Energy Efficiency Design Guide

For Net Zero Carbon Buildings and Deep Energy Retrofits

SUNY

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Purpose of Guide

Net zero carbon (NZC) buildings and deep energy retrofits (DER) are goals for SUNY campus buildings as per Directive 1B-2, Net Zero Carbon New Buildings and Deep Energy Retrofits of Existing Buildings[1] (Directive 1B-2). NZC and DER buildings are the gold standard in sustainable design; these energy efficient buildings have lower utility bills, improve occupant comfort, reduce carbon emissions, and minimize maintenance costs. NZC combines passive design strategies, energy efficiency, building electrification, and on-site renewable energy technologies to operate buildings with carbon-free energy sources. Across the country, NZC buildings are becoming increasingly common for new construction. Still, existing buildings can achieve NZC too: nearly one third of the projects in New Buildings Institute's Getting to Zero Buildings Database[2] of commercial zero energy buildings are deep energy retrofits of existing buildings. Directive 1B-2 requires all DER buildings to achieve a target annual energy use intensity and requires all system replacements to be electrically powered, recognizing the importance of electrifying both new and exisiting buildings on SUNY campuses.

This guide introduces viable strategies for project teams to explore to achieve the energy use intensity (EUI) targets specified in Directive 1B-2. Included are descriptions of applicable energy efficiency measures (EEMs) for several typical campus building typologies, including: Classroom, Office, Laboratory, and Student Union. Project teams will find qualitative and quantitative information about the EEMs and case studies illustrating EEM packages which achieve the EUI targets in Directive 1B-2. This guide is for new construction and major retrofit projects; partial building renovations and system or component replacements are excluded since all system replacements must meet the prescriptive requirements of NYStretch Energy Code-2020[3] (NYStretch) as specified in Directive 1B-2.

The intent is for this guide to be used during early design and to help project teams consider critical energy efficiency decisions. The technologies within this guide are not an exhaustive list of all options that could be used in a project but instead are those most applicable to show compliance with Directive 1B-2 for the SUNY building typologies. As each project has unique conditions that must be carefully considered, such as site, occupancy, and program distribution, the optimal solution in terms of building performance, energy efficiency, and costs will vary by project. Research and iterative energy modeling are necessary throughout the design to determine a project-specific approach on how best to meet Directive 1B-2 while working within the established project budget.

Industry research demonstrates that NZC buildings can approach the same first costs as minimally code compliant buildings. Teams can manage the hard cost budget by drastically reducing energy consumption, integrating building systems, and rethinking the conventional system's price per square foot.

For example, a high-performance building envelope may result in a cost premium but allow for a reduced HVAC system size due to lower envelope and infiltration loads. The synergies between the systems offer first cost savings as a result of the reduced HVAC size. To help offset additional costs incurred from the improved envelope performance, the smaller HVAC system can result in gaining additional program area and/or reduced building height. Additionally, operations and maintenance cost savings can be found in optimizing new and existing building equipment capacity, run time, and other controls. To help further reduce project costs, project teams are encouraged to seek financial incentives through utility energy efficiency programs and/or other available programs associated with high-efficiency equipment and design strategies.

NYStretch is currently required for all projects and is the basis of design used in the case studies included at the end of the guide. This guide does not offer guidance on creating an energy model but rather focuses on possible energy efficiency measures and design solutions for achieving the Directive 1B-2 EUI targets. Project teams should refer to ASHRAE on recommended energy modeling procedures as needed. The case studies are included to demonstrate feasible pathways to achieving the EUI targets. Please note incorporating the measures presented in the case studies will not necessarily yield the same results due to project specifics. As such, each project team is responsible for conducting project-specific energy analysis to confirm that the proposed design meets the Directive 1B-2 requirements.

[1] https://sucf.suny.edu/sites/default/files/docs/1B-2.pdf

[2] https://newbuildings.org/resource/getting-to-zero-database/

[3] https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Code-Training/NYStretch-Energy-Code-2020

INTRODUCTION

Directive 1B-2 Introduction

Building energy efficiency and fossil fuel free energy sources are fundamental to SUNY's energy and carbon reduction goals. SUCF's policies play a critical role in ensuring that all capital projects are planned and executed in alignment with the broader strategic plan: helping SUNY achieve net zero carbon in line with other New York agencies and the rest of the state.

Directive 1B-2 is central to the achievement of SUCF's bold clean energy vision. The Directive is aligned with SUCF's vision, the State University of New York Clean Energy Roadmap[4], and with the objective of economy-wide, net zero carbon emissions by 2050 as laid out in New York's 2019 Climate Leadership and Community Protection Act[5] (CLCPA.)

The Directive is intended to cover the majority of the SUNY building typologies. For any unique project-specific cases not covered by Directive 1B-2, please consult with the SUCF Project Coordinator for further information.

Directive 1B-2 includes detailed information which must be carefully reviewed by project teams. Briefly, projects must achieve the following:

NET ZERO CARBON NEW BUILDINGS:

- Comply with NYStretch via ASHRAE 90.1 pathway
- Use all-electric systems
- Meet NZC specific energy use intensity targets (EUI, as expressed in $kBtu/ft^2/yr$), which vary by building type per Directive 1B-2
- Only connect to central plants that do not rely on fossil fuels (or will decarbonize by 2050)
- Include on-site renewable energy, where possible

DEEP ENERGY RETROFITS OF EXISTING BUILDINGS:

- Comply with NYStretch via ASHRAE 90.1 pathway
- Any new equipment specified must be electric
- Meet deep energy retrofit specific EUI targets
- Only connect to central plants that do not rely on fossil fuels (or will decarbonize by 2050)

PARTIAL BUILDING RENOVATIONS OR SYSTEM/COMPONENT REPLACEMENTS:

- Comply with NYStretch via ASHRAE 90.1 pathway
- Replacement systems must be all-electric and meet NYStretch prescriptive requirements

[4] https://system.suny.edu/media/suny/content-assets/documents/capital-facilities/energy/SUNY_Roadmap_FINAL.pdf
[5] https://www.nyserda.ny.gov/All-Programs/Programs/CLCPA

New Construction and Deep Energy Retrofits

New construction projects include the design and construction of new structures and additions to existing buildings. All building systems (envelope, mechanical, electrical, plumbing, etc.) are included in the scope and are rarely constrained during design configuration and system selection.

Deep energy retrofits include the design and renovation, rehabilitation, alteration, or other significant improvements to an existing building or structure. However, all building systems need not be replaced or altered in major renovations. Design choices in deep energy retrofits can be constrained by the existing structure, the building footprint, or the site.

Retrofits on SUNY campuses are more common than new construction. Many buildings across the SUNY campuses have not reached their useful life but rather require envelope upgrades and systems modernization. Retaining the existing structure often produces less construction waste and reduces embodied carbon and other impacts associated with new material production and delivery. An additional benefit is that retrofits can help retain the historic character of a campus.

SUCF projects may include the retrofit of an existing building with a new construction addition. In these scenarios, the completed building's design energy performance target, measured in EUI, combines the deep energy retrofit EUI target and the new structure as an area-weighted EUI. Sample calculations can be found on the following pages.

Partial building renovations or single system component replacements differ from deep energy retrofits. System replacements generally involve removing building equipment (e.g., air handling unit, lighting, water heater, etc.) and replacing it with a similar product but not making significant building updates. SUNY may elect to evaluate a partial building renovation as a building deep energy retrofit to understand how the replacement would fit into the longer-term plan for the building.

Both new construction and deep energy retrofit systems must be electrically powered: on-site combustion of fossil fuel and biofuels is prohibited. Exceptions are available for emergency back-up power and emergency heat, and other special cases such as laboratory process loads, kilns, and some commercial kitchen equipment as approved by the SUCF Project Coordinator. New connections to existing central plants powered by fossil fuels may only occur if there is an energy master plan that details how the campus will meet the Climate Leadership and Community Protection Act (CLCPA) goals or a documented commitment to decarbonize the central plant before 2050. Existing buildings connected to a central plant that is not on track to decarbonize by 2050 must disconnect and use all-electric systems for the retrofit.

INTRODUCTION

EUI Equation + Sample Calculation

Project teams shall use a calculation to determine the weighted EUI for the building energy performance target based on program distribution. EUI is expressed as kBtu/ft^2/yr, representing the total energy consumed by the gross floor area per year. The weighted EUI should round up to the closest whole number. Each space type in the weighted EUI calculation should comprise at least 10% of the total floor area. Spaces that represent less than 10% shall be grouped with the dominant space category. If a space type is less than 10% of a new addition or existing building, the space type square footage should be associated with the building's dominant space category. For instance, if a small café is 5% of a new addition, the 5% area would be incorporated into the new construction project's dominant space category, not the existing building.

Support or back of house (BOH) spaces should be included with the program area it serves. For example, corridors, mechanical and electrical rooms, and storage spaces supporting office program within a building are incorporated into the office square footage for the weighted EUI. Note the lab EUIs included in Directive 1B-2 are unique and include program area where experiments take place, lab equipment is stored or used, lab benches are located, or other lab related tasks occur. As such, offices, write-up areas, and BOH spaces within the lab building should be included under the office program type.

EUI EQUATION:

EUIt = (A1% x EUI1) + (A2% x EUI2) + (A#% x EUI#)

Where;

EUIt = EUI target

A# = Area per space type

EUI# = EUI target from applicable tables

NEW CONSTRUCTION OR DEEP ENERGY RETROFIT WITH MULTIPLE SPACE TYPES:

For buildings with individual space types that constitute less than 10% of the total building gross floor area, project teams should classify these spaces as the majority space type of the building.

For example, if a new construction building consists of 50% classroom, 42% dry lab, and 8% office, the following calculation determines the EUI target.

EUIt = (58% x 30) + (42% x 128) = **71 EUIt**

Since the office area is less than 10% of the total square footage, it is incorporated into the majority space type, classroom, which is therefore considered to take up 50% + 8% = 58% of the total square footage. For buildings without a majority space type, work with the SUCF Project Coordinator to determine the best approach.

DEEP ENERGY RETROFIT WITH A NEW CONSTRUCTION ADDITION:

For projects that include a major renovation plus a new construction addition, use a weighted average to identify the project's EUI target.

For example, consider a project that includes a deep energy retrofit of an existing classroom building and an addition. The addition will comprise 30% of the combined building's gross square footage. Two thirds of the addition (20% of the new building) is offices and 1/3 (10% of the new building) is a coffee shop. The building is served by on-site HVAC systems (i.e. not connected to the central plant). The following calculation determines the EUI target.

EUIt = (70% * 38 EUI) + (20% * 29 EUI) + (10% * 79 EUI) = **40 EUIt**

NEW CONSTRUCTION ADDITION TO AN EXISTING BUILDING:

For projects that include additions to an existing building that is not being renovated, only calculate the new addition's EUI. Identifying the existing building's EUI is not necessary unless the existing building includes a major renovation.

For example, if an existing classroom building with hot water and chilled water provided from a central plant does not undergo any renovation but adds a new construction office addition. The new addition consists of 50% physics lab, 31% classrooms, and 19% offices. The following calculation determines the EUI target for the new addition. The project team does not need to track the EUI of the unrenovated existing building as it is out of the project scope.

EUIt(new addition) = (50% * 128 EUI) + (31% * 30 EUI) + (19% x 29 EUI) = **79 EUIt**

Greenhouse Gas Emission Calculation

All projects shall include annual GHG emission calculations calculated from the results of the building energy model. Directive 1B-2 lists the emissions rate factors to be used as the basis for these calculations. Refer to Directive 1B-2 for the current GHG emissions rates as they are expected to change over time. The following examples use the emissions rates in the December 2020 version of Directive 1B-2. Final values should round to the closest whole number.

Example 1: A new construction, all-electric, 160,000 ft^2 academic building in Purchase has an EUI of 31.9 $kBtu/ft^2/yr$ which translates to 1,495.8 MWh/yr of electricity. The project GHG emissions shall exclude any on-site renewable energy.

The Directive 1B-2 emissions rate for NYC/Westchester is 586.4 lbs. CO_2/MWH as of December 2020.

1,495.8 MWh/yr x 586.4 lbs. CO_2/MWh

= **877,137 lbs. CO_2/yr**

Example 2: A major renovation of a 125,000 ft^2 residence hall in Buffalo has an EUI of 42 $kBtu/ft^2/yr$. The building includes a small coffee shop on the first floor that was not part of the renovation scope. SUCF approved the existing natural gas equipment to remain since the café was not in the scope. The electric load is 1,417.7 MWh/yr and 377 therms/yr of natural gas.

As of December 2020, the Directive 1B-2 emissions rate for upstate NY is 253.1 lbs. CO_2/MWH and the emissions rate for natural gas is 121.0 lbs CO_2/MMBtu.

1,417.7 MWh/yr x 253.1 lbs. CO_2/MWh =358,819.9 lbs. CO_2/yr

377 therms/yr = 37.7 MMBtu/yr

37.7 MMBtu/yr x 121.0 lbs. CO_2/MMBtu = 4,561.7 lbs. CO_2/yr

= 358,819.9 lbs. CO_2/yr + 4,561.7 lbs. CO_2/yr

= **363,382 lbs. CO_2/yr**

Energy Efficiency Measures

Introduction

This chapter explores potential energy efficiency measures (EEMs) that can be applied to achieve the EUI targets specified in Directive 1B-2. The measures presented are not an exhaustive list of all EEMs that can be used in a project but instead represent possible EEMs to show compliance with Directive 1B-2 for the SUNY building typologies analyzed. Project teams are encouraged to explore additional EEMs as applicable. Inclusion of an energy efficiency measure in this guide does not indicate acceptance by SUCF. All proposed designs and systems must comply with SUCF Directives and be coordinated and approved by SUCF.

The EEMs are organized into four categories: envelope, load, conditioning, and ventilation measures. Each EEM includes qualitative and quantitative information about how the measure reduces energy.

The envelope section focuses on strategies to minimize heat loss and gain through the building envelope. Each envelope component is accompanied by an example sensitivity graph that indicates the relative impact the envelope component has on heating and cooling loads. The sensitivity graphs include three building typologies (Office/Classroom, Laboratory, and Student Union) for both new construction and major renovation projects. Such analysis can help project teams better understand the impact envelope has on the building's overall heating and cooling loads as well as the optimal envelope performance recommended for the building type.

The load measures describe EEMs which help reduce the building's connected load including: lighting efficiency, lighting controls, plug loads and process loads, plug load management, kitchen equipment, and lab equipment.

The conditioning measures focus on EEMs which help condition the building more efficiently including all-electric system options for generating chilled water and hot water and several system configurations to meet space conditioning needs including: variable air volume, decoupled systems, variable refrigerant flow, and displacement ventilation.

Finally, the ventilation measures include EEMs which reduce energy consumption associated with outside air requirements including: exhaust air energy recovery, reducing reheat energy associated with dehumidification, lab ventilation rates, and exhaust hood requirements for kitchens and laboratories.

On the following page, a matrix is included which aims to quantify the relative impact that each measure has using a good, better, best rating system. The matrix is organized by building type for both new construction and deep energy retrofits. Project teams should use the matrix to identify applicable energy efficiency measures for further investigation and analysis.

New Construction

	EEM Description	Office/ Classroom	Laboratory	Student Union
Envelope	Wall Insulation	◑	◔	◑
	Roof Insulation	◔	◔	◔
	Glazing U-value	◕	◑	◕
	Glazing SHGC	◔	◑	◑
	Infiltration	●	◑	◑
Load	Optimized Lighting Design	◑	◑	◑
	Energy Star Equipment (Kitchens)	⊘	⊘	◔
Conditioning	Occupancy Based Room Setpoints	◑	◑	◑
	Water-Side Cooling Efficiency	◔	◔	◔
	Water-Side Heating Efficiency	●	●	●
	Plant Energy Recovery	◑	◑	◑
	Decoupled System (DOAS + FCUs)	◑	◕	◑
	Decoupled System (DOAS + VRF)	◕	◑	◑
	SA Temperature Reset (VAV systems)	◕	◑	◕
Ventilation	Energy Recovery Effectiveness	◕	◑	◕
	Air Quality Based Ventilation	⊘	●	⊘
	Staged Constant Volume Lab Exhaust System	⊘	◕	⊘
	Wind Responsive Variable Volume Lab Exhaust System	⊘	●	⊘

⊘ N/A ◔ Good → ◑ Better → ◕ ● Best

Ratings based on energy efficiency advantage of improving beyond 2020 stretch code

Deep Energy Retrofit

	EEM Description	Office/ Classroom	Laboratory	Student Union
Envelope	Wall Insulation	◕	◕	◕
	Roof Insulation	◑	◔	◑
	Glazing U-value	◕	◕	●
	Glazing SHGC	◔	◔	◔
	Infiltration	●	◕	◕
Load	Optimized Lighting Design	◑	◑	◑
	Energy Star Equipment (Kitchens)	⊘	⊘	◑
Conditioning	Occupancy Based Room Setpoints	◑	◑	◑
	Water-Side Cooling Efficiency	◔	◔	◔
	Water-Side Heating Efficiency	●	●	●
	Plant Energy Recovery	◑	◑	◑
	Decoupled System (DOAS + FCUs)	◑	◕	◑
	Decoupled System (DOAS + VRF)	◕	◑	◑
	SA Temperature Reset (VAV systems)	◕	◑	◕
Ventilation	Energy Recovery Effectiveness	◕	◑	◕
	Air Quality Based Ventilation	⊘	●	⊘
	Staged Constant Volume Lab Exhaust System	⊘	◕	⊘
	Wind Responsive Variable Volume Lab Exhaust System	⊘	●	⊘

⊘ N/A ◔ Good → ◑ Better → ◕ ● Best

Ratings based on energy efficiency advantage of improving beyond 2020 stretch code

Building Envelope

The building envelope, which includes the exterior walls above and below grade, foundation, floor slabs, exposed floors, roof, and glazing, plays a critical role in regulating heat transfer between the indoors and outdoors. By designing a high-performance envelope, the heat gains and losses to the building from the envelope can be minimized consequently, reducing the required mechanical system size and energy expended to condition the building while simultaneously improving occupant thermal comfort. Due to the interdependencies between envelope performance and mechanical system capacity, it is strongly recommended that existing buildings be evaluated for envelope improvements in parallel with proposed mechanical improvements. Similarly, new construction projects should closely coordinate envelope loads with mechanical system design.

Conducting an envelope sensitivity analysis is strongly recommended at the beginning of all projects. Such analyses can help project teams better understand building energy use characterization and the impact envelope has on the building's overall heating and cooling loads as well as the optimal envelope performance required for the building type. Each envelope component should be analyzed to determine its relative impact on building energy use and loads and determine the point of diminishing returns where increasing the performance of the envelope component yields minimal benefit.

Depending on the building program and facade area to floor area ratio, the project heating and cooling loads will be influenced by the envelope loads to a varying degree. Identifying the extent to which building envelope components impact energy use will be critical in defining envelope performance targets.

Envelope improvements must be investigated in detail for building renovations and historic buildings to ensure facade integrity. The project team should conduct detailed hygrothermal and heat transfer anaylsis to help inform decisions regarding insulation type, thickness, and facade performance while mitigating risks of spalling.

Opaque Envelope

Providing optimal insulation, and thus lower assembly U-values, for the exterior walls and roof will help reduce heat loss during cold weather and heat gain during warm weather. New construction offers the best opportunity to design a high-performance envelope. Although improvements to existing envelopes can pose challenges with respect to constructability and historical considerations, envelope improvements to existing envelopes can offer significant energy savings. Air sealing around foundations, windows, joints, and other penetrations will reduce infiltration without intrusive envelope upgrades. Special attention must be paid to condensation risk when insulating existing envelope assemblies to avoid material damage.

To optimize the thermal performance of the opaque envelope, construction details must be carefully reviewed to minimize or eliminate thermal bridging. Thermal bridging occurs when the continuity of insulation is interrupted, such as structural and connecting members penetrating cavity insulation, and can greatly diminish the thermal performance of the envelope. To help mitigate the risk of thermal bridging and improve the thermal performance of the envelope the following strategies are recommended:

- Prioritize continuous insulation and air barriers.
- Eliminate exposed structures that extend from indoors to outdoors or thermally isolate these elements using low conductivity separation.
- Minimize penetrations, especially involving high thermal conductivity materials.
- Specify materials with lower conductivity.
- Commission the building envelope.

Envelope Sensitivity

The subsequent graphics demonstrate example sensitivity analysis for the following envelope parameters: opaque wall, roof, glazing U-value, glazing solar heat gain coefficient (SHGC), and infiltration. The graphs show the correlation between envelope performance and building HVAC energy. Three building types (Classroom/Office, Laboratory, and Student Union) are represented for both New Construction (NC) and Deep Energy Retrofits (DER) to demonstrate how the impact of envelope performance varies by building program and construction type. Savings are shown relative to the NYStretch prescriptive performance for Climate Zone 5 (CZ5). Negative savings therefore demonstrate the energy penalty for specifying an envelope that does not comply with the prescriptive requirements for New Construction. The starting point for DER projects represents typical existing conditions of a building on a SUNY campus. Since the envelope performance of existing buildings is often significantly worse than current code requirements to begin with, envelope improvements in DER cases are often more impactful. Note the DER cases are shown in a dashed line while the NC cases are shown in a solid line.

The intent of such analysis is to identify the relative impact that each envelope parameter has on building loads and to identify the optimal envelope performance. Note the graphics included in this section represent case studies; results will therefore vary depending on project details. Project teams are strongly encouraged to complete project-specific envelope sensitivity analysis at the beginning of all projects to help inform the envelope design.

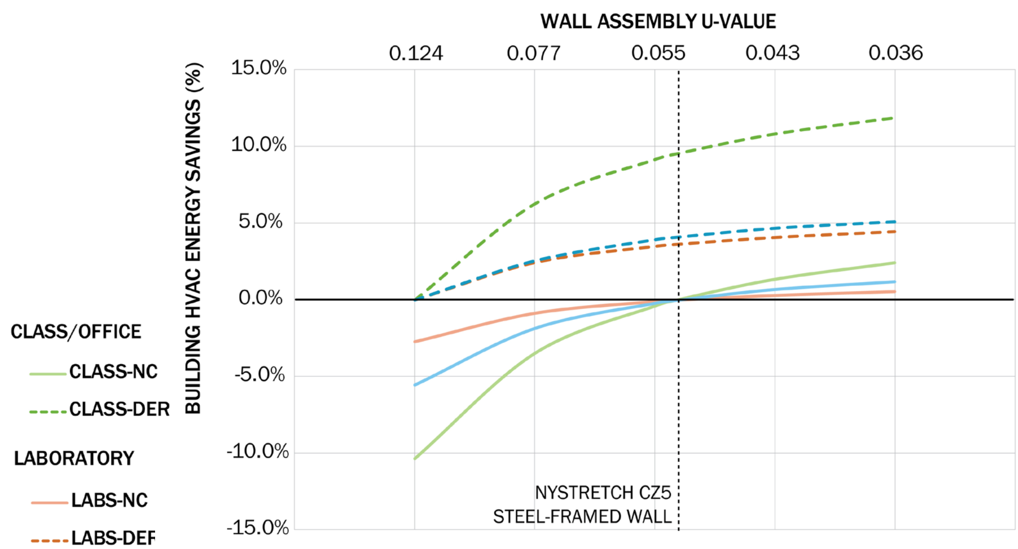


FIGURE 1.
WALL U-VALUE IMPACT

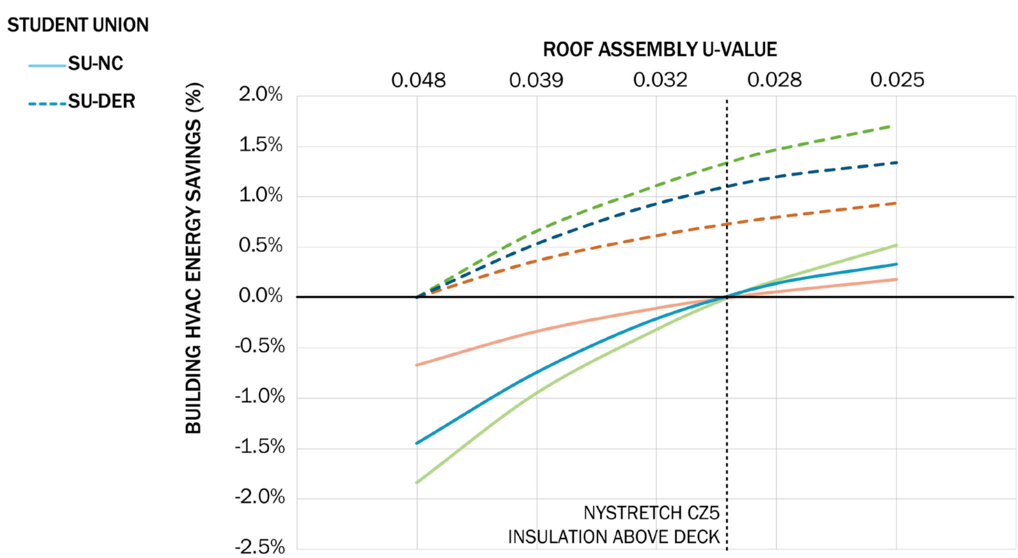


FIGURE 2.
ROOF U-VALUE IMPACT

Glazing

Glazing can significantly impact a building's energy consumption, daylight quality, and thermal comfort particularly in designs with high window-to-wall ratios (WWR). As such, project teams are encouraged to design with a WWR that balances access to daylight and views with glazing heat transfer. Through energy analysis, each orientation's WWR can be optimized to minimize net energy use. Specifying high-performance glazing systems with thermal breaks can significantly reduce a building's energy consumption by minimizing heat losses and gains to the space while simultaneously improving occupant thermal comfort.

The National Fenestration Rating Council (NFRC) rates glazing performance by U-value and solar heat gain coefficient (SHGC). The glazing assembly U-value measures the overall rate of heat transfer through the window and/or door assembly, including the framing. SHGC quantifies how effective the glazing is at blocking solar radiation from entering the building. Excessive solar gain can lead to overheating within a space, or if intentionally designed, it can minimize mechanical heating. A variety of technologies exist to improve the thermal performance of glazing systems including exterior shading, insulated glazing units, low-emissivity coatings, frame material, and spacer selection. For operable windows, investigate the impact of window types on glazing assembly U-value and infiltration.

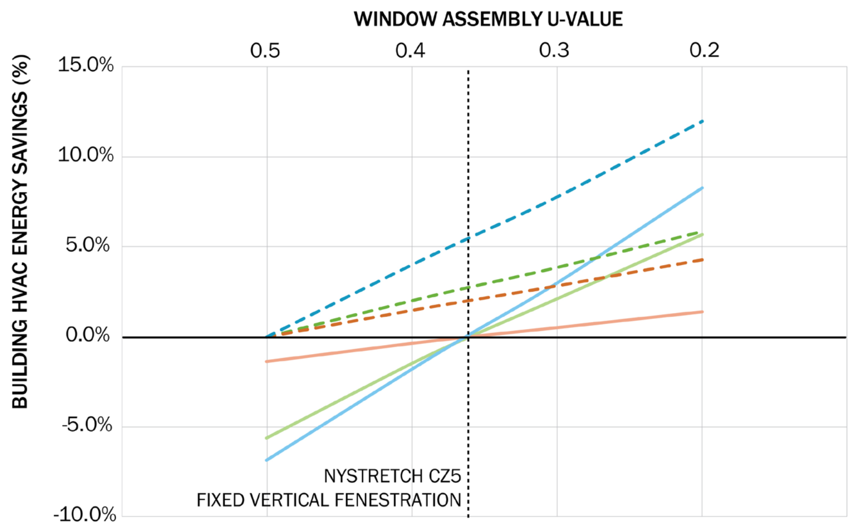


FIGURE 3.
WINDOW U-VALUE IMPACT

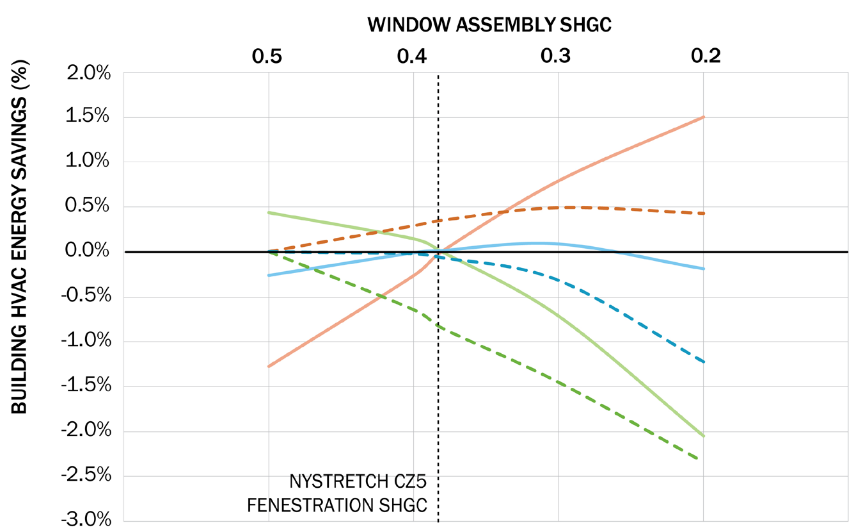


FIGURE 4.
WINDOW SHGC IMPACT

Air Leakage

For a well-insulated building envelope, it is essential to minimize air-leakage. Uncontrolled leakage through the façade significantly increases energy consumption associated with space conditioning, impairs occupant thermal comfort, and can damage wall assemblies. Minimizing the infiltration rate can be achieved by ensuring the air tightness layer is continuous around the entire envelope, staggering construction joints, sealing all sources of leakage, chases, penetrations, and other joints, using materials with low air permeance levels, and minimizing penetrations through the envelope. This detailed effort requires coordination during the design and commitment from the subcontractors in the field. Even where not mandatory, project teams should strongly consider contracting an independent third party to conduct whole-building pressurization testing in accordance with ASTM E779 to confirm the building envelope air leakage rate is operating as designed. Testing should occur with time to diagnose and resolve issues while the air barrier is accessible.

Following best practices described in this section and working with a trained and knowledgeable contractor offer the best opportunity to achieve air leakage rates equal to or better than the NYStretch prescriptive value of 0.40 cubic feet per minute per square foot of exposed facade (CFM/ft^2 façade). The Passive House US infiltration target value is 0.08 CFM/ft^2 facade, as a point of comparison.

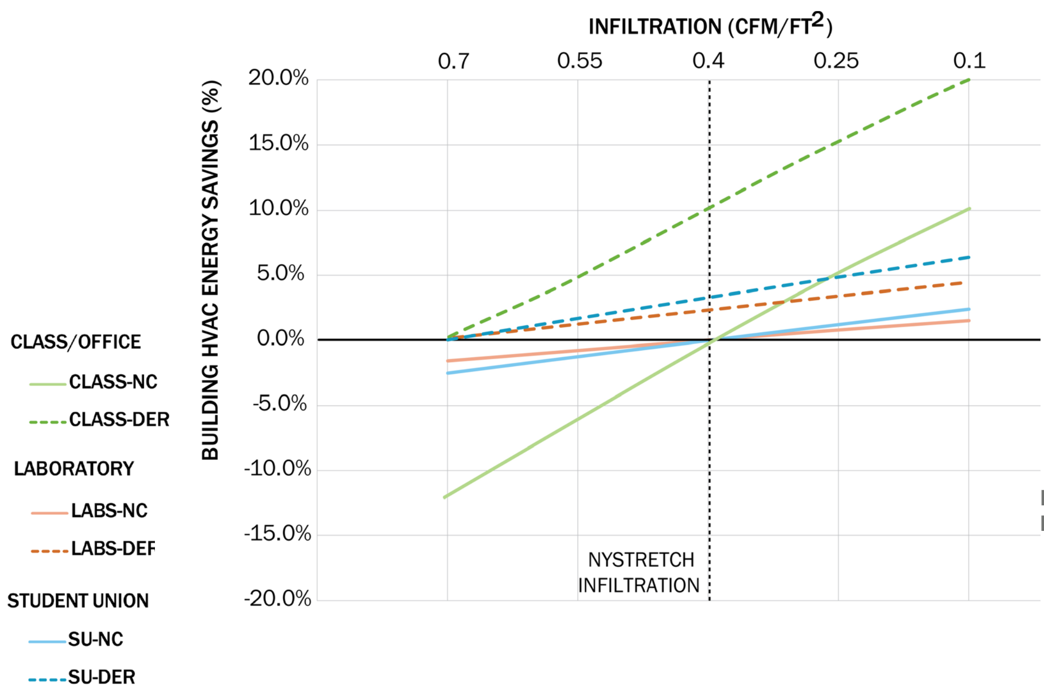


FIGURE 5. INFILTRATION IMPACT

Lighting

The goal of energy-efficient lighting design is to satisfy the lighting design criteria required for the program type while maintaining visual comfort, safety, and consuming the least possible energy. With the high impact of lighting energy consumption in buildings, reduction in lighting power density (LPD) is a practical target that can yield substantial results. Light emitting diodes (LEDs) offer high quality illumination and controllability at reduced energy consumption and maintenance costs. LED lighting is rapidly becoming the standard light source for newly constructed buildings, renovations, and lighting retrofit projects. Using LEDs can greatly diminish lighting energy consumption due to the increased efficiency as well as reduce cooling loads due to lower heat generation. LEDs typically last upwards of 50,000 hours which reduces the maintenance and purchasing costs in comparison to other available lighting technologies.

In addition to the lighting type, the control of electric lighting, either by occupants or an automatic system, has the potential to significantly impact energy usage. When choosing the appropriate control solution for luminaires in a space, the requirements must first be established. An existing room may benefit from installing a simple occupancy sensor or a networked wireless system while a new building may utilize the latest high-performance controls to integrate lighting and other building systems into the building management system.

Occupancy Sensors

Occupancy sensing is the most basic form of automatic lighting control for energy savings and is mandated by code for many space types. Using infrared or ultrasonic sensors to determine whether a space is occupied or vacant saves energy by automating the process of turning on or off lights without occupant intervention. By reducing the amount of time lights are left on when a space is unoccupied, energy savings are achieved, and the lifetime of the luminaires are extended due to reduced operating hours.

Occupancy sensors operate by immediately turning on the lights in a space when a person enters. This is commonly used in closed spaces such as bathrooms, closets, and storage rooms. Occupancy sensors are often combined with a vacancy function, where after a preset period has passed the sensor will trigger the lights to turn off. Vacancy sensors will turn off the lights when all occupants have left a room and are commonly used in classrooms, offices, and other non-critical spaces. Sensors may use infrared, ultrasonic, or dual-sensor technologies to identify human presence by heat, sound, or both. Dual technology sensors are best used in spaces where occupants may be still or unseen, such as offices, classrooms, and bathrooms.

Daylight Sensors

Automated daylight control saves energy and maintains occupant visual comfort. Depending on the size of the space, one or more daylight sensors will be necessary near doors, windows, or skylights that allow daylight to enter the space. At periodic intervals, the sensor will measure the brightness of the space; when certain thresholds are reached, the lights will either turn on, dim to a preset level, or turn off entirely.

Energy savings through this strategy occur by limiting the use of electric lighting when there is sufficient daylight. Additional energy savings can be realized when daylight dimming is combined with active shading strategies. When solar radiation is high, window shades will deploy to reduce the cooling load and a daylight sensor will adjust the electric lights appropriately to compensate for the reduced daylight entering the space, resulting in net energy savings while maintaining occupant comfort.

Networked Lighting Controls

A networked control solution connects zone-controlled luminaires in multiple spaces to a central controller that can manage an entire floor or building. This allows building management to schedule events and monitor lighting states across the building. A networked system will have a digital dashboard from which a facilities manager can monitor the system and quickly identify and fix performance issues.

Connecting lighting to a larger network offers several advantages over individual room control. A networked lighting system can communicate with other building systems via BACnet and share data collected by sensors. For example, a vacancy sensor can trigger the lights to turn off and simultaneously notify the HVAC system to decrease room airflow due to reduced occupancy. Facilities management teams can monitor the status of the entire lighting system from one location to proactively replace fixtures when they are nearing the end of lifespan as calculated by total operational hours or receive an alert when a fixture is malfunctioning.

Plug Loads

Plug loads include any device that plugs into a building's electrical system. With the ever-growing use of personal electronic devices, additional electricity is being drawn from the power grid for plug load consumption. As buildings continue to improve the efficiency of other end-uses such as, lighting, heating, and cooling, plug loads represent a larger portion of the overall annual building energy consumption. As such, it is critical to evaluate energy efficiency measures to reduce plug load energy consumption. Plug loads are often treated as an end-use to which EEMs cannot be applied. However, plug load controls are required by code and plug load energy consumption can be managed and reduced through low to no-cost measures that are easily implemented through ENERGY STAR-Certified equipment, device settings, controls, and occupant behavior.

Control Strategies

Automatic receptacle control is required by the NYStretch energy code: at least 50% of 125V 15A and 20A receptacles located in classroom, office, and certain other spaces must be automatically controlled by a device that turns power on and off based on a schedule, occupancy sensor, or an automated signal from another control or alarm system. Project teams can go beyond code by extending controls to more than 50% of relevant receptacles, by controlling receptacles not covered by the code requirements, and by enhancing integration between HVAC, lighting, and plug load control systems.

Beyond the receptacle, controls can be implemented via the plug strip. Occupancy-sensing plug strips detect the presence or absence of a user and automatically turn equipment on and off in response. Load-sensing plug strips use a primary-secondary relationship where the sensed load of the primary device, such as a computer, controls when secondary, dependent devices are turned on and off, such as monitors. Load-sensing controls are effective for secondary equipment such as imaging, monitors, and other miscellaneous workstation equipment.

Independent of what technology is selected, it is critical that plug load management strategies are accompanied by user education to ensure the building users are familiar with the intended operation of the control system.

Procurement

Appliance efficiency choices can make significant impacts on building energy use. As of 2021, New York State does not have electric appliance standards. Therefore, it is incumbent on project teams to minimize plug loads. Many devices contribute to plug loads, but some of the biggest users are computers, monitors, televisions, servers, and personal electronic chargers, all of which draw power even when not being used or fully charged. Ensure efficiency by procuring equipment with certified or rated high performance. For rated product types, specify Energy Star equipment as a minimum and seek equipment with higher CEE (Tier 2, 3, 4 and Advanced Tier) ratings.

Estimating Plug Loads

Project teams must establish the expected plug load capacity (W/ft^2) for a project and the anticipated usage of the building inform the energy analysis completed as part of Directive 1B-2.

Overestimating the required plug load capacity can result in oversizing of electrical and mechanical systems thus increasing energy usage and first costs. In addition to modeling the plug load capacity, the plug loads in the energy model must be accompanied by a usage schedule which predicts how the load will vary throughout the day. The ASHRAE 90.1-2016 User's Manual includes default usage schedules by building type that can be used as a starting point.

For added accuracy in predicting EUIs, project teams are encouraged to coordinate with the intended building users and facility manager to better understand the anticipated occupancy profiles of the building. For existing buildings, conducting a walk-through to identify existing equipment, device usage, and the schedule of the building can be helpful to identify changes that need to be made as part of the retrofit.

Specialty Equipment

Process Loads

Process energy is defined by ASHRAE as "energy consumed in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort and amenities for the occupants of a building." Process loads may include elevators, data centers, commercial kitchen equipment, ice rinks, swimming pools, and manufacturing equipment.

While it is traditionally challenging to reduce the energy use of process loads, there should be a discussion with the building user groups to address opportunities for energy savings. Creative solutions to set back process equipment during unoccupied hours, utilize waste heat recovery, or purchase more efficient equipment models are almost always necessary for NZC and DER buildings.

Kitchen Equipment

Food service represents one of the most energy intensive building program areas per square foot due to cooking requirements, kitchen appliances, and refrigeration needs. Projects with food service are strongly encouraged to specify ENERGY STAR certified kitchen appliances and work with equipment manufacturers to increase efficiency and reduce energy consumption. Most commercially available cooking equipment can be powered by electricity. Although electric cooking technologies based on electric resistance have been readily available for years, induction technology has revolutionized electric cooktop cooking by modifying the way in which heat is transferred to cookware. Commercial induction range tops are technologically mature and have become increasingly more available in the New York marketplace.

To align with the Directive 1B-2 goals and reduce carbon emissions associated with food preparation, projects must evaluate and implement an all-electric kitchen design unless specifically approved by the SUCF project coordinator. In addition to reduced carbon emissions, electric cooking equipment delivers heat more effectively than gas equipment, thus reducing cooling loads.

Laboratory Equipment

Since laboratories require extensive equipment to conduct research, energy consumption associated with equipment can comprise a major portion of the overall energy consumption. As such, it is important to identify and implement strategies that can help reduce energy consumption associated with lab equipment. In addition to efficiently managing lab plug loads, it is also important to accurately assess and determine the anticipated required plug load for the space. Overestimating lab plug loads will result in increased first costs and operating costs due to oversized mechanical systems. Below are several strategies which can reduce laboratory equipment energy:

ENERGY STAR LABORATORY EQUIPMENT

The ENERGY STAR Label indicates that the equipment reduces energy consumption by utilizing various technologies. Project teams are encouraged to specify and select ENERGY STAR labeled equipment when possible.

ULTRA-LOW FREEZER SET-POINT ADJUSTMENT

Recent research and field tests have demonstrated that resetting temperature set-points of ultra-low freezers by a few degrees can result in significant energy savings without significantly impacting the life of the specimens stored. For example, maintaining a -80°C ultra-low freezer at -70°C has shown to save 20-30% energy, according to the US Department of Energy.

SHARED LABORATORY EQUIPMENT

Generally, lab equipment does not get fully utilized or is used infrequently based on the research needs. Encouraging researchers to share equipment can help save space, conditioning energy, and reduce equipment energy consumption.

Building Automation System

While not traditionally considered an energy efficiency measure, the success of a NZC and DER building relies on its efficient operation. The building management system (BMS) and control system should be designed and commissioned in partnership with the SUNY operations staff. Early conversations about how the building will be staffed, maintained, and operated should inform the design of the BMS and other required controls.

Building automation technology is rapidly advancing and presents great opportunity to reduce operational energy consumption by integrating multiple building systems and analyzing building trends.

Hiring or assigning a design team member as a controls integrator can improve operational efficiencies and on-site diagnostic capabilities through the proper inclusion of energy controls and sub-meters. This professional helps bridge the gap between building automation and energy management and can assist with the layout, access, and format of the lighting, HVAC, plug load meters, and control considerations to support operational energy consumption reductions.

In addition, the opportunity of grid-connected controls to reduce real-time carbon emissions should be discussed and explored for projects. The energy model can be used as a tool to leverage design decisions related to demand response controls.

Water-Side Heating and Cooling Efficiency

Heating and cooling in larger buildings is typically delivered by circulating chilled and hot water. Chilled water absorbs excess heat in a space to cool it down while the hot water adds heat to a cold space to warm it up. In forced air systems, water is used indirectly to either heat up or cool down air, which is then delivered to a space for conditioning. Radiant systems, on the other hand, directly use hot water as a heat source and chilled water as a heat sink.

Chilled water and hot water are generated by water-side systems. Like air-side HVAC systems, different water-side systems offer varying efficiencies. Their efficiency is usually reported as a coefficient of performance (COP), which is simply the ratio of energy consumed to energy provided. A higher COP means higher efficiency. COP depends both on the system itself as well as the conditions in which the system is operated.

Conventionally, chilled water is provided by chillers, which use the refrigeration cycle to cool water, and hot water is provided by gas-fired boilers. Given that Directive 1B-2 prohibits the use of fuel-burning systems such as gas boilers, only electric water-side equipment solutions have been described in this report. These systems can be used independently or combined in a hybrid approach depending on the heating and cooling profiles of a project.

Ground Source Heat Pump

Ground source heat pumps (GSHPs) typically represent the most efficient water-side equipment. GSHPs are widely available and suitable for all building types. These systems pull heat from the ground in winter and reject heat to the ground in summer. They make use of the fact that the ground temperature of the earth tends to stay relatively stable throughout the year, usually only fluctuating between 45°F and 65°F. This temperature band narrows as one drills deeper into the earth.

GSHPs can have either a closed loop or open loop configuration. In a closed loop system, wells are drilled deep into the earth, typically around 500 ft. These wells are filled with large tubes of a water-glycol fluid that exchange heat with the ground. A heat pump in the building either pulls heat from or rejects heat to the ground wells through a heat exchanger.

In an open loop system, groundwater (or occasionally surface water from a lake, river, or other reservoir) is directly used as a heat source or sink. Once heat has been exchanged with groundwater, it is returned to the ground or reservoir.

Due to the requirement of ground wells or a nearby water source, GSHPs can have significant site constraints, particularly for smaller buildings, projects with limited site area, or retrofits, which may limit applicability.

Air Source Heat Pump

Air source heat pumps (ASHPs) function in a similar way to GSHP. These systems, however, perform heat exchange with outside air rather than the ground. Since heat pumps must work harder to pull heat from a colder source, ASHP system efficiency is typically lower than GSHP system efficiency.

Both the heating capacity and the efficiency of traditional heat pumps tend to suffer when the outside air temperature is low. This has been identified as a heat pump application barrier for over a decade. However, programs like the U.S. Department of Energy's Building Technologies Office Emerging Technologies program and the Northeast Energy Efficiency Partnership's High Performance Air Source Heat Pump Initiative have helped spur research, remove installation barriers, improve customer and installer knowledge, and widely publicize cold-climate products. Major manufacturers regularly release new models with improved low ambient temperature performance, generally defined as 100% capacity at 5°F and 75% capacity at -13°F. Air source heat pumps optimized for cold climates offer a viable pathway to electrifying heating in New York and achieving net zero carbon building design.

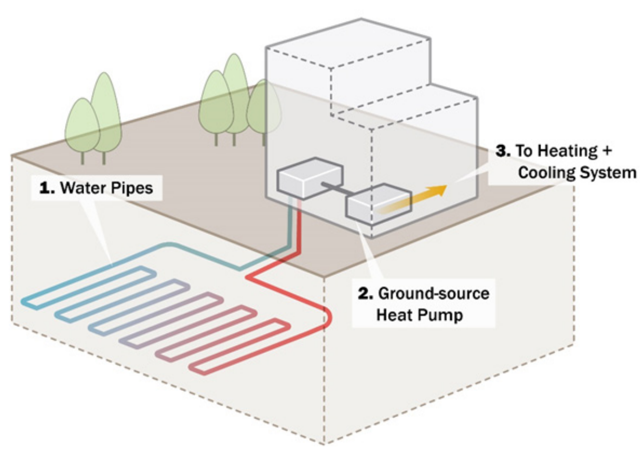


FIGURE 6. GROUND SOURCE HEAT PUMP

In retrofit applications previously served by combustion-based heating sources, such as a furnace, existing ductwork may need to be replaced. Combustion furnaces can produce hotter air than most heat pumps, therefore larger ductwork may be necessary to accommodate the additional airflow required to deliver equivalent heat to the space. When a deep energy retrofit occurs, ideally, improvements to the envelope are made concurrently with HVAC upgrades, thus decreasing heating loads. However, for projects where the envelope is not upgraded but an ASHP is installed the existing ductwork will likely need to be replaced.

Where ground access is limited due to site constraints, ASHPs provide a great substitute to GSHPs. These systems also have a lower first cost than GSHPs since they do not involve drilling into the earth.

Heat Recovery Chiller

Heat recovery chillers (HRC) are chillers that reject heat into a hot water loop used for space heating, instead of rejecting heat via conventional methods such as a cooling tower. This configuration allows the building to capture waste heat rather than reject it to the outside environment. These systems tend to work very well for projects that have simultaneous heating and cooling demands, such as lab buildings, mixed-use buildings, and larger offices.

Electric Chillers and Boilers

Chillers are the most common way to generate chilled water for larger buildings. This equipment pushes heat out of water by way of the refrigeration cycle. Heat is either rejected into the air (air-cooled) or through evaporation by way of cooling towers (water-cooled).

A building with chillers will typically use boilers to generate heating. In most cases, natural gas boilers are used. To maintain an all-electric building design, as required by Directive 1B-2, project teams have multiple options, including heat recovery chillers, heat pumps, or electric boilers. Electric boilers use electric resistance to generate hot water and can be relatively inexpensive in all-electric retrofit projects where a natural gas boiler needs to be replaced.

While electric boilers are cheap to install, they are expensive to operate. Compared to heat pumps, electric boilers are very inefficient: their COP is 1.0 whereas heat pump COPs are often in the 3-4 range. In addition, electric boilers are very power-intensive, which can drive high demand charges on top of their relatively high energy use. These high power requirements may increase the size of the electrical infrastructure needed as well as the operating utility costs of the building.

District Energy Systems

Rather than generating chilled water and hot water through on-site systems, projects may also be connected to district or campus energy systems which generate chilled water and hot water off-site and deliver the utilities to the building. Per Directive 1B-2, the intent is for central plants to be fully electrified or powered by carbon-free sources by 2050 at the latest. New connections or existing connections to central plants powered by fossil fuels may only occur or remain if there is an energy master plan in place detailing how the campus will decarbonize the central plant prior to 2050.

Domestic Hot Water

Domestic hot water (DHW) use varies widely by building type. Office buildings typically have low domestic hot water demands while residences or facilities on campus with food service will have large domestic hot water demands in comparison. Electrification of DHW focuses on heat pump water heaters (HPWH) which offer substantial energy savings in comparison to conventional gas water heaters due to the improved coefficient of performance. HPWH products are generally either “unitary” (50-100 gallon storage tank with integrated heat pump) or “central” (one or multiple heat pumps serving a water heating plant) and are applicable for new construction as well as some major renovations. Where central heat pumps are not possible, point of use electric water heaters should be considered in lieu of central electric boilers due to heat loss from piping and distribution.

Space Conditioning

Space conditioning can be provided through a variety of mechanical configurations and air distribution devices. Project teams are encouraged to study multiple design configurations to determine the most energy efficient solution to meet the project specific needs. Below are descriptions and schematics of several system options.

Variable Air Volume

Variable air volume (VAV) systems utilize air as a heat transfer medium to meet space conditioning needs. Heated or cooled air is delivered to the space through ducts. Zone level airflow is modulated by motorized dampers called VAV boxes, allowing the system to react to changes in space usage by modulating airflow. VAV systems are widely adopted in the building industry and represent one of the most common system types.

Several control strategies can be employed to optimize the performance of a conventional VAV system including:

- Outside air economizer
- Expanded supply air temperature (SAT) reset
- Static pressure reset
- Occupancy sensor-based thermostat setbacks
- Demand control ventilation

VAV systems should include an outside air economizer which enables the system to bring in additional outside air under favorable conditions, thus reducing the cooling energy consumption. A supply air temperature reset of 5-10°F is recommended which allows the air handling unit (AHU) to reset the supply air temperature when conditions permit, thus reducing unnecessary zone level reheat. To reduce fan energy consumption, the fan's static pressure set point can be automatically adjusted to match load conditions which allows the supply fan to operate more efficiently. Occupancy sensor-based setbacks rely on occupancy sensors to reset the space temperature setpoint if the space becomes unoccupied. This enables spaces to have an occupied setpoint and unoccupied setpoint, during building operating hours, to save conditioning energy.

Although widely adopted, there are several potential limitations associated with all air VAV systems including: additional space requirements for ducts and mechanical equipment, possibility of simultaneous heating and cooling, and comparatively lower efficiency if the VAV system is not coupled with perimeter hydronic heating.

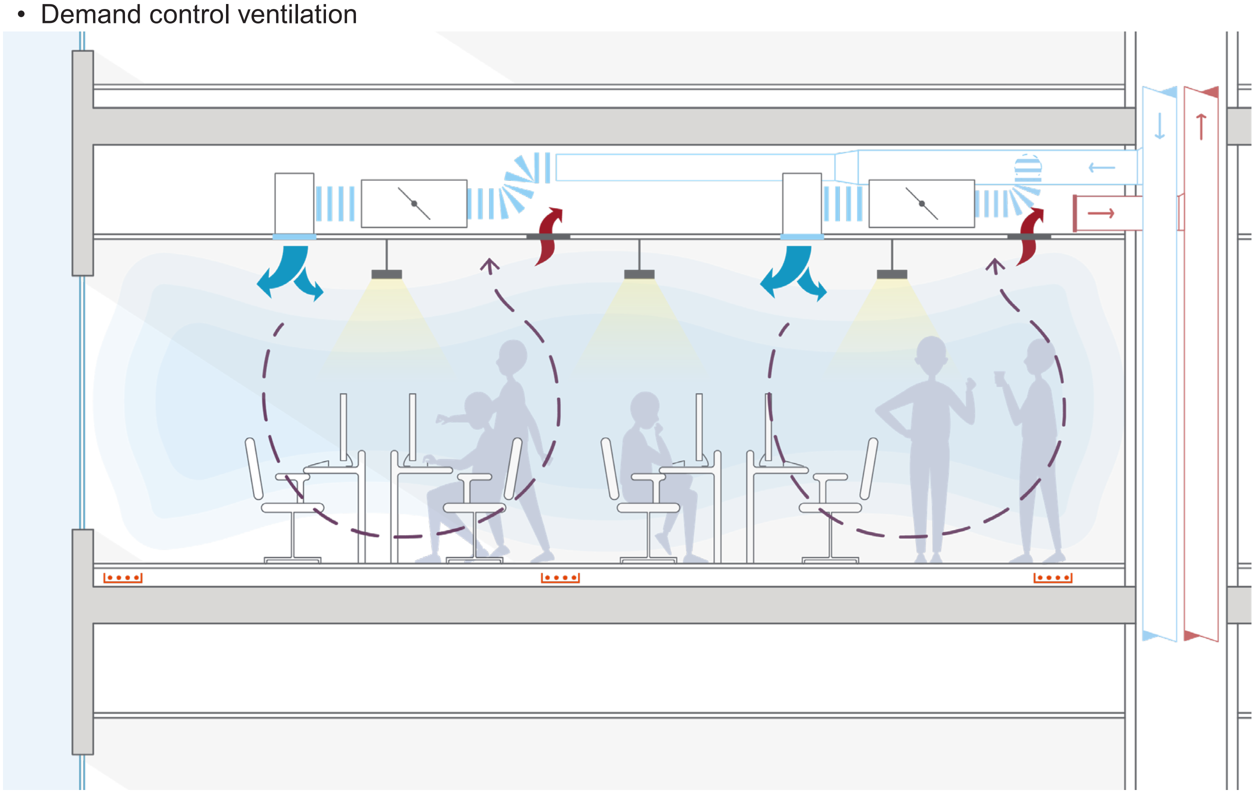


FIGURE 7. VARIABLE AIR VOLUME SCHEMATIC

CONDITIONING

Decoupled Ventilation and Hydronic Systems

Hydronic systems rely on water as the primary heat transfer medium, rather than air, to satisfy space conditioning requirements. Due to the high heat capacity of water, conditioning needs are more efficiently met in comparison to all-air systems. Conditioned ventilation air is provided to the space via a dedicated outdoor air system (DOAS) to meet the space latent loads and a portion of the sensible loads. By decoupling ventilation from space conditioning needs, fan energy consumption is decreased, and smaller ductwork is required than a conventional VAV system. However, cooling potential from air-side economizer operation is limited with a DOAS, therefore, water-side economizers in cooling towers should be explored when possible.

Active chilled beams (ACB) and fan coil units (FCU) represent two common zone-level hydronic system options. To further reduce fan energy consumption, passive hydronic systems such as radiant panels or passive chilled beams can be used in certain applications instead. These are most effective and efficient when designed as four-pipe systems to provide both space heating and cooling.

Variable Refrigerant Flow

Variable refrigerant flow (VRF) units are split heat pumps consisting of outdoor condensing units (ODUs) and an indoor cassette or fan coil unit connected by refrigerant piping. The ODU can either be air-cooled or water-cooled. The indoor cassette units can provide both heating and cooling as requested by the zone thermostat. Note VRF systems require the approval of SUCF and the corresponding campus.

Generally speaking, VRF systems offer a cost effective, energy efficient solution to achieving all-electric heating but it comes at a price: VRF systems contain large volumes of high global warming potential (GWP) refrigerants with varying leakage rates. The volume of high GWP refrigerants and potential leakage can reduce the GHG savings relative to other electric options. Additionally, as the New York grid decarbonizes, all-electric system options which do not rely as heavily on refrigerants will be preferable.

In cooling mode, VRF units are usually more energy efficient than air-cooled direct expansion (DX) units and air-to-water heat pumps, but less efficient than chillers. In terms of heating, VRFs are typically more energy efficient than other electric heating solutions such as electric resistance heating and air-source heat pumps, but less efficient than ground source heat pumps.

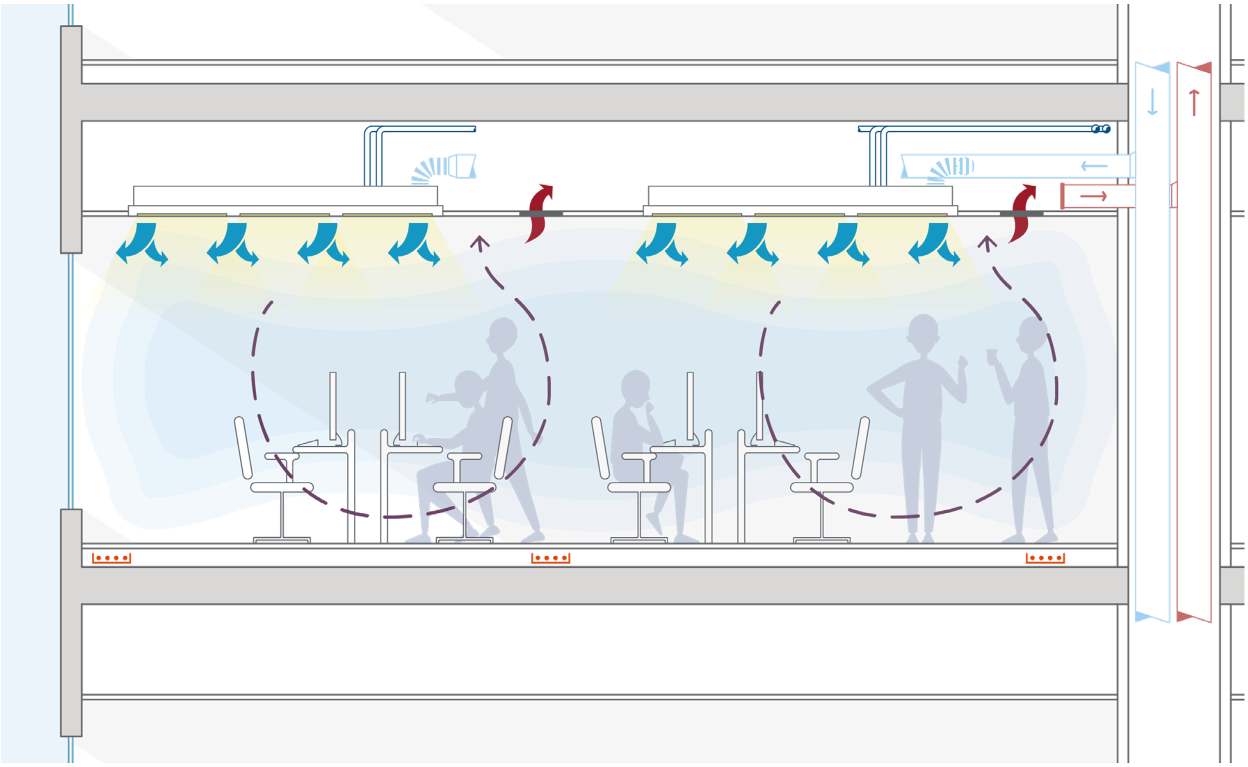


FIGURE 8. DOAS + ACTIVE CHILLED BEAMS SCHEMATIC

Variable Refrigerant Flow (Continued)

VRF systems can offer installation flexibility by reducing ductwork, but several installation limitations exist. Quality installation, with particular attention to refrigerant line joins and connections, is important to minimize refrigerant leakage. Indoor coil placement should be carefully considered as each coil requires maintenance access. In addition, VRF systems are limited by the maximum allowable vertical distance between the indoor and outdoor units and maximum allowable piping length due to refrigerant charge limitations. Lastly, the lifespan of the VRF system is much shorter than a central chilled water system which is important when considering future renovation needs and the project's overall GHG impacts from refrigerants and energy usage.

Displacement Ventilation

Displacement ventilation delivers low-velocity air close to or at the floor level either through underfloor or side wall distribution. Since air is supplied directly to the occupied zone, displacement ventilation provides better air distribution effectiveness compared to overhead supply, resulting in better indoor air quality, acoustics, thermal comfort, and more efficient space conditioning. Displacement ventilation is most advantageous in spaces which have high floor-to-ceiling heights such as auditoriums, convention halls, and atriums. In high ceiling spaces, displacement ventilation provides space conditioning to only the required occupied zone rather than the entire space volume.

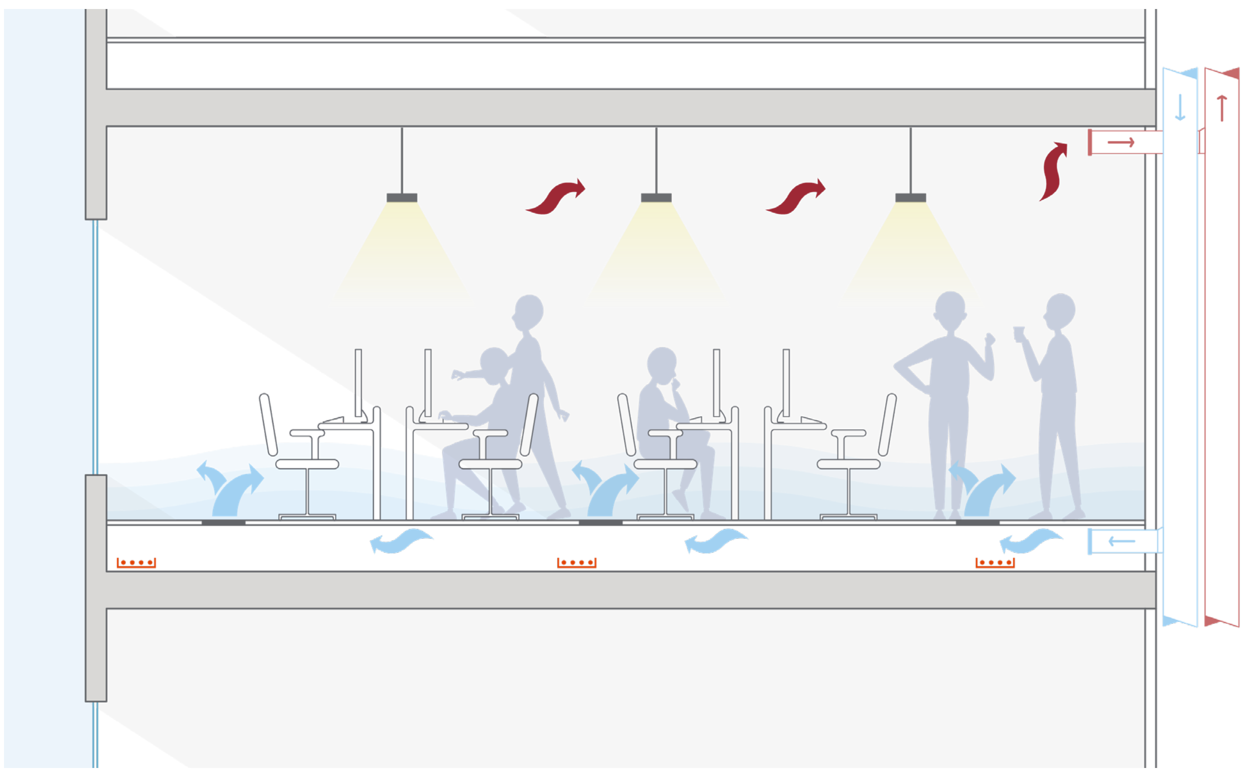


FIGURE 9. DISPLACEMENT / UNDERFLOOR AIR DISTRIBUTION SCHEMATIC

Exhaust Air Energy Recovery

Exhaust air energy recovery is the process of exchanging energy between outgoing and incoming ventilation air and is integrated into air handling units. During colder outdoor conditions, the energy recovery unit helps pre-heat the incoming outside air to save heating energy; during warmer outdoor conditions, the energy recovery unit helps pre-cool the outside air to save cooling energy. Energy recovery can either be sensible or total (sensible and latent) energy recovery. Sensible energy recovery refers to the exchange of heat only, thus changing the temperature content of the air stream, while latent energy recovery changes the moisture content of the air stream. When operating properly, energy recovery units should only transfer energy via an exchanger; the exhausted air does not directly come in contact with incoming air.

As per NYStretch-2020 amendments to ASHRAE 90.1-2016 Section 6.5.6.1, energy recovery with at least 50% enthalpy recovery is mandatory.

Enthalpy Energy Recovery

By exchanging both heat and moisture, enthalpy energy recovery devices have higher effectiveness and save additional energy compared to sensible only units. Common examples of enthalpy energy recovery devices are enthalpy wheels and membrane heat exchangers.

Sensible Energy Recovery

Sensible only energy recovery systems transfer only sensible heat and therefore only change the air temperature of the air streams. Sensible energy recovery systems are typically selected in applications where cross contamination between exhaust air and supply air needs to be avoided for occupant health and safety. Common examples of sensible energy recovery devices include plate and frame heat exchangers, glycol run around loop, or heat pipes. Sensible energy recovery is less effective than enthalpy type equipment.

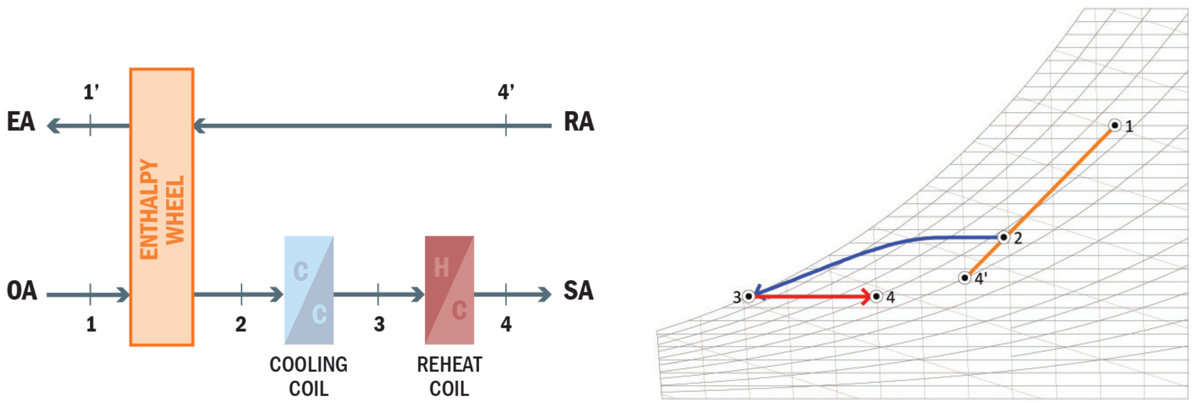


FIGURE 10. ENTHALPY ENERGY RECOVERY SCHEMATIC AND PSYCHROMETRIC DIAGRAM

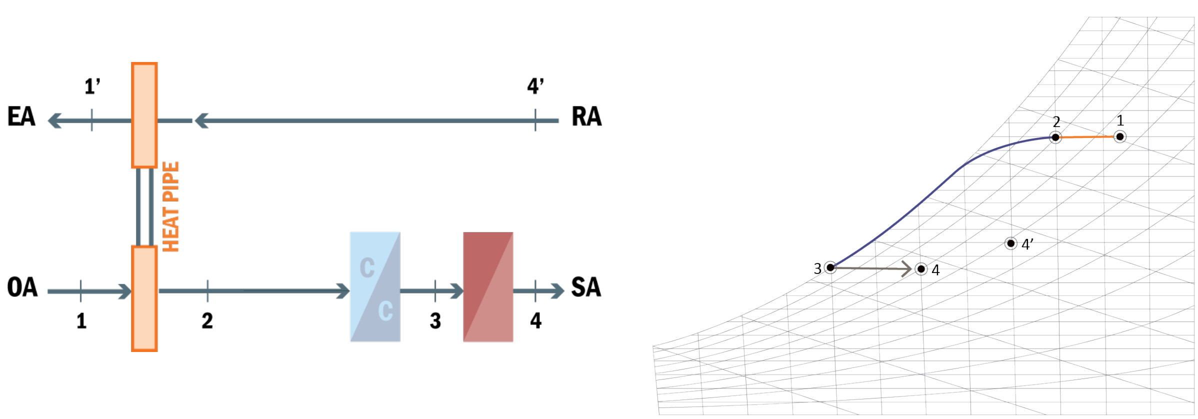


FIGURE 11. SENSIBLE ENERGY RECOVERY SCHEMATIC AND PSYCHROMETRIC DIAGRAM

Dehumidification & Reheat Energy Reduction

Strict space humidity requirements can cause buildings to consume additional cooling and reheat energy for dehumidification. In addition, high air change requirements in laboratories generally result in increased reheat energy consumption to maintain thermal comfort. In such cases, limiting reheat energy is critical to reducing the overall energy consumption of the building. The strategies below help reduce cooling energy as a result of dehumidification cooling and reheat energy.

Wrap Around Coils

A wrap around coil should be considered for a system that requires summer reheat. The system provides "free" reheat energy but also results in a small increase in the length of the air handling unit.

Wrap around coils, as shown in the figure below, consist of glycol run around coils or heat pipes that wrap around (installed before and after) the cooling coil. The first coil absorbs heat from the incoming un-conditioned ventilation air, thus cooling the air stream before it enters the cooling coil. The heat absorbed is then used to reheat the supply air stream after the cooling coil, thus providing free reheat. This system helps in both reducing the cooling and reheat energy consumption.

Dual Wheel

A dual wheel system should be considered for buildings that need 100% outside air and have large air volume needs. The dual wheel can offer greater energy recovery in comparison with a heat pipe; however they are physically large and require space planning early in the project design. Note that adding two wheels also increases system static pressure so fan energy penalties should be compared to heat recovery savings using energy modeling.

Dual wheel systems, as shown in the figure below, include two heat recovery wheels: an initial enthalpy wheel and a secondary sensible wheel. The sensible wheel extracts heat out of the return air stream and transfers it into the dehumidified supply air stream for reheat. By including a sensible wheel, the exhaust air temperature which enters the first enthalpy wheel is lowered, thus improving the summer-time heat recovery effectiveness of the enthalpy wheel. The dual wheel system reduces cooling energy due to the improved effectiveness of the enthalpy wheel and reduces reheat energy as a result of the secondary sensible wheel.

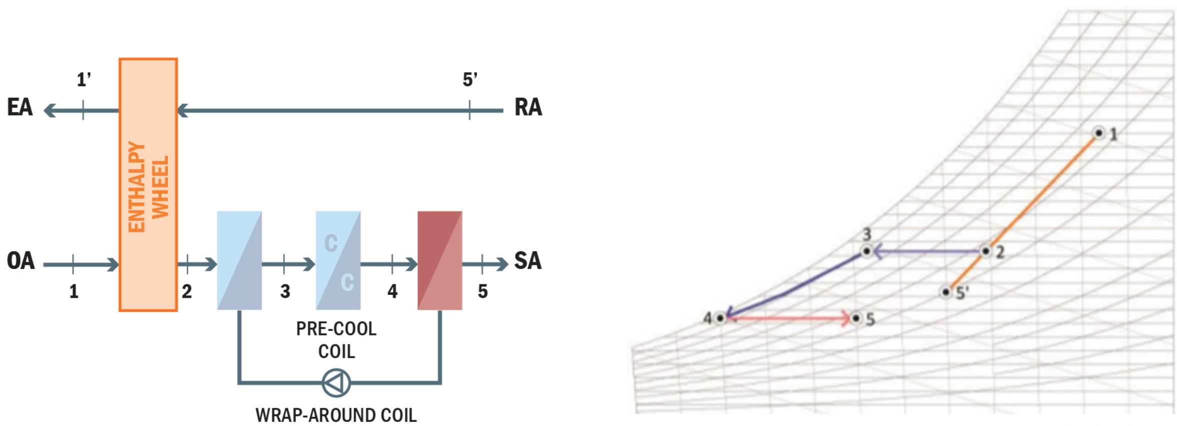


FIGURE 12. WRAP AROUND COIL SCHEMATIC AND PSYCHROMETRIC DIAGRAM

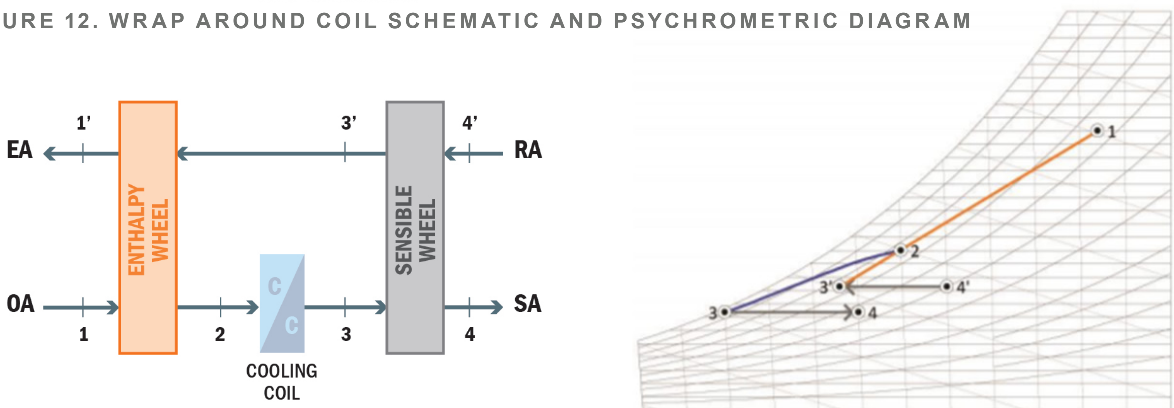
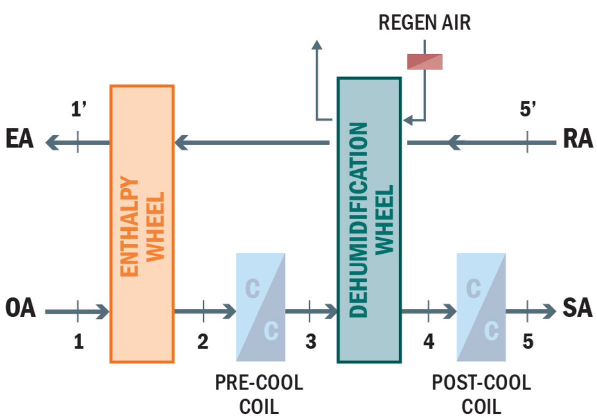


FIGURE 13. DUAL WHEEL SCHEMATIC AND PSYCHROMETRIC DIAGRAM

Desiccant

A desiccant system is a variation on the dual wheel system. The key difference is that the desiccant wheel is used to strip humidity out of the supply air whereas the sensible wheel (above) can only be used to reduce the supply air temperature. The dual wheel desiccant system can offer greater energy recovery in comparison with the strategies above; however, they are physically large and require space planning early in the project design. Note that adding two wheels also increases system static pressure so fan energy penalties should be compared to heat recovery savings using energy modeling. Desiccant systems typically also require more maintenance than other energy recovery wheel types.

Solid or liquid desiccant systems offer another strategy to achieve efficient dehumidification and reduce reheat energy consumption. To reduce the energy penatly associated with desiccant media regeneration, it is recommended to use recovered waste heat, such as cogeneration waste heat, or to install a solar thermal system as a heat source.



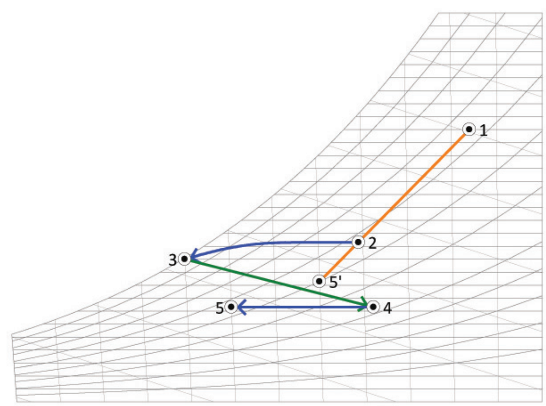


FIGURE 14. DESSICANT DEHUMIDIFICATION SCHEMATIC AND PSYCHROMETRIC DIAGRAM

Minimum Lab Ventilation Rate

Laboratories typically require high minimum ventilation rates to help mitigate potential risk to occupant health and safety. Ventilation rates are typically measured in air changes per hour (ACH). For spaces with high minimum required ACH rates and low internal gains, ACH rates often become a key energy driver; when the ACH rate supplies more air than is required to meet the space load, unnecessary cooling/heating energy is expended to maintain occupant comfort. Since ACH rates are a large driver of lab energy consumption, it is critical that project teams coordinate closely with the building users and Environmental Health and Safety team to determine the lowest possible ventilation rate that maintains occupant health and safety. Once the occupied ventilation rate has been determined, project teams should investigate implementation of an ACH setback to yield maximum energy savings. There are several ways to achieve automatic ventilation rate setback in laboratories.

Programmed Set-Back

In this strategy, the laboratory minimum ventilation rate is setback by the building automation system (BAS) from an occupied set-point (e.g., 6 ACH) to an unoccupied set-point (e.g., 2 ACH) based on a daily schedule or timeclock. This strategy provides limited energy savings because it can only be applied during pre-defined building unoccupied periods and does not consider potential savings during intermittent usage of individual lab spaces.

Occupancy/Vacancy Sensor Based Set-Back

Occupancy/vacancy sensors can be used to control the minimum variable air volume (VAV) box position when the laboratory spaces are unoccupied. This strategy can be applied during both daytime and night-time unoccupied hours, potentially saving additional energy compared to the programmed setback approach. Labs with variability in occupancy patterns should consider this method for additional energy savings.

Air Quality Sensor Based Set-Back

Automatic air quality or contaminant sensing can be used as an effective means to safely setback minimum ventilation rates in labs. In this strategy, contaminant sensors, capable of monitoring different chemicals used in labs, are used to continuously monitor space contaminant concentrations. If space contaminant concentrations are maintained below a set threshold, minimum ventilation rates are maintained at a setback mode and are reset to a higher value as concentrations start to rise, thus providing maximum energy savings compared to the strategies discussed above. Due to the requirement for additional equipment and controls, this strategy has an increased cost premium compared to the other strategies described. Note this strategy requires the approval of SUCF and the corresponding campus.

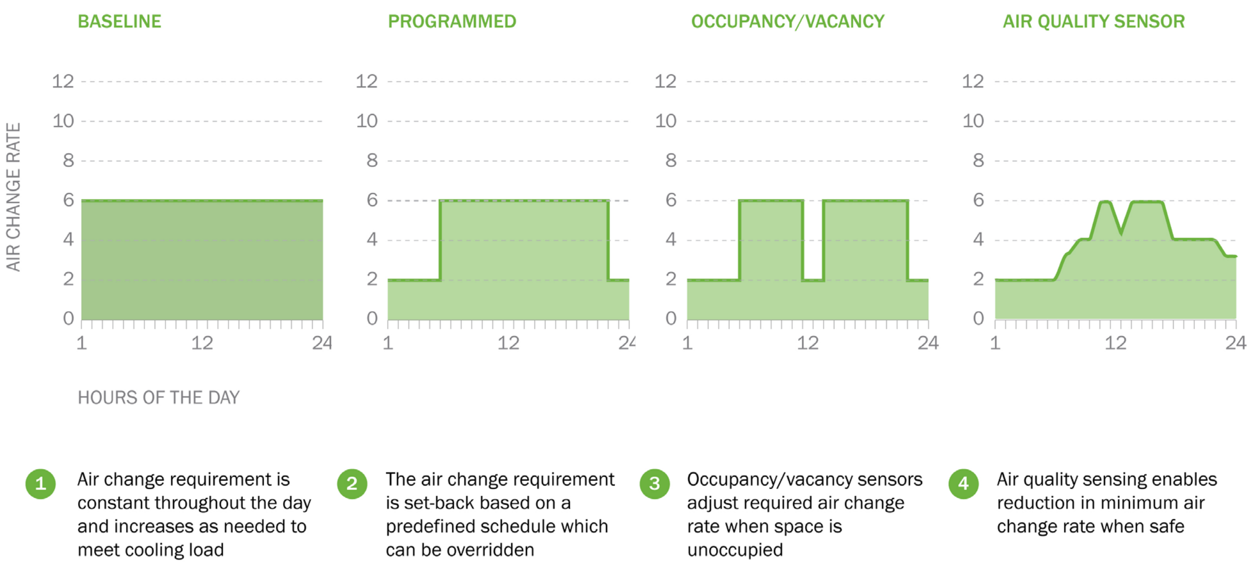


FIGURE 15. LABORATORY VENTILATION CONTROL

Laboratory Exhaust Fans

Most modern laboratory systems include variable air volume exhaust systems, which reduce the conditioned make-up air supplied to the space as the usage modulates. However, the laboratory exhaust fans selected typically operate at a constant fan speed to maintain the required plume height needed for contaminant dispersion. The exhaust fans include an outside air bypass damper that modulates to maintain a constant airflow volume as exhaust from the spaces change based on usage or operating hours. Operating exhaust fans at constant speed consumes significant fan energy. Below are a few options that help reduce fan energy associated with laboratory exhaust:

Manifolded exhaust fans with staging

Installing a manifold exhaust system with multiple fans allows for the staging of the fans based on the exhaust demand. The fans are sized for partial exhaust volume, allowing the airflow to ramp up or down by varying the number of fans in operation. By operating several fans at part load, fan energy savings are achieved.

Wind responsive fan speed control

Wind responsive fan controls utilizes a local, rooftop weather station. The weather station determines the wind speed and direction and dynamically modulates the required plume height necessary for contaminant dispersion, thus resetting the exhaust fan speed and reducing the associated fan energy.

Exhaust air contaminant sensing

In this strategy, an automatic contaminant sensing device is installed in the laboratory exhaust plenum. Based on the contaminant concentration in the exhaust air, the plume height is adjusted. When contaminant levels are low, the fans can be ramped down while still maintaining an acceptable plume height, thus reducing fan energy consumption.

Lab Hood Exhaust

In fume hood dense labs, fume hood exhaust requirements dictate the required air change rate supplied to the lab. In such cases, strategies to reduce or setback fume hood exhaust air flow rates significantly reduce energy consumption associated with conditioning the delivered air. Common strategies that help reduce energy consumption associated with fume hoods are listed below.

Low Flow Fume Hoods

Typically, labs use standard 100 feet per minute (FPM) velocity fume hoods. With advancements in fume hood design technology, high-performance low flow fume hoods operating at 80 FPM or 60 FPM are available. These hoods can reduce the fume hood exhaust air flow rate by 20% to 40%, thus saving conditioning energy. Fume hood selection must be closely coordinated with the project's Environmental Health and Safety team. Fume hoods must also meet ASHRAE 110 requirements for As Manufactured and As Installed test types.

Proximity Sensors

Proximity sensors on fume hoods detect occupancy near the fume hood and either setback the fume hood face velocity or automatically close the fume hood sash. Proximity sensors can contribute to meaningful energy savings in labs with high fume hood usage.

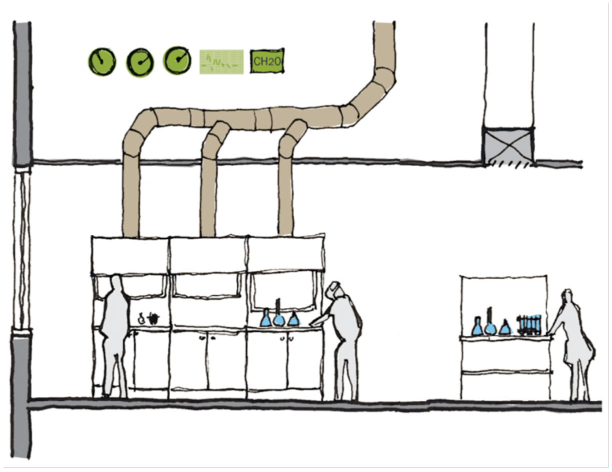


FIGURE 16. LABORATORY FUME HOODS

Kitchen Hood Exhaust

Commercial kitchen hoods serve to maintain a healthy work environment for workers and patrons alike as they exhaust smoke, grease particles, and cooking moisture. Hoods should be designed based on the kitchen equipment, menu items, and supply air, among other considerations. To improve energy performance, project teams should consider the mounting height, hood layout, make-up and conditioned air, and alternative ventilation sources, such as transfer air from adjacent rooms. Reducing the exhaust air flow rate or run-time is essential to reducing the kitchen HVAC energy demand. Hoods closer to the cooking equipment lose less energy to exhaust air and help maintain a more comfortable kitchen temperature. Other strategies such as incorporating side panels and sealing gaps behind equipment can improve the exhaust, providing up to a 30% airflow reduction.

Hoods often have a set airflow rate (measured in CFM) turned on when the kitchen opens and turned off at closing. In larger, high volume kitchens, demand control ventilation can be applied to adjust the exhaust based on the number of orders or food being cooked. Temperature, infrared, and smoke sensors located within the ducts can adjust the fan speed based on the exhaust needs. Newer controls connect the hood with the equipment for more accurate communication.

Project Examples

PROJECT EXAMPLES

Introduction

The case studies presented in this section demonstrate feasible pathways to achieving Directive 1B-2 EUI targets. Project examples are divided by new construction or major renovation and categorized by building type: Office/ Classroom, Laboratory, or Student Union. Using the EUI targets specified in Directive 1B-2, a project specific weighted EUI is calculated.

Three design cases are presented for each project: Base, High-Performance, and Exemplary. NYStretch is currently required for all SUNY projects and is therefore the basis of design used in the case studies. For new construction project examples, the Base Case represents the NYStretch prescriptive requirements. The Base Case for major renovation projects assumes the project renovates the HVAC and lighting systems to NYStretch prescriptive requirements, but does not improve the existing envelope.

The High-Performance and Exemplary cases represent improvements beyond NYStretch. The EEMs included in each design case are detailed and the resulting EUI. The following page includes a key which describes the information provided for each project example.

Please note incorporating the measures presented in the case studies will not necessarily yield the same results due to project specifics. As such, each project team is responsible for conducting project-specific energy analysis to confirm that the proposed design meets the Directive 1B-2 requirements.

Project Example Key

Building Typology

This section includes basic information about the project example including the building typology, project description, program types, window-to-wall ratio (WWR), and other relevant project details. The project's main energy drivers are summarized to help identify effective EEM strategies for the building type.

Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft^2)	Percent of Total Area	Target EUI ($kBtu/ft^2/yr$)
Space Type 1	xxxx	xx%	xx
Space Type 2	xxxx	xx%	xx
Space Type 3	xxxx	xx%	xx
Space Type 4	xxxx	xx%	xx

Total Program	xxxx
Weighted EUI	**xx**

Case Study EEM Packages

The EEMs included in each design case are summarized in this section. Three design cases are presented: Base Case, High-Performance, and Exemplary. NYStretch is currently required for all projects and is represented by the Base Case. The High-Performance and Exemplary Cases demonstrate pathways to achieving the Directive 1B-2 EUI target. Note all U-values are represented in imperial units.

Base Case

- EEM-1
- EEM-2
- EEM-X

High Performance

- EEM-1
- EEM-2
- EEM-X

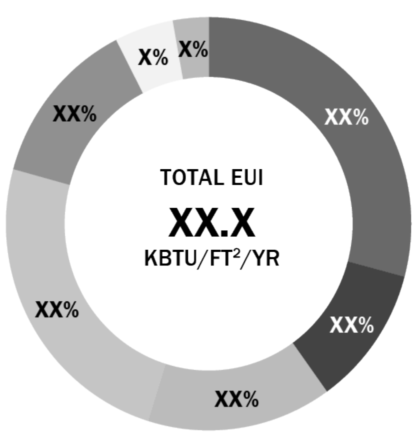
Exemplary

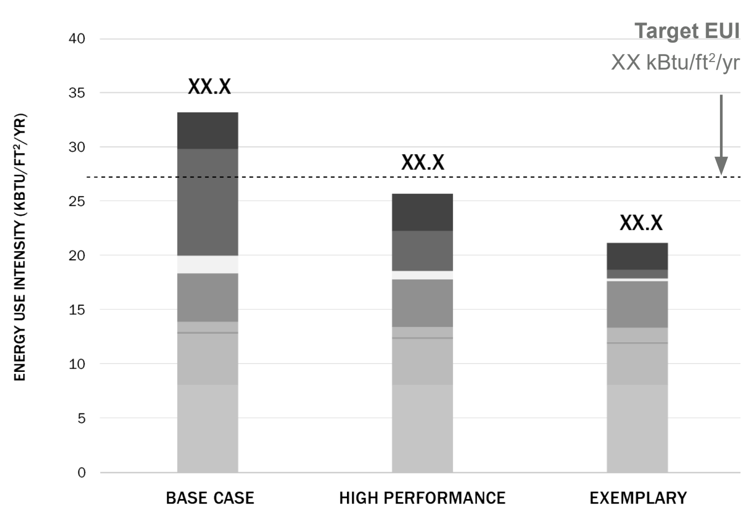
- EEM-1
- EEM-2
- EEM-X

Annual Site Energy Consumption

The pie chart on each page indicates the site energy use characterization for the Base Case to help identify the project's energy drivers.

The bar graph represents the site energy use breakdown for the Base, High Performance, and Exemplary Cases. The Directive 1B-2 target EUI is indicated on the graph to identify compliant cases.





NEW CONSTRUCTION

Office/Classroom

The project is an 82,000 ft^2 multi-story office and classroom building with a WWR ratio of 24%.

Per the Directive 1B-2 requirements, the base case is designed to meet the NYStretch and be all-electric. The project's main energy use categories are heating and lighting; therefore, most of the EEM strategies target reducing the heating load and increasing heating efficiency.

Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft^2)	Percent of Total Area	Target EUI (kBtu/ft^2/yr)
Office	46,328	57%	29
Classroom	35,591	43%	30

Total Program 81,919

Weighted EUI **30**

Case Study EEM Packages

Whilte the Base Case scenario approaches the target EUI, important EEMs such as infiltration reduction, energy recovery, and high performance HVAC systems ultimately achieve the EUI goal.

Base Case

- DX cooling, electric boiler

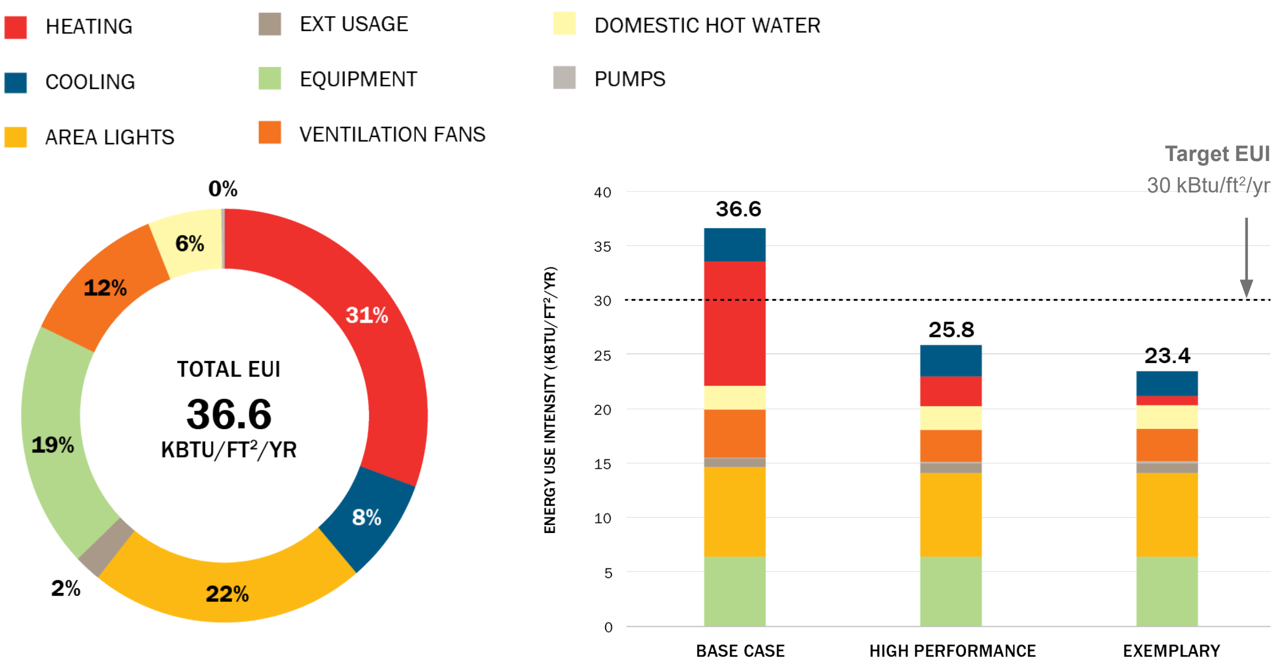
High Performance

- Air-source VRF with DOAS
- Enhanced wall insulation (U-0.066)
- Enhanced roof insulation (U-0.029)
- Enhanced glazing (U-0.3, SHGC-0.3)
- Reduced infiltration (0.25 CFM/ft^2)
- Optimized LPD
- High efficiency heat recovery (65%)

Exemplary

- GSHP with DOAS
- Enhanced wall insulation (U-0.05)
- Enhanced roof insulation (U-0.025)
- Enhanced glazing (U-0.2, SHGC-0.2)
- Reduced infiltration (0.1 CFM/ft^2)
- Optimized LPD
- High efficiency energy recovery (80%)

Annual Site Energy Consumption



NEW CONSTRUCTION

Laboratory

This project is a laboratory building designed to meet the NYStretch prescriptive requirements. The building program includes a range of spaces including "wet" research labs, offices, classrooms, and other support spaces. The project's main energy drivers are the ventilation and equipment loads. Laboratories, especially those considered "wet", are required to maintain higher ventilation rates. This project also contains unique high load spaces, such as a vivarium, which increase the process load requirements.

Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft^2)	Percent of Total Area	Target EUI (kBtu/ft^2/yr)
Lab: Bio/ Chem (wet)	41,600	37%	160
Classroom	5,763	5%	30
Office	61,064	56%	29
Café	2,706	2%	79

Total Program 111,133

Weighted EUI **78**

Case Study EEM Packages

High efficiency heating and heat recovery are required to reduce the heating as much as possible. The exemplary case achieves the EUI target through the use of air quality based ventilation and wind responsive variable exhaust fans to reduce ventilation energy.

Base Case

- Water-cooled chiller, electric boiler
- Constant volume exhaust

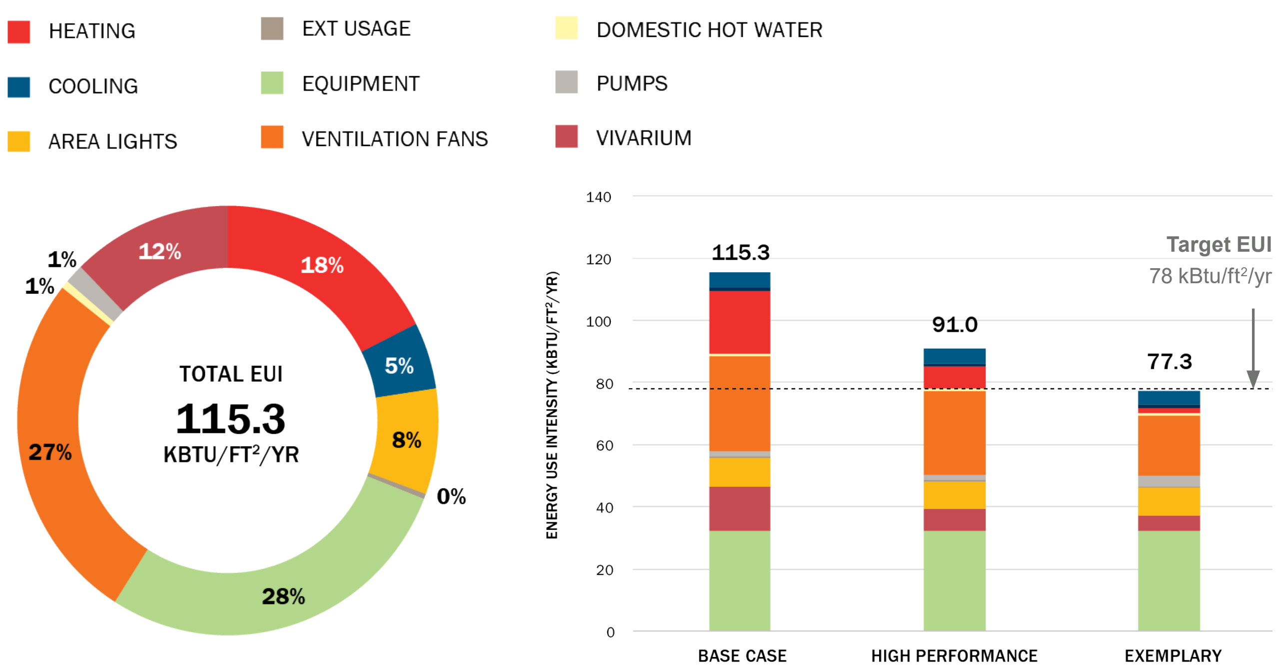
High Performance

- ASHPs + HRC +electric boiler
- Optimized LPD
- Staged CV exhaust Fans

Exemplary

- GSHPs (w/electric boiler)
- Optimized LPD
- Variable exhaust fans
- Reduced infiltration (0.25 CFM/ft^2)
- Air quality-based ventilation
- Advanced run-around coil

Annual Site Energy Consumption



NEW CONSTRUCTION

Student Union

This case study is representative of a student union building with a variety of program areas indicative of the building type. The 4-story project is approximately 108,000 ft² with a WWR of 50%.

Understanding the different energy profiles and use schedules for the variety of spaces types is critical to determining where energy use reductions can be achieved.

Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft²)	Percent of Total Area	Target EUI (kBtu/ft²/yr)
Theater	18,792	17%	22
Student Center	21,210	20%	26
Office	51,794	48%	29
Classroom	7,884	7%	30
Library	2,927	3%	58
Cafe	5,620	5%	79

Total Program	108,227
Weighted EUI	**28**

Case Study EEM Packages

In an effort to reduce the heating load of the project, many of the EEM strategies improve the envelope performance beyond the NYStretch prescriptive requirements. Improved heat recovery and heating efficiency were also utilized to meet the directive target in the high performance and exemplary cases.

Base Case

- Air-cooled chiller, electric boiler

High Performance

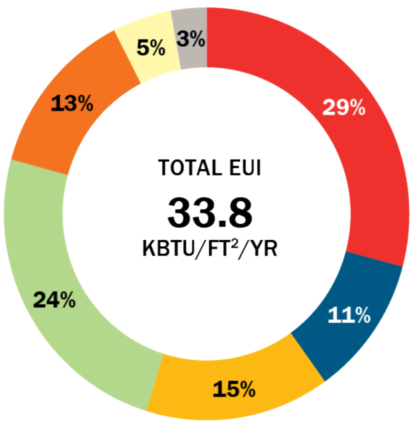
- Air source heat pumps (heating and cooling)
- Enhanced wall insulation (U-0.05)
- Enhanced glazing (U-0.3, SHGC-0.38)
- Reduced infiltration (0.25 CFM/ft²)
- Optimized LPD
- High efficiency heat recovery

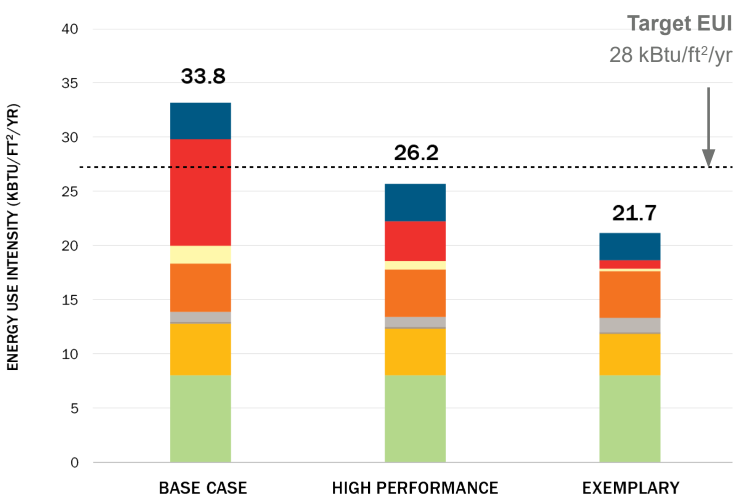
Exemplary

- GSHP (w/ electric boiler)
- Enhanced wall insulation (U-0.05)
- Enhanced glazing (U-0.2, SHGC-0.3)
- Reduced infiltration (0.1 CFM/ft²)
- Optimized LPD
- High efficiency heat recovery
- High performance airside controls

Annual Site Energy Consumption

HEATING · EXT USAGE · DOMESTIC HOT WATER · COOLING · EQUIPMENT · PUMPS · AREA LIGHTS · VENTILATION FANS





New Construction

PROJECTS

MAJOR RENOVATION

Laboratory Standalone

This case study represents a deep energy retrofit laboratory project that utilizes new on-site central heating and cooling equipment. The Base Case for major renovation projects assumes the project renovates the HVAC and lighting systems to NYStretch, but does not improve the existing envelope.

This project's main energy driver are the dry research labs. Unlike wet labs that are driven by their required ventilation rates, dry labs typically have higher equipment loads that require additional air flow for conditioning.

Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft²)	Percent of Total Area	Target EUI (kBtu/ft²/yr)
Lab: Physics/ Geology	23,066	37%	167
Classroom	13,233	21%	38
Office	26,624	42%	36

Total Program 62,923

Weighted EUI **85**

Case Study EEM Packages

Based on the building's configuration, the project's Base Case approaches the Directive 1B-2 target. By using a DOAS to decouple ventilation, the high performance and exemplary scenarios increase heating and cooling efficiencies to exceed the project's EUI target.

Base Case

- DX cooling, electric boiler
- Existing envelope conditions
- Constant volume exhaust

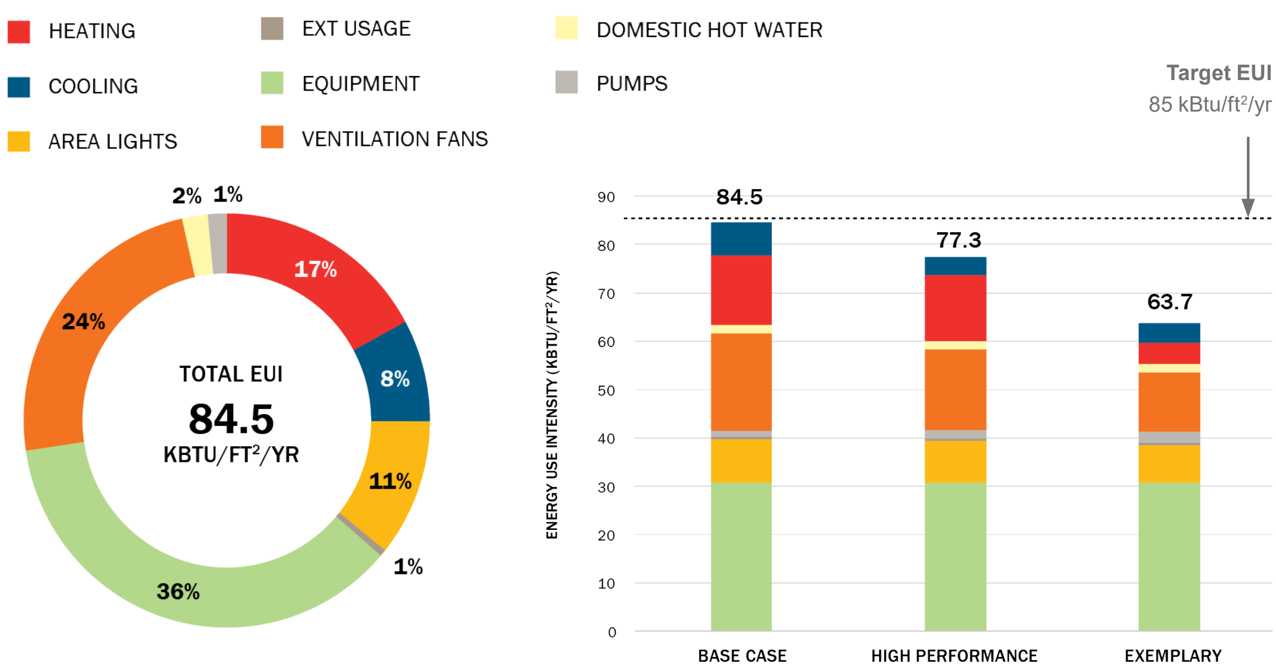
High Performance

- DOAS +FCUs
- WC chiller, electric boiler
- Optimized LPD
- Staged CV exhaust fans

Exemplary

- DOAS +FCUs
- WSHP, ASHP and electric boiler
- Optimized LPD
- Variable exhaust fans

Annual Site Energy Consumption



MAJOR RENOVATION

Laboratory DES

This case study represents a deep energy retrofit laboratory project that will remain connected to a district energy system (DES). The Base Case for major renovation projects assumes the project upgrades the HVAC and lighting systems to NYStretch, but does not improve the existing envelope or take credit for the DES heating and cooling efficiencies.

With the primary energy driver of the project being the ventilation load of the wet laboratory spaces, most of the EEM measures targeted improving airside heat recovery.

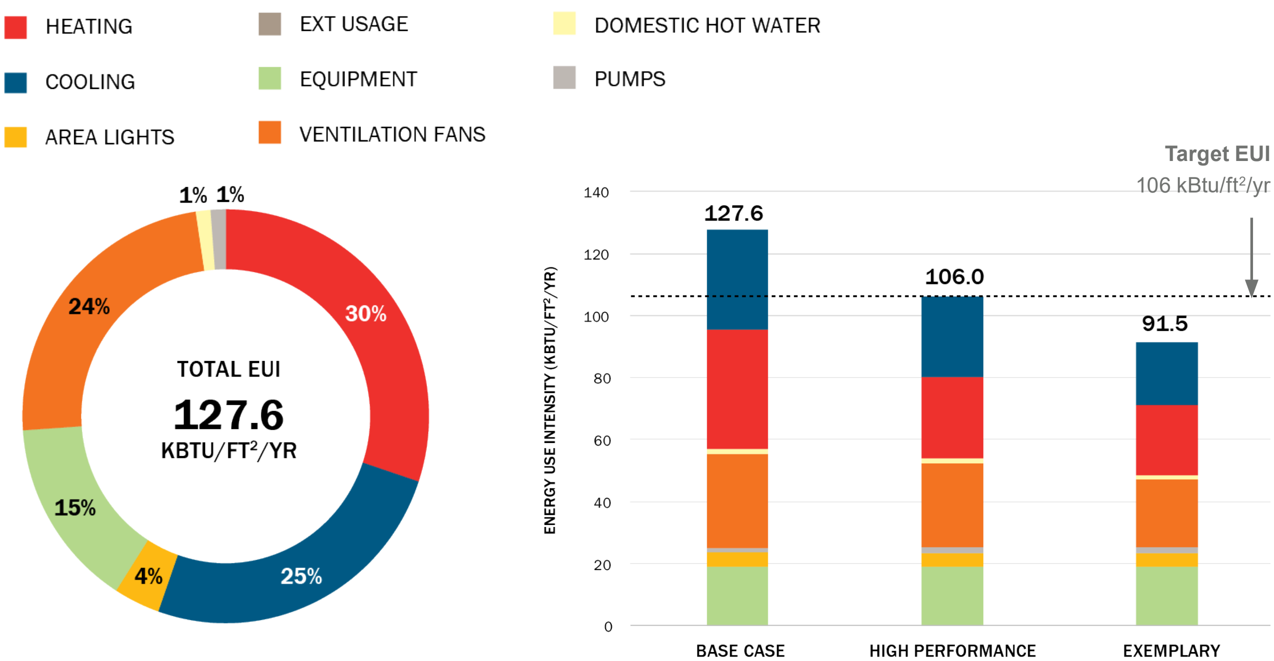
Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft²)	Percent of Total Area	Target EUI (kBtu/ft²/yr)
Lab: Bio/ Chem (wet)	47,953	37%	231
Classroom	6,595	21%	44
Office	86,327	42%	41

Total Program 140,875

Weighted EUI **106**

Annual Site Energy Consumption



Case Study EEM Packages

EEM strategies that improved the air-side heat recovery, such as run-around coil or improved exhaust energy recovery, were critical to achieving the project's target EUI. Additional EEMs involved insulating the project's existing envelope to meet the NYStretch prescriptive requirements.

Base Case

- VAV AHU
- Existing envelope conditions
- Constant volume exhaust

High Performance

- Optimized LPD
- Upgraded roof insulation to NYStretch
- Upgraded glazing to NYStretch
- Run-around coil
- Staged constant volume exhaust fans

Exemplary

- Optimized LPD
- Added wall insulation (U-0.20)
- Upgraded roof insulation to NYStretch
- Upgraded glazing to NYStretch
- Reduced infiltration (0.4 CFM/ft²)
- Enhanced run-around coil and energy recovery
- Variable exhaust fans

MAJOR RENOVATION

Office/Classroom DES

The case study below is a deep energy retrofit of a combination classroom and office building that will continue to be connected to a district energy system (DES). The project is an 82,000 ft² multi-story building with an existing WWR of 15%.

With heating being the predominant load and the projects limited ability to improve the heating efficiency due to the DES connection, the project targeted improving the performance of the envelope to reduce heating loads. Improved airside heat recovery also proved value in reaching the EUI target.

Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft²)	Percent of Total Area	Target EUI (kBtu/ft²/yr)
Office	46,328	57%	41
Classroom	35,591	43%	44

Total Program 81,919

Weighted EUI **43**

Case Study EEM Packages

While improving the existing envelope performane was critical to meeting the Directive 1B-2 performance in the High Performame case, further envelope improvements showed limited benefit in the Exemplary Case. Measures with the highest impact on EUI include infiltration and HVAC system selection.

Base Case

- VAV AHU
- Existing envelope conditions

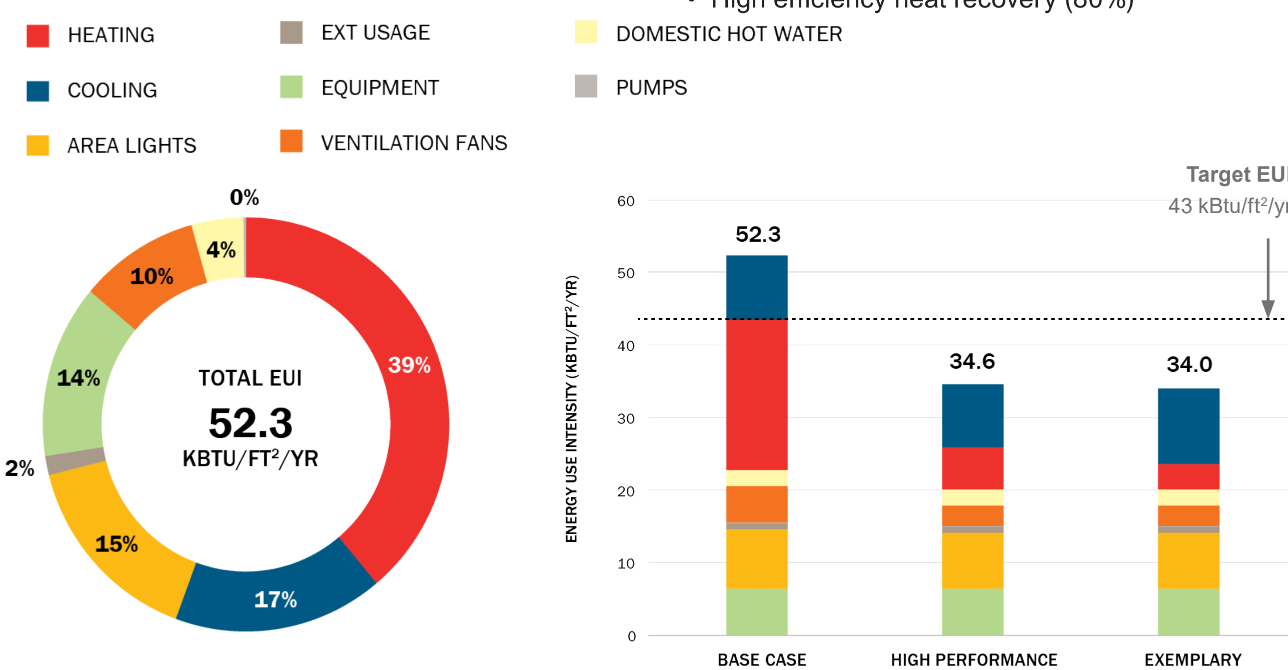
High Performance

- DOAS + FCUs
- Enhanced wall insulation (U-0.066)
- Enhanced roof insulation (U-0.029)
- Enhanced glazing (U-0.3, SHGC-0.3)
- Reduced infiltration (0.25 cfm/ft²)
- Optimized LPD
- High efficiency heat recovery (65%)

Exemplary

- DOAS + FCUs
- Enhanced wall insulation (U-0.05)
- Enhanced roof insulation (U-0.025)
- Enhanced glazing (U-0.2, SHGC-0.2)
- Reduced infiltration (0.1 cfm/ft²)
- Optimized LPD
- High efficiency heat recovery (80%)

Annual Site Energy Consumption



Student Union DES

The case study below is a deep energy retrofit of a student union project that will continue to be connected to a district energy system. The 4-story project includes 108,000 ft^2 and a WWR of 50%.

Due to a high WWR, the heating and cooling loads of the envelope were the dominant loads on the project. As such, these loads were targeted by improving the existing envelope beyond the NYStretch prescriptive requirements in both the high performance and exemplary cases.

Weighted EUI Calculation

Directive 1B-2 Space Types	Area (ft^2)	Percent of Total Area	Target EUI (kBtu/ft^2/yr)
Theater	18,792	17%	27
Student Center	21,210	20%	33
Office	51,794	48%	41
Classroom	7,884	7%	44
Library	2,927	3%	72
Cafe	5,620	5%	99

Total Program	108,227
Weighted EUI	**37**

Case Study EEM Packages

Enhancing the project's existing envelope, implementing improvements to the lighting systems, and including air-side heat recovery in targeted space types provided significant energy savings.

Base Case

- VAV AHU
- Existing envelope conditions

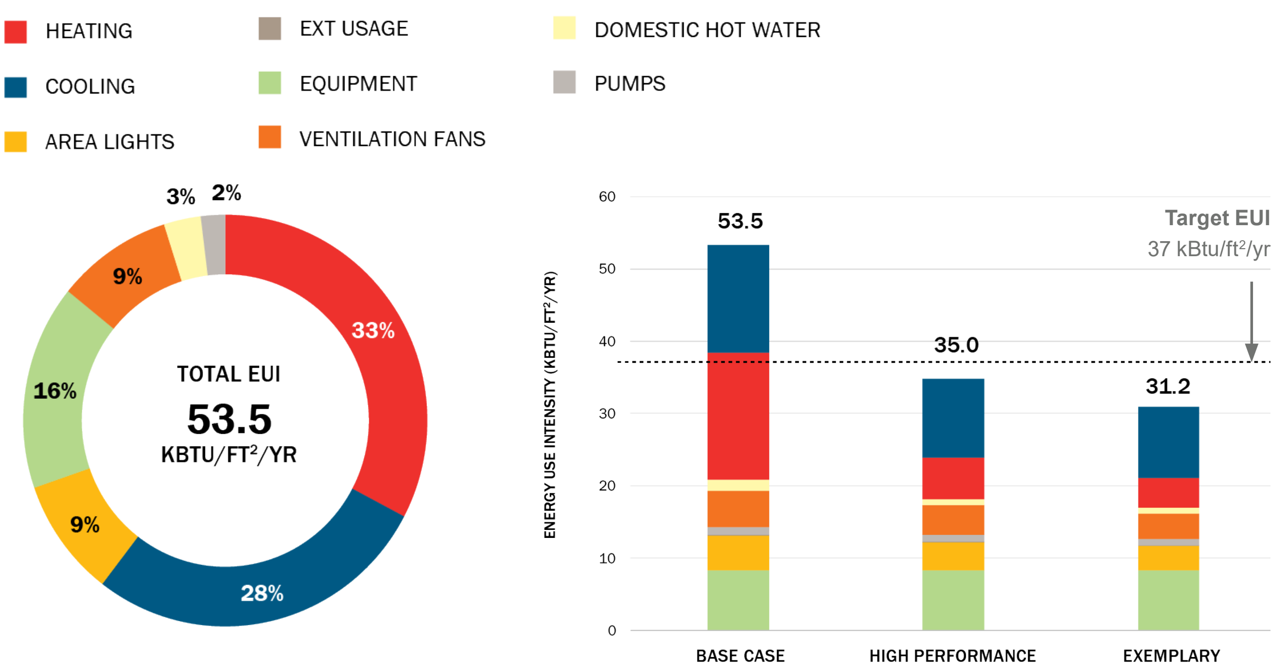
High Performance

- Enhanced wall insulation (U-0.066)
- Enhanced glazing (U-0.3, SHGC-0.3)
- Reduced infiltration (0.4 cfm/ft^2)
- Optimized LPD
- High efficiency heat recovery
- High performance airside controls

Exemplary

- DOAS + FCUs
- Enhanced wall insulation (U-0.2)
- Enhanced glazing (U-0.25, SHGC-0.25)
- Reduced infiltration (0.25 cfm/ft^2)
- Optimized LPD
- High efficiency heat recovery
- High performance airside controls

Annual Site Energy Consumption



Appendix

Net Zero Carbon and Deep Energy Retrofits Design Checklist

SUNY The State University of New York

SUNY State University Construction Fund

Instructions: This checklist should be used by the design team starting in Architectural Concept Design to identify critical energy and carbon considerations. Teams should refer to and complete this checklist throughout the design process. With the submission of the Schematic Design, Design Manual, and Construction Document phases, submit the completed the checklist to the SUCF project manager to confirm that the team has taken these critical considerations into account and will meet the SUCF Directive 1B-2 requirements. The SUCF project coordinator will review the checklist against submitted documents.

The examples included in each section provide clarifying detail and are not intended to be prescriptive requirements or exhaustive lists. Teams are encouraged to research, analyze, and select the best energy efficiency measures (EEMs) and emission reduction strategies for the project based on energy and emissions outcomes, project budget, equipment availability, site constraints, and other key factors.

GENERAL PROJECT INFORMATION

Project Name:

Number:

Phase:

Date:

Project Classification:

- ☐ Net Zero Carbon
- ☐ Deep Energy Retrofit
- ☐ Component Replacemen
- ☐ Not Applicable

Describe how the approach and design have been optimized to meet the Directive 1B-2. Explain if any questions aren't applicable. (500 words max)

Have you read and familiarized yourself with Fund Program Directives 1B-1, 1B-2, and 1B-7? ☐ Yes ☐ No ☐ N/A

Is the project in compliance with the NYStretch Energy Code? ☐ Yes ☐ No ☐ N/A

Has the team discussed and set energy and performance goals with the team? ☐ Yes ☐ No ☐ N/A

APPENDIX

Has the target EUI been established from the targets listed within Directives 1B-2? ☐ Yes ☐ No ☐ N/A

Has a pre-design site assessment taken place? ☐ Yes ☐ No ☐ N/A

Existing Buildings: Does the team have the facility's historic documents and information?

(Drawings, utility bills, energy studies, equipment surveys, etc.) ☐ Yes ☐ No ☐ N/A

Have the owners project requirements (OPR) been developed? ☐ Yes ☐ No ☐ N/A

Does the Basis of Design (BOD) include occupancy and operational schedules? ☐ Yes ☐ No ☐ N/A

Has the energy breakdown by end use been determined and developed? ☐ Yes ☐ No ☐ N/A

Has an iterative energy modeling schedule been developed and agreed upon? ☐ Yes ☐ No ☐ N/A

Have at least two unique bundles of proposed EEMs been developed and evaluated?
☐ Yes ☐ No ☐ N/A

Is a life cycle cost analysis planned for the project? ☐ Yes ☐ No ☐ N/A

Existing buildings: If retaining existing fossil fuel equipment, is the building electrification-ready? (Outlet adjacent to fossil fuel equipment, electrical panel sized for future loads, low temperature hot water design, etc.)

Are all energy-consuming systems and equipment electrically powered? ☐ Yes ☐ No ☐ N/A

If no, describe. (250 words max)

ENVELOPE

Is this section applicable to the project scope? ☐Yes ☐No

If yes, answer the following questions.

Does the building orientation and massing enhance energy outcomes? ☐ Yes ☐ No ☐ N/A

Examples: Building orientation and massing optimizes solar energy production; Building orientation and massing allows proper shading; Building orientation and massing utilizes natural ventilation and prevailing winds; Building orientation and massing balances daylight against electric lighting and mechanical HVAC needs; Prepare for future adjacent site development impacts

Are exterior insulation levels optimized? ☐ Yes ☐ No ☐ N/A

Examples: Continuous exterior rigid insulation; Thermal bridging breaks;
Total wall R-value; Total roof R-value

Is the air barrier designed to be adequately sealed? ☐ Yes ☐ No ☐ N/A

Examples: Continuous air barrier; Joints and seams sealed; Seal transitions between two or more materials; Seal envelope penetrations with caulk and/or gasket systems; Blower door test to identify leak target

Is the window to wall ratio (WWR) optimized per orientation? ☐ Yes ☐ No ☐ N/A

Examples: Optimize WWR per each façade orientation; Target appropriate WWR

Is high-performance glazing identified for each façade/orientation? ☐ Yes ☐ No ☐ N/A

Examples: Select window glazing that balances daylighting, views, and energy performance (Double or triple glazing, specialized transparent coatings, insulating gas between panes, and improved frames and glazing optimized per each building orientation); Whole product windows and doors with low U-factor and high solar heat gain coefficient (SHGC); Appropriate visible light transmittance (VLT) for each space

Describe the envelope EEMs. Explain if any questions aren't applicable. (250 words max)

HEATING AND COOLING

Is this section applicable to the project scope? ☐ Yes ☐ No

If yes, answer the following questions.

Were passive cooling and heating options evaluated? ☐ Yes ☐ No ☐ N/A

Examples: Incorporate thermal mass into the floor or walls (concrete/masonry, chilled water, Ice, phase change materials); Operable windows; Night flush ventilation; Stack effect

Have internal loads been reduced to downsize the mechanical system capacity? ☐ Yes ☐ No ☐ N/A

Examples: Shade glazing; High performance envelope; Less electric lighting; All LED lighting; High performance equipment and appliances

Have high-performance heating and cooling systems been incorporated? ☐ Yes ☐ No ☐ N/A

Examples: Radiant heating and cooling system (slabs, panels, chilled beams, refrigerant/chilled water/hot water, condensation considered and humidity controls integrated); Part-load system performance (variable capacity heat pump (VCHP), variable refrigerant flow, variable refrigerant volume); Ground Source Heat Pumps (GSHP); Right-size HVAC system; Boiler; Thermal energy storage; Heat recovery chiller

Describe the space conditioning EEMs. Explain if any questions aren't applicable. (250 words max)

VENTILATION

Is this section applicable to the project scope? ☐ Yes ☐ No

If yes, answer the following questions.

Does the ventilation use a different delivery system from heating and cooling? ☐ Yes ☐ No ☐ N/A

Example: Dedicated outside air systems (DOAS)

Is ventilation distributed efficiently? ☐ Yes ☐ No ☐ N/A

Examples: Variable air volume (VAV); Low-flow air diffusers; Underfloor air distribution; Limit fan power

Describe the ventilation EEMs. Explain if any questions aren't applicable. (250 words max)

DAYLIGHTING/LIGHTING

Is this section applicable to the project scope? ☐ Yes ☐ No

If yes, answer the following questions.

Is daylight prioritized over electric lighting? ☐ Yes ☐ No ☐ N/A

Examples: Tall or high windows; glare control; Internal shades; Scheduled automated shades; Daylight controls

Is glare controlled by external and/or internal shading systems? ☐ Yes ☐ No ☐ N/A

Examples: Shade exterior side of window glazing; Interior shade control; Model daylight patterns; Automate shading controls

Are interior and exterior lighting centrally controlled through programmable lighting?
☐ Yes ☐ No ☐ N/A

Examples: Vacancy sensors; Photosensors; Dimmable controls; Schedule exterior lighting; Zoned daylighting controls; Directive 16-8

Describe the lighting EEMs. Explain if any questions aren't applicable. (250 words max)

DOMESTIC HOT WATER HEATING

Is this section applicable to the project scope? ☐ Yes ☐ No

If yes, answer the following questions.

Have hot water demands been reduced? ☐ Yes ☐ No ☐ N/A

Examples: Low-flow water fixtures and appliances; Prioritize the highest tier of Consortium for Energy Efficiency (CEE) equipment

Have high-performance water heating systems been incorporated? ☐ Yes ☐ No ☐ N/A

Examples: Central or unitary heat pump water heaters

Is the distribution system efficient? ☐ Yes ☐ No ☐ N/A

Examples: Pipe insulation; Minimize or eliminate hot water recirculation; Group hot water loads near hot water storage; Serve each fixture directly from the hot water storage; Reduce pipe size

Describe the water heating EEMs. Explain if any questions aren't applicable. (250 words max)

PLUG LOADS

Is this section applicable to the project scope? ☐ Yes ☐ No

If yes, answer the following questions, even if the team does not have full control over the topic.

Have office equipment and workspaces been designed to reduced plug loads? ☐ Yes ☐ No ☐ N/A

Examples: Plug load and workstation vacancy sensors; Power strip monition activation; Energy Star equipment

Is the campus involved with coordinating the plug load reduction strategies? ☐ Yes ☐ No ☐ N/A

Have other spaces incorporated measures to reduce plug loads? ☐ Yes ☐ No ☐ N/A

Examples: Equipment and appliance timers, remote switch and master-controlled power strips; night overrides

Describe the plug load EEMs. Explain if any questions aren't applicable. (250 words max)

BUILDING CONTROLS

Is this section applicable to the project scope? ☐ Yes ☐ No

If yes, answer the following questions.

Have building automation controls been designed to reduce energy? ☐ Yes ☐ No ☐ N/A

Examples: Lighting sensors: occupancy, vacancy, dimmable; Operational hour override; HVAC: temperature, CO2, humidity; Operational hour override; Renewable energy and storage systems; Demand control ventilation

Is there a central building automation system that communicates with the campus system and electric grid? ☐ Yes ☐ No ☐ N/A

Examples: Controls automation; Provide system performance feedback; Demand response ready

Is building energy metered at both the building-level and individual system level? ☐ Yes ☐ No ☐ N/A

Examples: Building level metering may include electricity, chilled water, steam; Sub-metering may include HVAC, DHW, lighting, plug loads, unique equipment, electric vehicles, and be measured by system, floor, or department; Metering points may include sub-system, sub-panel, branch circuit, or end use energy

Is real-time data available from building metering and sub-metering? ☐ Yes ☐ No ☐ N/A

Describe the building controls and EEMs. Explain if any questions aren't applicable. (250 words max)

RENEWABLE AND STORAGE SYSTEMS

Is this section applicable to the project scope? ☐ Yes ☐ No

If yes, answer the following questions.

Is the project designed to include future renewable energy and/or energy storage? ☐ Yes ☐ No ☐ N/A

Examples: Dedicate appropriate roof area and/or site area; Empty capacity (space) in electrical panel for storage; Space in electrical panel for storage; Structural capacity to incorporate future solar panels: Plans should show a maximum open area by grouping roof penetrations; Dedicated walkways and optimized rooftop equipment removal; Electric diagrams should show future conduit runs and equipment locations

Can the renewable energy system's inverter disconnect from the grid to provide energy directly to the building? ☐ Yes ☐ No ☐ N/A

Examples: Automatic transfer switch; Building islanding

Is energy storage included in the project? ☐ Yes ☐ No ☐ N/A

If yes, describe. (250 words max)

Describe the renewable system and carbon neutral achievement. Please explain if any questions aren't applicable. (250 words max)

APPENDIX

SPECIAL ENERGY CONSIDERATIONS

Is waste-energy captured for reuse? ☐ Yes ☐ No ☐ N/A

Examples: Heat recovery capture from wastewater, ventilation exhaust, other equipment; Reusing cooking oil

Are peak energy load reduction and energy flexibility strategies incorporated? ☐ Yes ☐ No ☐ N/A

Examples: Shift or save system peak loads; Demand-control; Energy storage; Smart system controls to shift energy consumption (warm-up timing, temperature setbacks, "shut down" schedule, and proactively pre-cooling or pre-warming during opportune times)

If a laboratory project, did the project use the Laboratory Benchmarking Tool? ☐ Yes ☐ No ☐ N/A

If a kitchen is included in the project, did the project use Frontier Energy (FishNick) and California Energy Wise's equipment calculators? ☐ Yes ☐ No ☐ N/A

Describe the special energy considerations. Explain if any questions aren't applicable.

Net Zero Carbon and Deep Energy Retrofits Analysis Report Checklist

SUNY The State University of New York

SUNY State University Construction Fund

Instructions: This checklist should be used by the energy lead on the project team during all phases of design to confirm that the energy analysis has addressed critical energy and carbon considerations in the design. The energy lead should refer to and complete this checklist throughout the design process.

With the submission of the Schematic Design, Design Manual, and Construction Document phases, submit the completed checklist to confirm that the team has planned and incorporated measures to meet the requirements for Directive 1B-2 for net zero carbon new construction or deep energy retrofits. The SUCF project coordinator will review the checklist against submitted documents.

Note: This checklist must be provided in addition to, and not in place of, the required energy analysis report.

GENERAL PROJECT INFORMATION

Project Name:

Number:

Phase:

Date:

Project Classification:

- ☐ Net Zero Carbon
- ☐ Deep Energy Retrofit
- ☐ Component Replacemen
- ☐ Not Applicable

REPORTING

Is the project designed to meet the calculated EUI target per Directive 1B-2? ☐ Yes ☐ No ☐ N/A

Have back-up calculations been provided to demonstrate how the target EUI was calculated? ☐ Yes ☐ No ☐ N/A

Are the target EUI and proposed design EUI stated? ☐ Yes ☐ No ☐ N/A

Do the energy model results include all necessary reporting data? (see table on the next page) ☐ Yes ☐ No ☐ N/A

Does the Ventilation operation appropriately respond to the building occupancy based on the anticipated occupancy described in the BOD? ☐ Yes ☐ No ☐ N/A

Select how the energy model operating and occupancy schedules were derived:

- ☐ ASHRAE User's Manual
- ☐ COMNET
- ☐ Other

ENERGY ANALYSIS RESULTS MATRIX

Energy Analysis Results Matrix	Annual Site Energy	Site Energy Use Intensity	Annual Utility Cost	Annual Utility Cost Intensity	Annual Carbon Emissions	Annual Carbon Emissions Intensity	Cost of Measure	Net Present Value	Simple Pay-back
	kBtu/year	*kBtu/ft2-year*	*$/year*	*$/ft2-year*	*MT CO2-e/year*	*CO2-e/ft2-year*	*$*	*$*	*year(s)*
BASELINE									
PROPOSED									
EEM 1									
EEM 2									
EEM 3									
EEM 4									
EEM X									
Combo 1									
Combo 2									
Combo 3									
Combo 4									
Combo 5									

Is there an interpretation provided of the energy analysis results? ☐ Yes ☐ No ☐ N/A

Which scenario(s) meet the directive, which do not, and why? (250 words)

Assumptions for energy analysis or code compliance:

Have detailed modeling inputs been provided for all energy models? ☐ Yes ☐ No ☐ N/A

Select the accepted form of modeling inputs used:

- ☐ LEED Minimum Energy Performance Calculator
- ☐ NY State Energy Performance Checklist
- ☐ NYC EN-1 documentation
- ☐ NYSERDA Whole Building Template
- ☐ Other

Modeling assumptions to include details on the following inputs: modeling software, weather file, energy modeling standard, conditioned area and gross area, envelope constructions, occupancy, lighting power density, and equipment power density values and variation profiles, HVAC system parameters (air-side and water-side), ventilation rates, utility rates, carbon emission factors, renewable systems, and summary of energy efficiency measure input parameters

Net Zero Carbon Resources

General:

State University Construction Fund, Directive 1B-2, Net Zero Carbon New Buildings and Deep Energy Retrofits of Existing Buildings: **https://sucf.suny.edu/sites/default/files/docs/1B-2.pdf**

NYStretch Energy Code-2020: **https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Code-Training/NYStretch-Energy-Code-2020**

State University of New York, Clean Energy Roadmap: **https://system.suny.edu/media/suny/content-assets/documents/capital-facilities/energy/SUNY_Roadmap_FINAL.pdf**

New York State, Climate Leadership and Community Protection Act: **https://www.nyserda.ny.gov/All-Programs/Programs/CLCPA**

Planning:

New Buildings Institute, Getting to Zero Buildings Database: **https://newbuildings.org/resource/getting-to-zero-database/**

New Buildings Institute, Zero Energy Case Studies: **https://gettingtozeroforum.org/case-studies/**

New Buildings Institute, Zero Energy Charrette Guide: **https://newbuildings.org/wp-content/uploads/2017/10/GtZ_ZNEChametteGuide.pdf**

New Buildings Institute, Zero Energy Communications Toolkit: **https://gettingtozeroforum.org/zero-net-energy-communications-toolkit/**

Cost Studies:

National Renewable energy Laboratory, Cost Control Strategies for Zero Energy Buildings: **https://www.nrel.gov/docs/fy14osti/62752.pdf**

US Green Building Council Massachusetts Chapter, Zero Energy Buildings in Massachusetts: Saving Money from the Start: **https://gettingtozeroforum.org/zero-energy-buildings-in-massachusetts-saving-money-from-the-start/**

Whole Building Guidance:

ASHRAE, Zero Energy Advanced Energy Design Guides (K-12 Schools and Small to Medium Office Buildings): **https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download**

Canada Green Building Council, Making the Case for Building to Zero Carbon: **https://www.cagbc.org/cagbcdocs/advocacy/Making_the_Case_for_Building_to_Zero_Carbon_2019_EN.pdf**

Continental Automated Buildings Association, Zero Net Energy: Building Controls, Characteristics, Energy Impacts, and Lessons Learned: **https://www.caba.org/product/zero-net-energy-building-controls-2015/**

National Institute of Building Science, Whole Building Design Guide: **https://www.wbdg.org/**

New Buildings Institute, Building Electrification Technology Roadmap: **https://newbuildings.org/wp-content/uploads/2021/01/BuildingElectrificationTechnologyRoadmap.pdf**

New Buildings Institute, Zero Energy Project Guide: **https://newbuildings.org/wp-content/uploads/2017/10/GtZ_ZEProjectGuide_NBI.pdf**

Redwood Energy, Zero Carbon Commercial Construction: An Electrification Guide for Large Commercial Buildings and Campuses: **https://www.redwoodenergy.tech/wp-content/uploads/2019/09/Pocket-Guide-to-Zero-Carbon-Commercial-Buildings-2nd-Edition.pdf**

UK Green Building Council, Building the Case for Net Zero: A Feasibility Study into the Design, Delivery, and cost of New Net Zero Carbon Buildings: **https://www.ukgbc.org/wp-content/uploads/2020/09/Building-the-Case-for-Net-Zero_UKGBC.pdf**

Zero Energy Ready Oregon, Five Steps to Zero: **https://newbuildings.org/wp-content/uploads/2017/02/NetZero_Etradebook.pdf**

Energy Modeling:

ASHRAE, Standard 209-2018: **Energy Simulation Aided Design for Buildings except Low Rise Residential Buildings**

NYSERDA, Energy Modeling Guidelines: **https://www.nyserda.ny.gov/-/media/Files/Programs/Commercial-Tenant-Program/Energy-Modeling-Guidelines.pdf**

Perkins & Will, Energy Modeling Guidance: Guidelines for Energy Analysis Integration into an Architectural Environment: **http://research.perkinswill.com/articles/energy-modeling-guidance-guidelines-for-energy-analysis-integration-into-an-architectural-environment/**

ASHRAE, Standard 90.1-2019: **Energy Standard for Buildings Except Low Rise Residential Buildings**

Envelope:

BC Hydro, Building Envelope Thermal Bridging Guide: **https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/builders-developers/building-envelope-thermal-bridging-guide-1.1.pdf**

Efficient Windows Collaborative, Windows for High Performance Commercial Buildings: **https://www.commercialwindows.org/**

Load Measures:

Food Service Technology Center, Energy Savings Calculators: **https://caenergywise.com/calculators/electric-combination-ovens/#calc**

New Buildings Institute, Daylight Pattern Guide: **http://patternguide.advancedbuildings.net/**

New Buildings Institute, Luminaire Level Lighting Control: **https://newbuildings.org/wp-content/uploads/2015/11/LLLC_ZNE_TAG1.pdf**

New Buildings Institute, Plug Load Best Practices Guide: Managing Your Office Equipment Plug Loads **https://newbuildings.org/wp-content/uploads/2015/11/PlugLoadBestPracticesGuide1.pdf**

NIH, Automated Receptacle Control Factsheet: **https://www.orf.od.nih.gov/TechnicalResources/Documents/Technical%20Bulletins/20TB/Automatic%20Receptacle%20Control%20%20August%202020%20-%20Technical%20Bulletin_508.pdf**

Conditioning:

ASHRAE, High Performance Sequences of Operation for HVAC systems: **http://gpc36.ashraepcs.org/**

Center for the Built Environment, HVAC Systems: **https://cbe.berkeley.edu/research-category/hvac-systems/**

Energy Star, Heat Pump Water Heaters: **https://www.energystar.gov/products/water_heaters/heat_pump_water_heaters**

New Buildings Institute, Zero Net Energy Technology Application Guide: Radiant Heating and Cooling + Dedicated Outdoor Air Systems: **https://newbuildings.org/resource/zero-net-energy-technology-application-guide-radiant-heating-and-cooling-dedicated-outdoor-air-syste/**

Northwest Energy Efficiency Alliance, Interaction between Heat Pump Water Heaters or Other Internal Point Source Loads and a Central Heating System: **https://neea.org/img/uploads/interaction-between-heat-pump-water-heaters-and-heating-system.pdf**

Ventilation:

ASHRAE, Standard 154-2003: **Ventilation for Commercial Cooking operations**

ASHRAE, Standard 62.1-2019: **https://www.ashrae.org/technical-resources/bookstore/standards-62-1-62-2**

Center for the Built Environment, Research on Displacement Ventilation: **https://cbe.berkeley.edu/research/displacement-ventilation-research/**

International Institute for Sustainable Laboratories: **https://i2sl.org/labs21/**

National Renewable energy Laboratory, Laboratory Evaluation of Energy Recovery Ventilators: **https://www.nrel.gov/docs/fy17osti/66560.pdf**