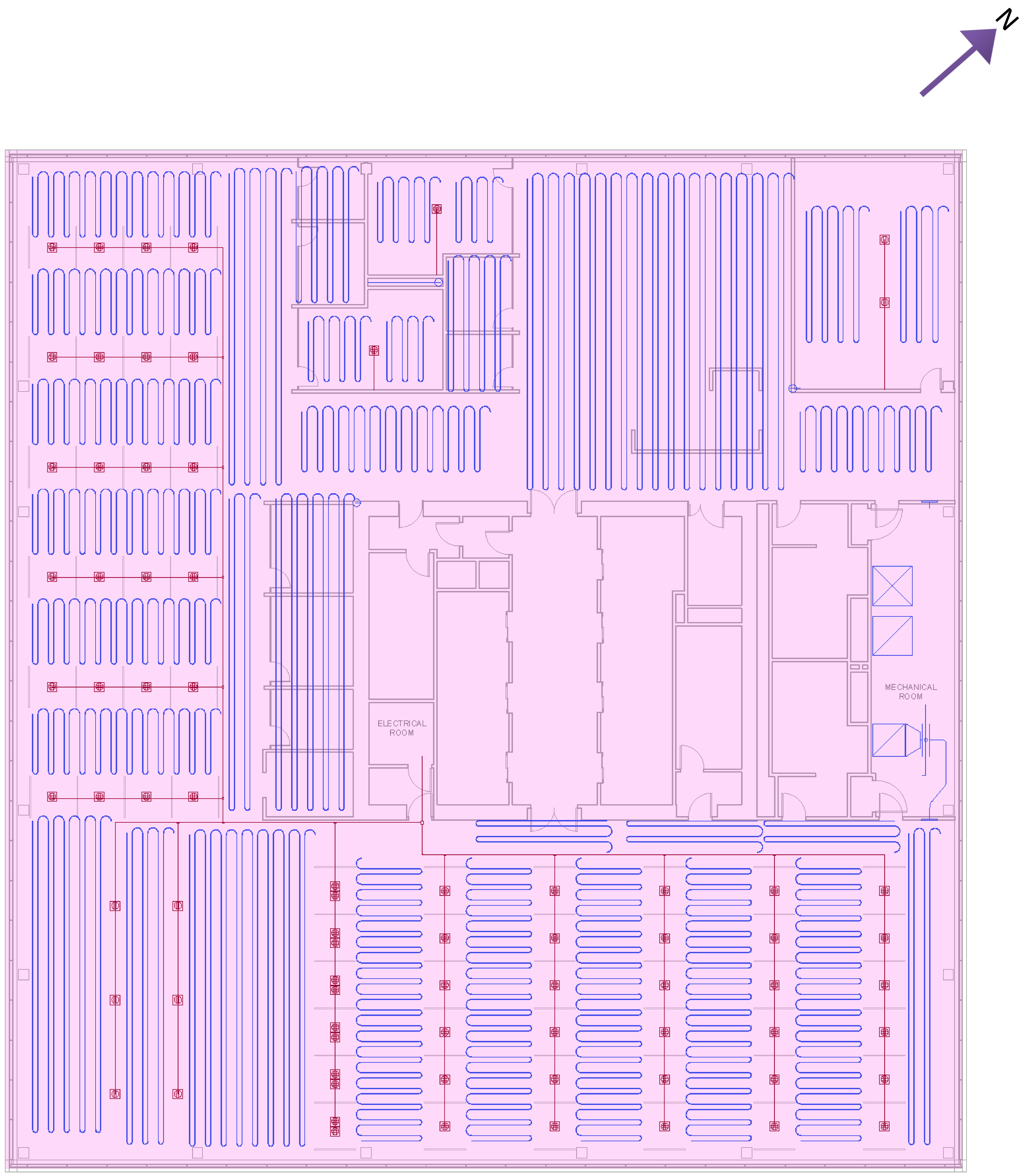
HYDRONIC HEATING LOOP

Three 1000 MBTU boilers supply both DOAS fan coils as well as tertiary radiant systems on each floor. Only the lobby and typical office floor radiant systems are modeled above. Fuel cell heat generation is added to the return loop through a heat exchanger.



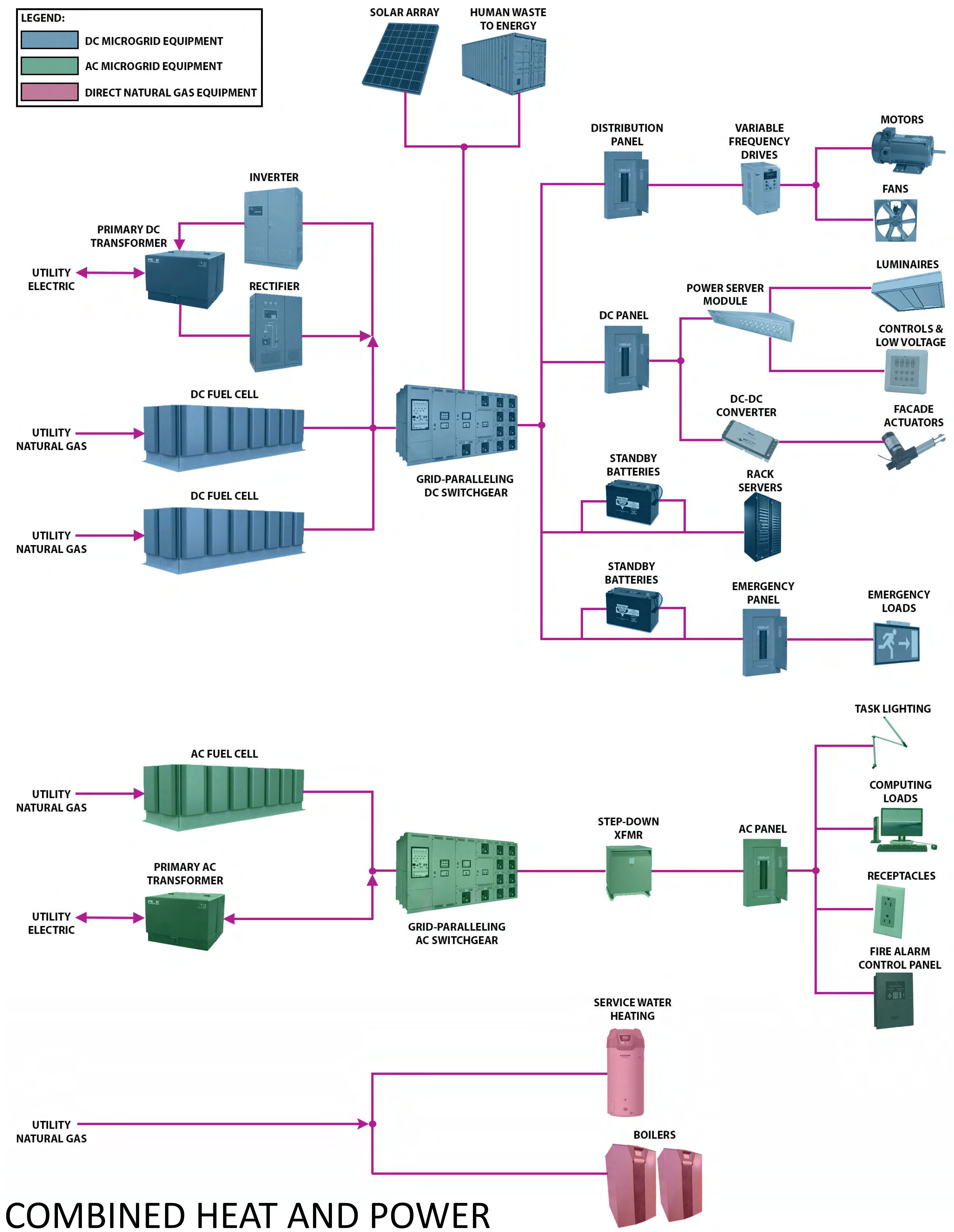
HYDRONIC COOLING LOOP

Three 400 Ton chillers supply both DOAS fan coils as well as tertiary radiant systems on each floor. Only the lobby and typical office floor radiant systems are modeled above. Heat is rejected to the cooling tower located on the roof. During cooling conditions, fuel cell heat generation is rejected to the cooling tower by means of a heat exchanger.



RADIANT PIPING & ELECTRICAL CONDUIT COORDINATION

The radiant piping layout has been coordinated with the electrical conduit and floor receptacle locations, in order to ensure adequate conduit pathways. The radiant tubing is highlighted in blue, while the electrical conduit is highlighted in red.



COMBINED HEAT AND POWER

In collaboration with the electrical engineers, an effective combined heat and power system was devised. This diagram shows how the gas, AC electric and DC electric serve 350 Mission.

WATER-COOLED CHILLER SCHEDULE

TAG	COMPRESSOR TYPE	CAPACITY (TONS)	WATER DATA		ELECTRICAL	BASIS OF DESIGN		NOTES
			EWT (F)	LWT (F)	VOLT/PHASE/HERTZ	MANUFACTURER	MODEL	
CH-1,2,3	Single Screw	400	56	44	460/3/60	Daikin	ZUW 410AM	1, 2

Notes:
1. COOLING CAPACITY IS BASED ON THE ENTERING CHILLED WATER TEMPERATURE OF 53.6 F AND LEAVING CHILLED WATER TEMPERATURE OF 44.6 F.
2. CHILLERS SHALL BE FURNISHED AND INSTALLED WITH NON-FUSED DISCONNECT SWITCH, LOW FLOW MONITORING, TAGGED PRESSURE RELIEF VALVES, HIGH LIMIT SWITHCES, AND DOC INTERFACE.
3. FUNISH AND INSTALL WITH VFD PRIMARY PUMPS.

HOT WATER BOILER SCHEDULE

TAG	FUEL TYPE	MAX INPUT (MBTU)	WATER DATA		ELECTRICAL	BASIS OF DESIGN		NOTES
			EWT (F)	LWT (F)	VOLT/PHASE/HERTZ	MANUFACTURER	MODEL	
B-1,2,3	NATURAL GAS	1000	140	176	120/1/60	CLEAVER BROOKS	CFC - 1000	1, 2

Notes:
1. FURNISH AND INSTALL WITH VENT AND PROVIDE COMUSTION AIR PER BOILER MANUFACTURER.
2. FURNISH AND INTSTALL WITH VFD ON PRIMARY PUMPS, DOC INTERFACE, TAGGED PRESSURE RELIEF VALVS, LOW FLOW MONITORING, HIGH LIMIT SWITCHES AND MAXIMUM FIRING STAGES AVAILABLE.

PUMP SCHEDULE

TAG	PUMP TYPE	SERVICE	FLUID TYPE	FLUID TEMP (F)	GPM	NPSH REQD (FT)	EFFICIENCY (%)	ELECTRICAL DATA			BASIS OF DESIGN		NOTES
								MOTOR HP	NOMINAL MOTOR RPM	VOLTS/PHASE/HERTZ	MANUFACTURER	MODEL	
CHW-1,2,3	VERTICAL INLINE	CH-1,2,3	WATER	54	675	15	57	7.5	1760	460/3/60	TACO	SKS4075	1, 3
CHW-4A, 4B	VERTICAL INLINE	CHW LOOP	WATER	44	2000	60	77	50	1760	460/3/60	TACO	SKS8011	1, 2, 3
CHW-5	VERTICAL INLINE	LOBBY CHW	WATER	44	125	15	60	1	1760	460/3/60	TACO	SKS3006	1, 3
CHW-6, 7, 8, 9, 10, 11 , 12, 13, 14, 15, 16 Z, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30	VERTICAL INLINE	OFFICE SPACE CHW	WATER	50	75	20	63	1	1760	460/3/60	TACO	SKS3006	1, 3
HW-1,2,3	VERTICAL INLINE	B-1,2,3	WATER	140	75	20	63	1	1760	460/3/60	TACO	SKS3006	1, 3
HW-4A, 4B	VERTICAL INLINE	HW LOOP	WATER	176	225	60	69	7.5	1760	460/3/60	TACO	SKS2508	1, 2, 3
HW-5	VERTICAL INLINE	LOBBY HW	WATER	176	25	15	54	0.25	1760	460/3/60	TACO	CI1206	1, 3
HW-6, 7, 8, 9, 10, 11 , 12, 13, 14, 15, 16 Z, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30	VERTICAL INLINE	OFFICE SPACE HW	WATER	140	8	7	--	0.125	1760	460/3/60	TACO	L1111	1, 3
DHW-1	VERTICAL INLINE	DHW LOOP	WATER	140	75	60	53	3	1760	460/3/60	TACO	SKS3009	1, 3
CW-1, 2	VERTICAL INLINE	CT-1	WATER	85	1425	30	73	14.5	1760	460/3/60	TACO		1, 3

Notes:
1. PUMPS SHALL BE INSTALLED WITH VARIABLE SPEED DRIVES.
2. PUMPS SHALL BE INSTALLED IN PARALLEL WITH EACHOTHER IN AN N+1 FASHION. BOTH PUMPS SHALL BE POWERED.
3 INSTALL ON ISOLATED SLAB WITH EXPANSION JOINT.

DIFFUSER AND REGISTER SCHEDULE

TAG	DESCRIPTION	AIRFLOW RANGE (CFM)	FACE SIZE (IN)	INLET SIZE (IN)	THROW (FT)		NOISE CRITERIA	BASIS OF DESIGN		NOTES
					MAX	MIN		MANUFACTURER	MODEL	
SA-1	SLOT SUPPLY DIFFUSER	50-120	3 X 60	6	21	2	--	PRICE	ASPI210	1, 2
SA-2	SLOT SUPPLY DIFFUSER	120-200	3 X 60	8	26	5	16	PRICE	ASHI210	1, 2
SA-3	ROUND SUPPLY DIFFUSER	80-140	6	6	6	2	20	PRICE	RCDA	1, 2
RA-1	REGISTER W/ ALUM, DAMPER	50-100	8 X 4	8 X 4	--	--	15	PRICE	610ZDAL	1, 2
RA-2	REGISTER W/ ALUM, DAMPER	100-275	12 X 6	12 X 6	--	--	19	PRICE	610ZDAL	1, 2
RA-2	REGISTER W/ ALUM, DAMPER	275-540	16 X1 0	16 X 10	--	--	18	PRICE	610ZDAL	1, 3

Notes:
1. EXACT LOCATION OF DIFFUSERS SHALL BE COORDINATED WITH THE ARCHITECTURAL RCP.
2. DIFFUSER AND REGISTER FINISH SHALL BE COORDINATED WITH THE ARCHITECT.

AIR HANDLING UNIT SCHEDULE

TAG	UNIT TYPE	LOCATION	AREA SERVED	MAX SUPPLY AIR (CFM)	MIN SUPPLY AIR (CFM)	MIN OA (%)	SUPPLY FAN						BASIS OF DESIGN		NOTES
							FAN TYPE	MAX AIRFLOW (CFM)	MAX DAN SPEED (RPM)	TOT/EXT SP (IN WG)	MTR HP	VOLTS/PHASE/HERTZ	MANUFACTURER	MODEL	
DOAS-1	CAV	LEVEL 5 MECHANICAL	LOBBY, LEVEL 6-18	49500	49500	100	F.C.	49500	1330	2.5	75	460/3/60	CARRIER	39MN85	1, 2, 3, 4, 5
DOAS-2	CAV	PENTHOUSE	LEVEL 18-30	45500	45500	100	F.C.	45500	1330	2.5	75	460/3/60	CARRIER	39MN85	1, 2, 3, 4, 5

Notes:
1. PROVIDE UNITS WITH ACCESS SECTIONS AND INSTALL WITH MANUFACTURER REQUIRED ACCESS AREA.
2. DAMPERS PROVIDED AT UNIT WITH SUFFICIENT ACCESS SECTIONS.
3. TOTAL STATIC PRESSURES LISTED ASSUME CLEAN FILTER MATERIAL.
4. AIR HANDLING UNITS SHALL BE PROCIDED WITH NON-FUSE DISCONNECTS.
5. UNITS SHALL BE INSTALLED WITH MANUFACTURER PROVIDED CONDENSATE PANS AND DRAINED IN ACCORDANCE WITH MANUFACTURER SPECIFICATIONS.