AMHERST COLLEGE

HIGH-PERFORMANCE BUILDING GUIDELINES

January 2006

TABLE OF CONTENTS

INTRODUCTION

INTRODUCTION

Amherst College has a long-standing commitment to energy conservation and has enthusiastically incorporated energy conservation strategies in the operation, renovation and construction of its facilities. Until recent years, advancing the concept of energy conservation has largely been the domain of the Facilities Department and has been driven by the fact that sound business practices demanded efficient use of the College's financial resources. However, more recently, the College has become increasingly aware that it has a moral obligation to embrace the concept of sustainability and environmental stewardship. As such, the College now actively and aggressively pursues energy conservation and sustainability in all of its projects. We have learned that it is far more effective to incorporate these features into our facilities right from the start rather than to retrofit these features.

This document strives to codify the approach and practices used by the Facilities Department relative to energy conservation and sustainability. It is intended as a framework for the College to use with its design professionals and contractors to establish guidelines by which projects will be designed and constructed. These guidelines will serve to prompt the triumvirate of client, architect and contractor to take a collaborative, thoughtful and deliberate approach toward high-performance building design and construction. The guidelines ensure that the integrative nature of building systems will be considered for all aspects of a building design.

These guidelines are not absolute. There may be projects for which aesthetics or contextualism dictates that not all elements of the project are designed consistently with these guidelines. For example, Amherst College's facilities are arranged on a rigid orthogonal grid that may not allow for new facilities to be oriented to take full advantage of solar gain as was the case with the new James and Stearns dormitories. However, despite the sub-optimal orientation of these new facilities for passive solar and light gain many other sustainable initiatives outlined in these guidelines were seamlessly incorporated into the design of the dormitories.

The LEED certification process has been a powerful force in prompting institutions to incorporate sustainable features in newly constructed buildings. LEED certification has gained popularity with institutions wishing to be environmental stewards and gain the benefit of positive public relations for doing so. The LEED process, however, can force institutions to make decisions that are potentially unfavorable to the institution simply to achieve the point rankings necessary for certification. These guidelines, which borrow standards from LEED, strive to steer the College in the direction of making fundamentally sound business and environmental stewardship decisions for our projects. While Amherst projects may not be LEED certified, we can be assured that our projects are being implemented in an environmentally and fiscally responsible manner.

ACKNOWLEDGMENTS

ACKNOWLEDGMENTS

In developing this document, Amherst College relied considerably upon the pioneering energy-conservation and sustainability work performed by the State University of New York (SUNY) at Buffalo. SUNY Buffalo is one of the first institutions in the country to embrace an integrative approach towards high-performance building design and sustainability. Their approach of sensibly applying sustainable design strategies, rather than focusing solely on the goal of LEED certification, closely parallels Amherst College's philosophies. SUNY Buffalo first published a high-performance building guideline document in 2004 that details their approach towards the design, construction and operation of facilities. The SUNY Buffalo document served as a model for this document, which reflects Amherst's own unique requirements and philosophies.

GOALS FOR THIS DOCUMENT

GOALS FOR THIS DOCUMENT

The following are the goals for Amherst College's High-Performance Building Guidelines:

- To reinforce Amherst College's commitment to campus environmental excellence.
- To inform and direct the College's new construction and renovation design process in order to prioritize energy sustainability and guarantee a commitment to high-performance and green building principles.
- To provide a clear, comprehensive listing of potential high-performance green design and construction goals and strategies.
- To coach a project team step-by-step through an integrative green design process that emphasizes a sensible commitment to green design and not simply an accumulation of LEED points.
- To enable buildings to function pedagogically while instructing and inspiring occupants and visitors in the principles of environmental sustainability.
- To create an awareness in the College campus constituents regarding energy and resource efficiency in the College's buildings.

RATIONALE AND BASICS

- Defining High-Performance Buildings
- National Trends
- The Benefits of High-Performance Buildings

I. Defining High-Performance Buildings

High-performance buildings reflect design excellence. These buildings--often also referred to as "green" or "sustainable"--minimize environmental impact and produce cost savings over their life cycle. These buildings are best designed in an integrative fashion wherein owners, designers and contractors commit from the onset to work together and follow high-performance building principles when addressing critical issues such as:

- **New construction vs. adaptive reuse**
- **Site selection, planning and design**
- **Energy- and water-efficiency**
- **Use of renewable energy**
- **Indoor environmental quality**
- **Efficient and environmentally friendly materials**
- **Recycling during and after construction**
- **Building commissioning**

II. National Trends

The national green building movement has arisen out of several significant trends, including:

- **A growing public awareness of environmental issues** and human health concerns linked to buildings
- **A recognition that buildings are responsible for a significant portion of the nation's energy use** and environmental footprint
- **Technological advances and the evolution of smart design practices** that demonstrate that the "first costs" of green buildings need not be any higher than those of conventional buildings
- **Parallel emphasis at the federal, state and local level** that promote and/or require smart growth and green building initiatives
- **Special interest in green buildings,** especially on college and university campuses with environmental stewardship programs

The combination of these factors is rapidly increasing demand for greener buildings, changing markets and construction practices. The delivery of better-performing buildings is an economic and environmental necessity and an ever-increasing expectation.

III. The Benefits of High-Performance Buildings

High-performance buildings use less energy while providing a variety of environmental, economic, human resource, design and construction benefits, including:

- **Reduced "Environmental Footprint."** High-performance facilities not only reduce fossil fuel dependence, energy use and pollution, they also showcase a more environmentally benign use of materials and contribute positively to restoring their local environment.
- **Lower Operating Costs.** Energy efficiency, use of renewable energy, water conservation, design for ease of cleaning and maintenance and reduced waste streams all contribute to lower operating costs as well as improving the reliability of the building systems and reducing the long-term costs of educational facility ownership.
- **Improved Productivity and Learning Environment.** Studies have demonstrated a link between an educational facility's physical condition and student, faculty and staff performance. Optimized lighting that combines controlled day-lighting and artificial lighting together with superior indoor air quality, contribute to student performance, lower rates of absenteeism and higher faculty and staff satisfaction.

PROCESS

- Achieving Integrated Design
- Design Process Deliverables

I. ACHIEVING INTEGRATED DESIGN

Excellence in building design is best achieved through a collection of "best practices" and through an "integrated" or "team-driven" approach to design and construction. It is the application of integrated design that takes energy and resource efficiency practices into the realm of high-performance. Integrated design focuses designers from all the disciplines--landscape, hydrology, civil, electrical, mechanical, architectural, interior design, etc.--interactively in design decision-making. Coming together at the project outset and at key points in the project development process, professionals can collaborate on creative design solutions that bring multiple benefits, usually at lower cost, and achieve truly beneficial synergies.

Today’s design integration strategies recall aspects of traditional building design when building shape, orientation, materials and means of achieving comfort responded to local climate and acknowledged the location of the sun. In a similar way in today's facilities, design teams can reduce dependence on energy-intensive mechanical systems that operate at odds with the natural environment and place primary emphasis on effective day-lighting, passive solar heating and natural ventilation.

For example, the civil engineer, landscape architect and lead design architect can work together to manipulate the ground plane, building shape, section and planting scheme to provide thermal protection and reduce wind loads and heat loss/gain. In this way, they can reduce heating and cooling loads and, with the participation of the mechanical engineer, reduce the size of mechanical equipment necessary to achieve comfort.

High-performance projects are best initiated with a green design "charrette" or multi-disciplinary kick-off workshop which creates a road map for the project team to follow. This goal-setting workshop, which involves the owner and the design professionals, identifies green strategies for members of the design team and helps facilitate the group's ability to reach a consensus on performance targets for the project.

The charrette is part of a larger process which involves establishing a performance plan and making a consistent effort throughout the project to achieve the goals established by that plan. Based on the charette, a "Performance Plan" will be prepared which summarizes all environmental and energy-performance targets for the project together with the strategies elected from this guide to meet those benchmarks.

II. DESIGN PROCESS DELIVERABLES

Amherst College suggests that the following process be followed:

A. Pre-Design:

- **Performance Plan –** A document listing goals and strategies under consideration based on the initial meeting, including:
  - Design Intent – A narrative description of the design.
  - Potential Financial Incentives – Available financial incentives for energy-efficiency, renewable energy or other green design measures.
  - Building-Community Interface – Pedagogical opportunities to use the building's features as part of the curriculum.

B. Schematic Design:

- **Environmental Site Analysis Plan** - Site plan diagrams indicating solar path, prevailing winds and other climate information relevant to design.
- **Design Energy Use Targets** - Initial performance goals for operating energy use and costs, including description of Basis of Design. Goals for lighting and power density, for the project as a whole and for all major spaces.
- **Schematic Phase Commissioning Plan** (if appropriate).
- **HVAC Systems Alternative Plan** - Alternative HVAC systems considered and their impact on the architectural design. Simple buildings do not require computer modeling during SD. An experienced energy consultant can give an energy efficient direction to the project. If the building is more complex, or if different massing or HVAC alternatives are considered, then a simplified model can be used.
- **Computer Base Case Model** (if appropriate)- Computerized base case energy model developed as a baseline building against which all designed energy efficiencies will be measured.
- **Building Massing Alternatives Plan** - Diagrammatic analysis of alternative massing, orientation and layout.

C. Design Development:

- **Computer Energy Model Report** - Constructed model of the building based on owner-specified operating hours and equipment proposed.
- **Energy Efficient Strategies including Life-Cycle Cost Analysis** - Strategies for mechanical systems, lighting and envelope improvements with individual life-cycle cost-analysis reports.
- **Draft Commissioning Plan** - Prepared by Commissioning Agent (if appropriate).
- **Preliminary Green Materials Specifications** - Prepare materials specifications that reflect sensible use of sustainable materials.

D. Construction Documents:

- **Final Specifications Coverage for High-Performance Issues** during construction, including:

  - Commissioning Plan - Prepared by Commissioning Agent. Outline appropriate commissioning-related activities undertaken during this project phase and determinations made.
  - Waste Management Plan - Provide language requiring the Construction Manager to take all efforts to divert construction, demolition and land-clearing debris from landfill disposal and redirect recyclable material back to appropriate waste handlers.
  - Site Protection/Health & Safety Plan - Develop any site-specific requirements for inclusion in a Site Protection Plan/Health and Safety Plan, covering such issues as noise mitigation, dust and odor control.
- **Final Computer Energy Design Goal Model**.

E. **Bidding Phase:** Highlight green aspects required of the contractor.

- **Pre-Bid Conference** to address the following so contractors understand requirements:
  - Waste Management
  - Materials Log
  - Health and Safety
  - Site Management/Protection/Storm Water Management
  - Commissioning

F. **Construction Phase:** Monitor and administer construction.

- **Collect Lab Results** of Soil, Air Quality, Chemical Source, Water
- **Materials Certifications** (if required)
- **Waste Management Certifications** (if required)

G. **Final Acceptance/Occupancy:**

- **Owner's Manual** - Consultant to assemble completed as-built records, including instruction manuals prepared by equipment manufacturers, fabricators or installers for inclusion in the Owner's Manual.
- **Commissioning Report**

TECHNICAL STRATEGIES

- Site Selection and Design
- Architectural Design for Sustainability
- Indoor Environmental Quality
- Building Energy Use - Mechanical Systems
- Building Lighting, Equipment, Energy Management and Utilities
- Water Management
- Materials and Resources
- Construction
- Commissioning

I. SITE SELECTION AND DESIGN

Site considerations are critical to creating an environmentally friendly building as well as an aesthetically cohesive campus. The siting of green buildings should take into account the surrounding natural environment. For a green building within an undeveloped natural setting, careful design is necessary to mitigate the damage inflicted on natural systems, wildlife habitat and biodiversity. The use of previously developed "brownfield" sites that have been disturbed and contaminated by past uses also benefits the environment in that it avoids impacts on natural resources, provides for site remediation and capitalizes on existing infrastructure.

A. Selecting Appropriate Sites

- **Develop appropriate sites and reduce the environmental impact** from the location of the building.
  - ➢ Select sites without sensitive natural features and restricted land uses.
  - ➢ Consider adaptive reuse of existing building space whenever possible.
  - ➢ Consider previously used and/or damaged sites, thereby reducing pressure on undeveloped land.
  - ➢ Consider the proximity/availability of central campus utilities such as steam and chilled water.

B. Sustainable Site Analysis and Development

- **Evaluate the site** to determine how best to conserve and restore ecological habitats and support building energy and resource efficiency.
  - ➢ Map sun and shade patterns associated with new construction. Design landscaping features to take advantage of sun/shade for plants.
  - ➢ Examine opportunities to minimize disruption to existing hydrological features such as creeks, streams, ponds, lakes and/or wetlands.
  - ➢ Test soil and groundwater to determine pollution levels, depth to water table, soil-bearing capacity and what types of soil amendments may be required for planting.
  - ➢ Examine opportunities to restore the surface-cover of impacted areas.
  - ➢ Design building, parking and roadways to complement existing site contours by limiting cut and infill.
  - ➢ Prioritize the site's natural attributes for protection, conservation or restoration.

C. Site Design

- **Create building and site synergies**.
  - ➢ Complement the building with site features that minimize negative environmental impacts and restore natural systems.
  - ➢ Organize building mass, orientation and outdoor spaces to provide efficient access and service.
  - ➢ Use earth forms, plantings, drainage, water detention systems and soils to support the functions of the building and site (e.g., screening, windbreaks, etc.)

- Coordinate landscape design with building envelope. Orient building, windows and outdoor spaces to take advantage of light, airflows and interesting views.
- Use deciduous shade trees and exterior structures such as arbors and trellises, louvers, overhangs and light shelves to reduce cooling load of the building.

- **Provide creative parking solutions** to reduce pollution and land development impact from automobile use.
  - Minimize parking lot size. Consider sharing parking facilities with adjacent buildings. Excess parking spaces encourage increased automobile use and can increase pollution from storm water runoff.
- **Minimize the area of development footprint** in order to reduce site disturbance. Conserve existing natural areas to provide habitat and promote diversity.
  - Design the building with a minimal footprint to minimize site disruption. Strategies include stacking the building program.
  - Preserve open space area adjacent to the building.
  - Cluster underground utilities running in conduits, such as telephone, cable, electric, water and wastewater.
  - Locate underground utilities in fire lanes and drives, as appropriate, to minimize site disturbance. (Separate sewer/water and high-temperature piping as required.)
- **Reduce or eliminate storm water runoff** to limit disruption of natural water flows.
  - Maintain natural storm water flows by designing the project site to promote infiltration.
  - Specify pervious paving to minimize impervious surfaces. Pervious paving includes such materials as gravel, sand, "Grasscrete" and "geo-block."
  - Reuse storm water for non-potable uses such as landscape irrigation and exterior site washing. Establish with the appropriate regulatory body that no adverse health effects would be associated with this water reuse. Use underground cistern storage, if possible.
  - Prevent non-point source pollution by planting watershed buffers, allowing infiltration via porous surfaces, and minimizing paved parking areas.
  - Design roads and parking lots without curbs, or with curb cuts and openings that drain to storm water treatment and infiltration features.
  - Minimize paved areas for roadways and parking lots to the extent practicable to minimize storm water runoff and also meet the needs of the building program.
- **Treat storm water on site.** Limit contamination of natural water flows by eliminating contaminants and increasing on-site filtration.
  - Provide on-site storm water treatment systems to remove suspended solids and phosphorus and other contaminants.

  - Consider natural treatment systems such as constructed wetlands, vegetated filter strips and bioswales to promote infiltration and "bio-remediate" the site's storm water flows.
  - Provide grading and drainage via vegetated buffers to reduce the need for artificially constructed drainage channels and storm water piping.
- **Use sustainable landscape practices** to promote the conservation and restoration of existing biological and water resources.
  - Emphasize plant diversity. Select plants native or adapted to the region and microclimate. Consider those that grow together naturally and are self-sustaining (i.e., can reseed and spread without much maintenance). Avoid invasive plant species and those that threaten local native ecosystems.
  - Reduce the use of plant species that require frequent maintenance.
  - Avoid plants that require chemical treatment, especially pesticides. Use plant combinations and maintenance methods that do not require chemicals.
  - Avoid allergy-causing plantings adjacent to building openings such as air intakes, entries or operable windows.
- **Reduce water use for plant irrigation.**
  - Use plants that do not require irrigation or that have water requirements that can be provided by natural precipitation patterns.
  - Consider drip irrigation where irrigation is necessary, or other water efficient irrigation systems. Avoid misting sprinklers, which waste water.
- **Improve soil quality.**
  - Analyze planting soil to identify contamination and determine if remediation is needed.
  - Use mulch to conserve soil moisture, restore soil fertility and reduce need for fertilizers.
  - Allow grass clippings and small plant debris to decompose on the ground.
  - Obtain compost for soil amendment from on-site sources, when available, in lieu of peat moss.
- **Select appropriate materials for landscape features.**
  - Use recycled, renewable and/or locally available materials when constructing landscaping features.
  - Use chromated copper arsenate-free pressure-treated wood.
  - Consider natural woods that have rot resistance, such as ipe ("ironwood"). To be environmentally sound, the ipe wood should come from a sustainably-harvested forest.

II. ARCHITECTURAL DESIGN FOR SUSTAINABILITY

Our society is dependent on fossil fuels which contribute to global climate change. Other environmental and social costs associated with energy consumption (from fossil fuel and nuclear power) include air and water pollution, acid rain, loss of wilderness and the generation of radioactive waste. Therefore, finding sustainable ways of meeting our energy needs is imperative. Energy sustainability will require enhanced energy conservation and efficiency as well as a transition to clean, renewable energy resources. Reducing energy loads and incorporating renewable energy in campus building design is possible by optimizing site plans, building orientation and envelope and by incorporating architectural features which enhance the potential for daylighting, solar heating and passive cooling. These strategies will allow campus buildings to be less dependent on mechanical systems.

A. Siting for Passive Design

- **Optimize site placement and building form** to reduce energy loads.
  - Use topography. On hilly sites, use or modify existing topography to obtain the insulating effect of earth through berming and other manipulations of the section.
  - Use/control wind on-site. Whenever possible, orient buildings to protect entrances and minimize infiltration from prevailing winter winds. During other seasons, take advantage of non-winter air movement by utilizing prevailing winds for natural ventilation.
  - Review location of existing and proposed deciduous and evergreen trees on-site. Where feasible, locate buildings so that deciduous trees block summer sun to the south and west and evergreens block winter wind.
  - Maximize solar opportunities by elongating the building structure on its east-west axis. This orientation will allow use of sun-controlled natural daylight and winter solar gain, while minimizing summer heat gains and resulting cooling loads on the east and west facades of the building.
  - Avoid use of large glass atria or large glazed surfaces that cannot be justified from a programmatic perspective or by operating savings returns (e.g., from passive solar heating).

B. Daylighting/Sun Control

- **Optimize use of daylight** in new and renovated campus facilities.
  - Configure the fenestration system to achieve a high daylight factor.
  - Consider glare-protection strategies that minimize the time when interior-shading devices must be drawn.
  - Orient windows for regularly occupied spaces to create views and to visually connect indoors and outdoors.
  - Consider computer modeling of daylight spaces and design features to ensure that daylight spaces will be comfortable areas (with no glare) and that energy

gains in terms of avoided electric lighting costs are greater than the energy costs from increased cooling loads.

- **Orient building to optimize daylight.**
  - Create an elongated massing allowing for daylighting using north-facing and south-facing glass. An east-west elongated building with an appropriate overhang will permit effective daylighting while increasing winter solar gain through south glass and reducing the direct penetration of summer sun.
  - Avoid exposed, east-facing and west-facing glass because of the large variation in light levels throughout the day and greater solar gains in the warmer months, resulting in increased cooling requirements. Eastern exposures are less problematic than the western ones in terms of heating and cooling costs.
  - Consider north-facing glazing for occupants requiring more uniform levels of diffuse daylight.
- **Shape form to guide daylight.**
  - Incorporate daylight-enhancing techniques to bring light into interior spaces.
  - Evaluate such design elements to ensure that they do not add to building heating and cooling loads.
  - Place and size glazing apertures appropriately. Maximize daylight through location and size of windows, roof monitors and skylights and through use of glazing systems and shading devices appropriate to building orientation and space use.
  - Design to avoid glare by using top lighting such as monitors in the roof or ceiling plane that allow a greater quantity and more even distribution of daylight within spaces. Flat, bubble and low-slope skylights have a negative heat balance, but provide glare-free light with light-deflecting devices installed underneath them.
  - Consider high clerestory windows (often preferable to skylights) to provide deep daylight penetration especially for spaces needing useable wall space.
  - Consider the use of interior and/or exterior light shelves, especially on south-facing windows and appropriate east or west facades, for deeper daylight penetration.
  - Provide exterior shading devices (overhangs, fins, projecting light shelves, etc.) where solar gain and direct light are undesirable.
- **Provide daylighting controls.**
  - Design appropriate daylight harvesting controls. Review alternatives for reducing electric lighting use through daylight harvesting. Continuous daylight dimming has broad occupant acceptance, especially if, in individual spaces, it is coupled with a manual dimmer that allows for adjustment for maximum intensity of the artificial light from lamps. On/off or three-stage controls are appropriate for spaces with transitory occupancy (e.g., corridors) and where the glazed areas are large so that the change from one light level to another rarely occurs.

C. Passive Heating, Cooling and Ventilation – Use passive strategies to control and maintain building climate.

- **Passive Solar Heating.** Use passive solar heating to reduce energy use. Passive solar strategies are most effective if the space temperature can fluctuate over 5 to 10 degrees during occupied periods.
  - Design for direct solar gain for appropriate space types. Direct solar gain should be considered for all south-facing spaces where critical visual activities are not typically conducted.
  - Consider the use of interior south-facing opaque mass walls exposed to direct sunlight in the interior of a passive solar space to provide thermal storage during the day and passive heating at night.
  - Perform computer energy modeling to determine if a passive solar configuration saves energy in a cost-effective manner. Issues to be explored in this analysis include:
    - determining whether energy gains from passive solar heating will exceed energy loss due to additional fenestrations
    - investigating the effect of south-facing glass with low U-value but high solar heat coefficient
    - assessing the effectiveness of thermal mass
- **Passive Cooling and Natural Ventilation**. Evaluate the potential of thermal mass for both existing shells and new buildings.
  - Moderate interior temperatures, where appropriate, through the use of sufficient thermal mass. Consider different design solutions for storing heat in the building structure or materials.
  - Balance solar heat gain properties of glass by selecting high-performance glass.
  - Use shading devices. Consider shading to let in natural light but exclude heat and glare and control contrast ratios. Shading strategies include vertical fins on east and west fenestration; overhangs or light-shelves on south fenestration; arcades; trees; and deep window insets.
- **Naturally ventilate the facility** to the extent possible in appropriate buildings types, building zones and building locations.
  - Consider natural ventilation strategies in design of HVAC and exterior window and wall openings to reduce reliance on mechanical ventilation at least during swing seasons.
  - Design for cross-ventilation.
  - Consider providing operable windows with appropriate HVAC interlocks or occupant annunciation systems to avoid HVAC operation and energy loss when windows are open.
  - Carefully balance the deficits of operable windows, which may compromise the efficiency and maintenance of central systems, with the psychological benefits of operable windows, e.g., operable windows in offices but not labs.
  - Consider fan-powered night ventilation in lieu of operable windows. Employ computer modeling to decide on the period for nighttime ventilation. In many situations, one or two hours of fan operation would be sufficient; longer run times may be ineffective and can waste energy. Night ventilation must be enthalpy-controlled to avoid introducing excessive humidity in the building.

  - Use stack effect for cooling through high vent reliefs on stairwells and other high outlets where smoke evacuation will not be compromised.
  - Design for maximum benefit from economizer cooling in mechanical systems.

D. Building Envelope.

- **Optimize window frame performance.**
  - Provide thermal break in metal window frames for best thermal performance and to minimize condensation.
  - Consider security issues and water intrusion in glazing and design details.
  - Provide high-performance, durable weather stripping to minimize infiltration.
  - Consider wood window frames that provide a natural thermal break where appropriate in new construction (e.g. residential) and in window replacement on historic buildings.
- **Select glazing for optimal performance.**
  - Select appropriate high-performance energy characteristics. Consider U-value, solar heat gain coefficient and visible light transmittance.
  - Optimize glazing by orientation using energy modeling. Glass on south, east and west facades should be highly protective against solar heat gain, except glazing that is protected by shading devices or south-facing glazing being used for passive solar heating.
  - Consider specifying glazing with high visible light transmittance and high shading coefficients on north walls where glare is much less of a problem. Glass on north facades can be clear or lightly tinted.
  - Consider fritted and spectrally selective glazing, tuned to use and orientation on south, east or west elevations.
- **Provide effective insulation to minimize heating, cooling and energy-use loads.**
  - Optimally insulate the building shell (walls, roof, basements/foundation). Use computer modeling to determine cost-effectiveness of adding insulation beyond code requirements.
  - Avoid thermal bridging in metal-framed assemblies through exterior wall, roof and floor details and components.
  - Avoid irregular exterior building shapes or soffits, which increase surface area, resulting in unwanted heat loss. Compensate for extra surface area with additional insulation.
- **Control air and moisture in the building envelope.**
  - Detail the building envelope to minimize infiltration and to prevent moisture build-up within the walls due to condensation. In humidified spaces that have masonry walls, do not place the insulation on the winter-cold surface of the concrete masonry wythe. If the insulation must be placed on the winter-cold surface of the masonry wythe, examine potential moisture condensation (dew point position).
  - Ensure that all internal sources of humidity are properly ventilated.

E. Interior Facility Layout.

- **Organize programmed spaces for maximum energy- and resource-efficiency as well as comfort.**
  - Program the facility for efficient use of built areas (multi-functional spaces and appropriate net-to-gross). Avoid adding non-productive square footage to the building.
  - Group similar program functions to concentrate heating/cooling and simplify HVAC zoning loads. Consider this zoning strategy for differing uses, i.e., classroom, office, lab and public functions.
  - Use public areas and circulation zones as thermal collectors and buffers. Such spaces tolerate a wider range of temperatures and greater temperature swings than continuously occupied spaces.
  - Design building layout to use natural systems. Arrange occupied spaces for daylighting and natural ventilation whenever possible. Locate open occupied spaces adjacent to exterior windows and use borrowed light for interior offices. Use low partitions adjacent to window walls to enhance daylight penetration to interior areas.
  - Provide well-lit, pleasant, secure stairwells/staircases to encourage the use of stairs instead of elevators.
  - Provide vestibules at major entries with minimal heat but no cooling, consistent with freeze protection.
  - Combine water-use zones for plumbing to decrease heating and pumping requirements and reduce construction costs.

III. INDOOR ENVIRONMENTAL QUALITY

Indoor environmental quality and occupant comfort can be achieved with improved air quality. Occupants typically experience a greater sense of well-being if they have greater control over their immediate environment as well as access to windows that provide daylight and a visual connection to the outdoors.

A. Air Quality

- **Reduce air quality problems at the source.**
    - Reduce potential water problems. Design surface grades, drainage systems and HVAC condensate collection systems to prevent accumulation of water under, in or near buildings.
    - Control unwanted moisture. Prevent condensation of water vapor inside the building envelope by proper use of air retarders, vapor retarders, proper location and amount of thermal insulation; control of indoor-to-outdoor pressure differences; and control of moisture-generating activities at the source.
    - Specify non-offgassing materials. Specify construction materials with low volatile organic compounds and low odor emissions.
    - Isolate exhaust and plumbing systems in rooms with contaminants.
    - Install permanent architectural entryway systems such as grills or grates to prevent occupant-borne contaminants from entering the building.
    - Segregate chemical use areas. Where chemical use occurs (including housekeeping areas, laboratories, art rooms, floor cleaning machine recharging area and copying/printing rooms), provide segregated areas and separate outside exhaust. Provide heat recovery or other efficiency strategy where cost-effective.
    - Design the building to maximize views for students, faculty, staff and other personnel through direct line-of-sight-to-perimeter glazing in all regularly occupied spaces. Such views are important to physiological as well as psychological well-being.
    - Consider interior material color and reflectance. Choose light-colored flooring (a trade-off, as it requires greater cleaning and maintenance) to enhance lighting levels. Ceilings should be white for high reflectance. Walls adjacent to windows should be light in color. Avoid saturated colors except as accents or special effects in corridors.
    - Provide lamps with high color rendering index.
    - Use photometric analysis for lighting design of all significant spaces.

B. Control of Building Systems

- **Provide a high level of control for thermal comfort, lighting and ventilation systems.**
  - Where possible, provide temperature and lighting controls for each occupied space to manage comfort variation according to orientation and other factors

as well as occupant preferences. Controls should be consistent with Amherst's heating and cooling policies. Integrated controls systems for temperature will allow variation within a range 68 +/- 2°F in the heating season and 76 +/- 2°F in the cooling season.
- Provide interlock controls with HVAC to turn off heating and cooling when windows are open.
- Consider workstation-based ventilation (fan) and heat (radiant panel) controls.

C. Acoustic Quality

- **Control noise**.
  - Reduce exterior noise (traffic, other loud noise) through appropriate building orientation, landscaping, insulation or other means of attenuating sound.
  - Isolate equipment. Locate noisy mechanical equipment and functions (e.g., shops, music rooms) away from noise-sensitive spaces.
  - Use offset studs and deck-to-deck partitions around noisy functions, incorporating sound-attenuating insulation, floating floor slabs and sound-absorbent ceiling systems as appropriate.
  - Use internal insulation or sound attenuators for sound control on ducts. Do not use internal lining to prevent airborne fibers and IAQ problems.
  - Select appropriate surfaces (ceilings, floors, walls) to achieve good classroom acoustics for resonance and reverberation time between.
  - Abate corridor noise through use of resilient floor surfaces, ceiling tiles and other interior surface materials that minimize noise.

IV. BUILDING ENERGY USE – MECHANICAL SYSTEMS

Mechanical and lighting systems consume the majority of energy used by buildings. Dependence on fossil fuels cannot be reduced without optimizing HVAC, hot water, process utilities, controls and energy management systems. The first step in HVAC system design is to reduce heating and cooling loads and to determine to what extent a new building can run on sunlight or meet occupant needs in a passive manner. Having minimized the need for mechanical systems, life-cycle analysis can help decide the appropriate systems for a building. Certain types of campus facilities, such as laboratory buildings with substantial ventilation requirements, deserve special attention in design. Opportunities for heat recovery and distributed generation should not be overlooked.

A. Energy Sources - Best design practices must first address load reduction, then capitalize on solar heating, natural ventilation, daylight use and other renewable strategies.

- **Proximity and availability of central utilities** such as steam and chilled water must be considered. Central systems take advantage of diversity and are almost always more efficient than distributed systems.

B. HVAC Systems - The following general approaches to HVAC systems are recommended for new buildings, additions and major rehabilitations of existing buildings to ensure an integrated approach to building and systems design for optimal energy efficiency and indoor air quality.

- **Optimize HVAC systems** through design integration. Design the architectural features in concert with selecting appropriate HVAC alternatives and sizing the systems. Use acceptable computer modeling for system choices.
  - Assess the interaction between the HVAC equipment and other related systems such as lighting, office equipment, fire protection, security, etc. in order to optimize design and energy efficiency.
  - Use separately-zoned HVAC systems to serve areas with different users, loads, orientations and hours of operation.
  - Program HVAC systems for occupied and unoccupied setback controls.
  - Keep computer server rooms on separate cooling systems when rooms require continuous cooling.
  - Locate thermostats or other sensors to cover areas of similar load.
  - Design for "diversity of use," assuming that not all spaces will be used at all times, with full occupancy or at full load.
  - Consider distributed air-handling mechanical rooms to reduce the size and complexity of ductwork systems. Special attention should be paid to noise control.
  - Evaluate the potential heat recovery by performing a lifetime-cost analysis.
  - Isolate building air intakes, placing them upwind and away from building exhaust air, loading dock, or parking lot vehicular exhaust air, as well as away

from adjacent spray, combustion gases, sanitary vents, trash storage and other sources of undesirable air contaminants.
    - Locate and design air intakes for the best air supply source for the HVAC system and in favorable direction for full airside economizer mode operation, as well as for minimizing snow intake in winter.
    - Avoid use of ceiling plenums as return air ducts.
    - Provide low-leak outside-air dampers, which use separate dampers for minimum outside air and main outside air functions in order to accurately control minimum outside-air-intake quantities. Do not use main outside-air damper to set minimum fresh air level.
    - Provide modulating dampers to ensure minimum outside air.
    - Avoid rooftop units that preclude other roof top uses and add maintenance difficulty which may result in inefficient operation. Always install air-handling units in accessible locations where they can be maintained.
- **Heating Equipment Optimization** - With building loads minimized, designers should select heating systems and equipment based on meeting those loads at maximum efficiency.
    - Consider using central steam or hot water.
    - Do not oversize boilers more than recommended by ASHRAE.
    - Consider the installation of multiple modular boilers, or multiple boilers of different sizes, that provide redundancy and are often easier to fit into existing buildings because of their smaller individual size.
- **Select appropriate boiler control strategies.**
    - Water temperature reset control based on the outside air temperature. Alternatively, specify supply water temperature reset based on return water temperature (more efficient than that based on OA).
- **Design for heat recovery.**
    - Explore waste heat recovery options to reclaim waste heat from air handling and other equipment, including enthalpy wheels, run-around loops, heat wheels, heat pumps and air-to-air heat exchangers, as well as any opportunities for stack heat recovery.

C. Cooling Equipment Optimization - With building loads minimized, designers should select cooling systems and equipment based on meeting those loads at maximum efficiency.

- **Maximize cooling equipment efficiency.**
    - Consider using central chilled water loop, if available.
    - Select electric chillers that operate at high efficiency at full and anticipated partial loads. Model overall chiller efficiency based on seasonal ton-hours at likely load profile (not just peak load). Consider variable speed-driven chillers.
    - Consider alternative cooling technologies, e.g., passive cooling and natural ventilation, natural-gas-fired absorption or engine-driven chillers with heat recovery or cogeneration, etc.
    - Select high-efficiency cooling towers, generally draw-through style. Provide variable speed drives on all cooling tower fans.

- Consider chemical-free cooling tower water treatment.
- Control the cooling tower operation with wetbulb reset instead of constant temperature.
- Consider water-cooled vs. air-cooled condensers on a systems-efficiency basis. Also consider maintenance issues for cooling towers and cost of chemical treatment, water and maintaining additional equipment.
- Consider winter free-cooling from air economizers that can reduce chilled water use and cost for the district.
- Consider enthalpy heat recovery in conjunction with a reduction in the size of the chiller plant.
- Consider desiccant dehumidification.
- Provide variable speed drives on chillers and chilled water pumps.

- **Cooling equipment should be the correct size.**
  - Avoid oversizing chillers or other cooling equipment more than recommended by ASHRAE.
  - Consider chillers of different sizes that could allow for more efficient part-load operation of the system, or chillers with variable speed drives.
  - Segregate spaces that need cooling from spaces that do not need it, thus providing cooling only where required. Downsize cooling equipment accordingly.
  - If an increase in cooling load is possible in the future, provide space in the central plant for another chiller, if and when it becomes necessary. Avoid purchasing an additional chiller now, since future chillers will be more energy efficient and more environmentally friendly.
- **Do not use environmentally damaging refrigerants.**
  - Comply with zero use of CFC-based refrigerants in new base building HVAC & R systems.
  - Minimize use of hydro-chlorofluorocarbons (HCFCs). Consider installing fire suppression systems that do not contain HCFCs or Halon if alternate systems are consistent with safety requirements.
  - Consider the replacement of refrigerants with those of preferred environmental performance. Be sure that system capacity and efficiency will not be adversely affected.
  - Consider replacement of equipment that uses CFCs. Be sure that efficiency will not be adversely affected.
  - Refrigerants such as R123 is preferable to R134a in terms of efficiency and CO_2 emissions. Ozone depletion is not as great with R123.

D. Distribution System Optimization

- **Optimize distribution system.**
  - Use premium-efficiency motors for fans and pumps to reduce operating costs and energy consumption.
  - Use variable air volume (VAV) systems to reduce operating energy cost of main air-handling units unless analysis clearly indicates that an alternative system would be more cost-effective over the life cycle.

  - Use variable speed drives to vary air and water volumes in order to reduce fan and pump energy requirements.
  - Consider the use of under-floor air distribution systems in applications where this design produces efficiency, occupant controllability, reliability and renovation ease and cost benefits sufficient to justify added costs.
  - Design energy efficient ductwork, minimizing duct runs, duct velocity and duct resistance in order to reduce horsepower requirements and energy use.
  - Locate ductwork to avoid exposure to building skin or outside temperatures.
  - Avoid three-way bypass valves in order to reduce needless pumping.
  - Consider adding Direct Digital Controls to the VAV boxes, especially if the boxes have reheat coils. Minimize the reheat by increasing the air temperature when most boxes are in reheat mode.
  - Design for supply water temperature reset in heating and cooling loops.
- **Optimize use of sensors.**
  - Consider providing a thermostat in every room (with digital readout and the ability for occupants to adjust temperature within a limited range consistent with temperature policy).
  - Locate sensors proximate to occupants for readings of temperature and carbon dioxide.

E. Domestic Hot Water

- **Optimize hot water system.**
  - Use low-flow water fixtures.
  - Do not oversize water heaters or hot water tanks.
  - Use steam or gas-fired hot water booster heaters rather than electric.
  - Use heat recovery methods, when available, to provide service or domestic hot water.
  - Consider using point-of-use water heaters for small loads and where hot water demand is spread out within a building.
  - Consider solar water heating.
  - Consider alternatives to recirculating hot water systems or employ an automatic control for recirculating hot water systems to reduce temperature or cycle pumps off during hours of non-use.

F. Building Process Utilities

- **Produce and use process steam efficiently.**
  - Use central steam, if available.
  - Use high efficiency boilers.
  - Consider smaller, instantaneous point-of-use boilers instead of a single boiler with a large distribution system.
  - Optimize pipe insulation.
  - Use removable insulation on valves and on all components; such insulation may need occasional repair.
  - Design system for easy maintenance, which will help maintain efficiency.
- **Produce and use compressed air efficiently.**
  - Select an energy-efficient compressor.

- Avoid once-through water-cooled compressors.
- Size and select compressor(s) based on anticipated full and part-load conditions.
- Design and install piping system to highest standards so that it is leak-free.
- Specify piping size and receiver tanks so that compressor generation pressure is as close to the end-use pressure as possible. Do not undersize these critical components.
- Use dryers to remove moisture from the air in order to avoid maintenance problems and efficiency loss in temperature control systems.
- Scrutinize dew point requirements (fixed vs. floating) and use desiccant dryers only where necessary.

G. Ventilation/Indoor Air Quality

- **Provide for the effective delivery and mixing of fresh air** to support the safety, comfort, and well-being of building occupants.
  - Provide CO_2 and other sensors for variable-occupancy spaces, including classrooms.
  - Eliminate short-circuiting and dead air zones by careful study of air supply and return locations and their effect on airflow.
  - Provide economizer cycle in ventilation system to allow 100% of outdoor air in supply airstreams during mild weather and for periodic building flushing. Design and control HVAC economizers to prevent moisture problems.
  - Provide modulating dampers in air distribution systems with airflow measurement devices or those activated with C02 sensors to ensure minimum outside air intake during all operating conditions.
- **Use natural ventilation whenever possible.**
  - Where appropriate, design to provide effective cross-ventilation in rooms but specify tightly closed windows to avoid a significant increase in air infiltration in winter.
- **Provide appropriate filtration and duct lining.**
  - Provide multi-gradient polyester filtration to intercept all make-up air. If outdoor air has high dust levels, use higher efficiency air filters. (60-65% ASHRAE standard efficiency with 30% efficiency pre-filters)
  - Consider use of low-pressure drop, high-efficiency air filters with pressure-drop monitoring.
  - Do not use fibrous duct or duct liners and loose mineral fibers for internal ductwork insulation. These bring potential for dirt accumulation and dampness, leading to mold growth and potential fiber release into conditioned spaces.
  - Avoid use of internal lining on ducts for sound control. Instead, use external insulation, sound attenuators or acoustical baffles in lieu of linings.

H. Central Heating and Cooling Systems vs. Satellite Systems

- **Use efficient campus-wide heating and cooling.**
  - Investigate providing building heating and cooling from campus-wide steam, hot water or chilled water when more energy-efficient and cost-effective.

I. Laboratory building-specific HVAC strategies

- **Maximize energy efficiency** while preventing occupant exposure to potentially hazardous chemicals.
  - Design fume hood exhaust systems for maximum energy efficiency while maintaining safety.
  - Incorporate VAV or multiple-speed designs to reduce outside air and exhaust air volume.
  - Incorporate heat recovery to extract heat from exhaust air streams.
  - Select fume hoods based on efficiency. Consider low-flow hoods. Consider non-bypass-type hoods which can maintain face velocity while reducing airflow when hood sash is closed.
  - Design exhaust systems and controls to allow individual fume hoods or appropriate groupings of hoods to be safely turned off or slowed down to produce an energy savings.
  - Consider recirculating air that passes through non-lab spaces into laboratory zones for fume hood makeup air to reduce overall exhaust air volume.
  - Separate general lab exhaust from fume hood exhaust to permit heating and cooling reclamation through the use of enthalpy wheels.

IV. BUILDING LIGHTING, EQUIPMENT, ENERGY MANAGEMENT AND UTILITIES

Efficient lighting design begins with daylighting; electric lighting should be designed to maximize savings from daylighting. Because lamp, ballast and light fixture efficiencies keep improving each year, it is possible to design high-quality lighting systems with lower and lower wattage densities. More efficient plug load and hard-wired equipment is also now available, in part due to the Energy Star program.

A. Energy-Efficient Lighting

- **Use energy-efficient interior lighting.**
  - Select the most energy-efficient lamps, ballasts and fixtures to achieve low lighting densities.
  - Use lamps with a high color-rendering index (CRI) for indoor use.
  - Incandescent lights should not be used except when required in historic structures or specialty areas in museums and art buildings.
  - Use plug-in (not screw-in) compact fluorescent lights in all "high hat" can-type fixture applications. High CRI, dimming, compact fluorescent lamps are available.
  - Select fluorescent fixtures on the basis of efficiency. Consider reflectorized fixtures (with fewer lamps) to maximize fixture efficiency. Consider high-efficiency lenses to improve fixture efficiency. Avoid inefficient parabolic and paracube fixtures.
  - Consider T5HO lamps in lieu of HID light sources.
  - Consider indirect or direct/indirect fixtures only if the watts-per-square-foot efficiency is comparable to or lower than what would be achieved with direct fixtures.
  - Use task lighting to permit reduced ambient lighting and lower lighting power density (watts per square foot).
  - Select LED (light emitting diode) exit lights.
  - Minimize any decorative electric lighting.
  - Minimize the number of lamp types on any given project.
- **Use lighting controls to reduce lighting hours of operation.**
  - Provide multi-zone and multi-level switching for multiple use spaces.
  - Incorporate time clock or energy management system controls, or infrared, ultrasonic or combination occupancy motion detectors in spaces where cost-effective.
  - Properly zone lighting circuits and switches to optimize energy-efficient operation, including in perimeter zones, using photocell control, dimming controls and daylight harvesting.
  - Provide multi-level controls in corridors with occupancy, timeclock and/or daylight controls.
- **Provide energy-efficient outdoor lighting.**

- Use energy-efficient high-pressure sodium fixtures to illuminate streets, parking lots and walkways to achieve foot-candle thresholds.
- Minimize outdoor decorative lighting.
- Eliminate light trespass from building site by using energy-efficient fixtures which direct light downward. Use cut-off luminaires, low-reflectance surfaces, etc., to prevent light trespass.

B. Energy-Efficient Equipment

- **Select energy-efficient equipment and load-consuming devices.**
  - Specify only energy-efficient plug load equipment for office, lab, kitchen, food service, vending, etc. Specify Energy Star label, when available, and/or equipment with built-in timers or power management features set as default to maximize likelihood of use.
  - Purchase liquid crystal display (LCD) low-wattage flat screens in lieu of conventional CRT monitors for computers.
  - Use premium-efficiency motors and controls.
  - Use variable-speed drives to control all motors 5-HP or larger that run for extended hours and where reduced, variable flow is possible.

C. Energy Load Management

- **Provide appropriate energy management.**
  - Use direct digital control energy management systems.
  - Provide building automation systems with the following characteristics:
    - Computerized monitoring and control of all major HVAC systems and equipment, capable of implementing a full range of energy conservation and efficiency strategies. These should include setback strategies for when spaces are unoccupied.
    - Energy consumption monitoring and trend-logging through hourly graphs to follow the effect of operational changes and monthly graphs to analyze historical data.
    - Load tracking and load anticipation capability to optimize system response to building pickup and power demand level.
    - Load shedding and demand control through scheduled equipment cycling.
    - Local controllers able to manage equipment operation independently and gather data for reporting.
    - Appropriate interconnection with central energy management systems on campus.
  - Employ appropriate peak-shaving strategies to reduce demand and flatten load profile when electricity is most costly.
  - Consider shifting electric power consumption by using a thermal storage system in conjunction with a conventional chiller system.
  - Provide controls for vending machine, water cooler and other refrigeration loads.
- **Improve strategies for controlling HVAC and ventilation.**

- Operate based on need. Do not air condition all spaces. Do not air condition spaces when not in use.
- Eliminate or strictly minimize simultaneous heating and cooling. Design for zero reheating during the cooling season.
- Install CO2 sensors and implement demand control ventilation to allow for the reduction of outside ventilation air in large spaces with variable occupancy. Verify that recommendations are consistent with code requirements.
- Provide supply air temperature reset controls for air distribution systems based on space occupancy.

- **Provide for the metering of building energy (steam, chilled water, electricity) and water consumption performance over time.**

D. Electrical Power Systems

- **Provide the most efficient sources of power.**
  - Avoid electric space and water heating.
  - Evaluate the cost-effectiveness in existing facilities of converting electric space and/or water heating to natural gas or some other energy source.
  - Explore cogeneration and distributed power generation applications.
  - Install adequate metering to monitor electric loads.

VI. WATER MANAGEMENT

New design should conserve water and protect water quality. There are many energy and environmental costs associated with wasting potable water. Green design measures conserve water by increasing fixture efficiency and by avoiding technologies that waste water.

A. Water Efficiency

- **Create water efficient landscaping.** Limit the use of potable water for landscape irrigation.
  - ➢ Perform a soil/climate analysis. Determine appropriate landscape types and design the landscape with indigenous plants to reduce or eliminate irrigation requirements.
  - ➢ Eliminate permanent irrigation systems through use of indigenous plant materials, allowing for temporary "quick couple" systems during the establishment period or extreme drought.
  - ➢ Consider high-efficiency irrigation systems such as drip irrigation or soaker hoses.
  - ➢ Collect and use rainwater or gray water for landscape irrigation, urban gardening and site washing purposes.
- **Implement water use reduction strategies.** Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.
  - ➢ Use high-efficiency fixtures. Consider the use of low-flow toilets and urinals.
  - ➢ Consider reusing storm water and gray water for non-potable applications such as toilet and urinal flushing, mechanical systems and custodial uses.
  - ➢ Consider use of automatic, usually spring-loaded, shut-off controls on sinks to lower water usage.
  - ➢ Improve water efficiency of HVAC equipment. Do not use "one pass" cooling units that use potable water and discharge it to a drain, as is typically used for computer room installations and supplementary space cooling.
  - ➢ Improve water efficiency of water-cooled cooling towers. Provide metering for both the makeup and the blowdown rate. Use a water analysis program to monitor water quality and to minimize blowdown rate.
  - ➢ Consider alternatives to chemicals for cooling tower make-up water.
  - ➢ Use horizontal axis, Energy Star compliant clothes washers.

VII. MATERIALS AND RESOURCES

The materials used in the construction of buildings have life cycles that include harvesting, extraction, refining, manufacturing, transportation, use and eventual disposal. At every step of the way, energy is used and there are environmental impacts that include resource depletion, air and water pollution, disruption to wildlife and damage to the land, forests and ecosystems. Most materials are being used globally at an exponential rate that is not sustainable. Green design emphasizes strategies to increase the efficiency of materials use so that less material is required.

Environmentally friendly materials are those that are reused; recycled; low in embodied energy; renewable; sustainably harvested; non-toxic in production, use and disposal; and local (to reduce transportation impacts). Carefully selected materials can significantly reduce the environmental impact of new construction. In addition, planning recycling collection spaces and strategies for building occupants in the original design can reduce material waste over the life cycle of the building.

A. Waste Prevention

- **Consider renovating existing buildings** instead of new construction to extend life of existing building stock, conserve cultural resources and reduce new building environmental impacts.
  - Consider reuse of existing buildings, including structure, shell and non-shell elements, and upgrading outdated components such as windows, mechanical, electrical and plumbing systems.
- **Use materials efficiently and prevent waste.**
  - Maximize resource conservation through efficient space design. Explore options for smaller buildings that still meet program guidelines through tight net-to-gross compact form and use of multi-purpose spaces.
  - Consolidate program uses wherever possible and co-locate communal spaces to reduce building area.
  - Reduce material used and waste generated through efficient design and detailing.
  - Design for disassembly and reuse of materials where possible, particularly for applications that are likely to change frequently.
  - Eliminate unnecessary finishes in areas where not required.
  - Design using modular sizing of spaces and materials (as an organizing concept) to the extent practicable.
  - Select products for durability, reducing replacement costs, occupant disruption and waste disposal.
- **Reuse materials. Use salvaged, refurbished, or reused materials.**
  - Establish a project goal for the incorporation of salvaged, refurbished or reused materials into the building design.
  - Identify materials and suppliers that can achieve the project goal.

  - Retain nonstructural elements such as roofing material and portions of interior walls, doors, flooring, and ceiling systems when doing major renovation of an existing building.
  - Consider salvaged materials such as beams and posts; floor coverings; paneling, doors and frames; cabinetry and furniture; and brick and decorative items.
- **Promote storage and collection of recyclables.**
  - Provide a dedicated recycling area, appropriately sized and easily accessible to serve the entire building for separation, collection and storage of materials including (at a minimum) paper, cardboard, glass, plastics and metals. Provide appropriate access for collection vehicles.
  - Provide areas on each floor or in each major department for recycling collection stations consistent with facilities recycling program.
  - Consider employing cardboard balers, aluminum can crushers, recycling chutes and other waste management technologies to further enhance the recycling program.
- **Divert construction and demolition debris from landfills by recovering usable resources.**
  - Develop quantifiable waste management goals to redirect recoverable and recyclable materials back to secondary waste handlers.
  - Develop appropriate specification language and details for the required Construction and Demolition Waste Management Plan for the Construction Manager to implement.
- **Materials for a Healthy Indoor Environment - Select low emitting materials to reduce quantity of indoor air contaminants.**
- **Materials for Reduced Environmental Impacts - Give preference to materials with life cycle analyses indicating avoided or reduced environmental damage.**
  - Avoid materials that may cause environmental damage in their manufacture, use or disposal.
  - Give preference to materials with low embodied energy, where other performance criteria have been satisfied. Products with higher embodied energy involve more air emissions and pollution.
  - Use materials manufactured or harvested regionally. Give preference to local firms (design professionals, construction firms, commissioning and equipment manufacturers.)
  - Select materials with recycled content.
  - Use certified wood to reduce negative environmental impacts on forests.
    - Specify Forest Stewardship Council (FSC) certified wood materials including (but not limited to) structural and general dimensional framing, mill-work, flooring, finishes, furnishings and non-rented temporary construction applications such as bracing, concrete form work and pedestrian barriers.
    - Reduce the use of large timbers by utilizing assemblies that require smaller pieces of wood and by using glue-laminated beams and other types of manufactured wood floor joists.

  - Reduce emission of toxic preservatives such as ACQ (ammonium copper quaternium) or CDDC (copper hydroxide sodium dimethyldithiocarbamate) by using safer alternative chemicals, and ensure that treated wood is sealed or not located where physical contact may occur. Alternately, use ipe wood that has been harvested in a sustainable manner (FSC-certified).
- Use rapidly renewable building materials (made from plants that are typically harvested within a 10-year or shorter cycle) for the maximum amount of building materials and products used in the project.
- Consider rapidly renewable materials such as linoleum, cork or bamboo flooring, poplar Oriented Straw Board (OSB), straw board or wheat grass for cabinetry materials, and others.
- Consider life cycle costs in product and assembly selection. Durable, low-maintenance products are often less expensive over time than other products that require frequent replacement.

VIII. CONSTRUCTION

The construction phase is critical to the success of green design, because it is during construction that the design intent is realized. The construction process can be wasteful and damaging to the environment if not managed properly. The construction footprint may be reduced while protecting the site's natural features and minimizing negative impacts to the adjoining community. Health and safety measures must be implemented to protect workers and those adjacent to construction. Recycling of construction debris should be maximized. From early design to post-construction, the building commissioning process can provide documented confirmation that building systems function according to design and thus capture the anticipated energy, environmental and financial benefits.

A. Construction Administration for Sustainability

- **Educate the Construction Manager (CM) on high-performance construction.** Advise on specific requirement and client expectations to build and manage construction in a sustainable manner.
  - Hold Pre-Bid Conference. A Pre-Bid Conference conducted by the owner should highlight the importance of sustainable design in building construction, how it is to be measured, and the role the Contractor plays in meeting that goal. Highlight requirements for preparing and updating the following submittals:
    - Waste Management Plan (including recycling, salvaging materials, reduced packaging and other waste-prevention measures).
    - Health and Safety Plan (including hazardous materials handling).
    - Construction Site Management and Protection Plan (including erosion control and integrated pest management, where applicable).
- **Implement the construction waste management plan.** The CM must ensure responsible management of the waste generated by construction and demolition. Divert waste from landfills for recycling and reuse.
  - Require a Waste Management Plan. Stipulate a requirement in the contract documents for Contractor's submittal of a draft and implementation of a final Waste Management Plan. The Waste Management Plan must track the following:
    - Identify waste materials generated, including salvaged, recycled and reused materials.
  - Review construction waste recycling specifications with the CM and subcontractors.
  - Ensure that CM allocates adequate time for salvage of materials and fixtures prior to actual demolition.
  - Encourage reuse of salvaged material at the site, where applicable. Provide for reuse of existing systems, equipment and materials whenever possible.

    - Ensure that the CM or general contractor educates and follows up with workers on waste prevention, waste management and the proper handling and storage of materials.
    - Ensure that the CM becomes familiar with procedures required to comply with local recycling laws.
    - Manage hazardous materials. Identify hazardous waste by-products of construction, (e.g. paints, solvents, oils, lubricants) and develop procedures for separating and for disposing of these wastes according to appropriate federal, state or local regulations.
    - Enforce proper handling, storage and disposal of hazardous and toxic materials.

- **Health and Safety Plan**
  - Prevent indoor air quality (IAQ) problems during the construction/renovation process to help sustain the comfort and well-being of construction workers and building occupants.
  - Contractor must develop, maintain and implement a health and safety plan. The plan shall provide for the following:
    - Confirm that special construction-related IAQ procedures, such as construction sequencing of finish installation, temporary ventilation, and so on, are being met as required by the Specifications.
    - Protect ducts and airways from accumulating dust, moisture, particulates, VOCs and microbes resulting from construction/demolition activities.
    - Schedule construction procedures to minimize exposure of adsorbent building materials to moisture or VOC emissions. Complete 'wet' construction procedures--and allow them to dry or cure--before storing or installing 'dry' adsorbent materials.
    - Confirm that construction materials, such as concrete, are dry before they are covered with finish surfaces or enclosed in wall cavities.
    - Implement appropriate steps to control vermin during construction using Integrated Pest Management (IPM), which strictly minimizes the use and toxicity of chemical pesticides.
  - Manage Hazardous Materials. Identify hazardous waste by-products of construction (e.g. paints, solvents, oils, lubricants), and develop procedures for separating and for disposing of these wastes according to appropriate federal, state or local regulations.
- **Environmental and community considerations.** Prepare specification language that requires the CM or general contractor to prepare a construction site management and protection plan.
    - Mobilization:
      - Develop and implement plans to mitigate dust, smoke, odors, etc.
      - Institute noise control measures and procedures, including schedules for particularly disruptive, high-decibel operations.
      - Schedule construction to take maximum advantage of seasonal weather conditions.
    - Tree and vegetation protection.
    - Water management during construction:

  - Enforce protection and preservation of water sources during construction.
  - Enforce water conservation, and avoidance of unnecessary use of water during construction.
  - Consider water reuse strategies including the use of settling tanks for wash water and directing rainwater and/or filtered wash water toward landscaped areas for irrigation.
- Erosion control:
  - Use stormwater runoff and erosion control measures.
  - Consider strategies such as temporary and permanent seeding, mulching, earth dikes, silt fencing, sediment traps and sediment basin.
- Soil management:
  - Institute measures to salvage existing clean topsoil on site for reuse.
  - Expose only the smallest practical area of soil at any one time during development. Exposure should be kept to the shortest practical period of time. Temporary plantings should be used to stabilize exposed soil areas during construction.
  - Scarify soils prior to the addition of mulch to increase water retention capacity and soil permeability.
  - Identify on-site stockpile locations for topsoil after excavation. Cover it and reuse it for landscaping if it meets specification requirements.
- Plant management:
  - Schedule the installation of permanent vegetation immediately upon completion of improvements such as streets, storm sewers or other features of the development.

IX. COMMISSIONING

Commissioning activities transform many building systems into an integrated whole. During all tests and performance protocols, a dedicated commissioning authority oversees the building team to ensure that the systems have been well-designed, appropriately installed and functionally tested, and that the staff is trained to operate and maintain the facility in conformance with design intent.

A. Fundamental Systems Commissioning. Ensure that fundamental building elements and systems are designed, installed, and calibrated to operate as intended.

- **The project and design team shall verify that the requirements of each phase** of a project are enforced, to ensure that the fundamental systems commissioning goals are met.

B. Administer requirements of the construction observation phase. (Design Team, Commissioning Authority, Contractor, Construction Manager)

- **Finalize details of the commissioning procedures.** Confirm development of a detailed commissioning plan including any required static (one-time) or dynamic tests.
- **Review shop drawings and equipment submittals.**
- **Conduct periodic commissioning team meetings.**
- **Observe and document construction, installation, start-up, operation, testing and balancing and control testing and calibration.**
- **Provide a maintenance plan for HVAC equipment.** (Contractor, coordinated with Design Team, Commissioning Authority)

C. Administer requirements of the acceptance phase. (Commissioning Authority)

- **Verify conformance of building system performance** with design intent and basis of design. Verify that specified equipment efficiencies have been met.
- **Identify deficiencies** discovered during the commissioning process and make corrective recommendations.
- **Verify air and water flows** and, where in excess of design specifications, resheave fans or trim impellers as appropriate.
- **Assemble completed as-built records**, including electrical data; instruction manuals prepared by equipment manufacturers, fabricators or installers; and maintenance plan for HVAC equipment, for inclusion in Owner's Manual.
- **Prepare Systems & Energy Management Manual**, including detailed maintenance plan and information required for re-commissioning building systems.
- **Verify the accuracy and completeness of final testing**, adjusting and balancing reports.
- **Prepare Certificate of Readiness**, a document stating that all equipment, systems and controls have been correctly installed, operated as specified, tested,

adjusted and balanced and are verified as ready for Functional Performance Testing. (Provided by the Contractor/CM to the Commissioning Authority)

- **Perform Functional Performance Testing.**
- **Prepare Commissioning Report.**
- **Issue a Statement of Certification of Work.** Issue a written statement certifying that all work has been completed, tested and verified and that all equipment and systems are functional and operational in accordance with the complete contract documents, including (but not limited to) design intent documents, shop drawings, submittals, commissioning plan, commissioning specifications, all systems manuals, operation and maintenance manuals, functional performance testing and final commissioning report.
- **Review building operation with O&M staff**, including a plan for resolution of outstanding commissioning-related issues within one year after construction completion date. Also include a reassessment of occupied/unoccupied hours and temperature setpoints.
- **Conduct operations and maintenance-staff training.**