Colorado College Facility Life-Cycle Design Guidelines for Sustainability

A. Design Goals for Sustainability

The design team should follow the Colorado College Campus Master Plan guidelines and processes. The strategic program states that the college serves as a "model of environmental stewardship and innovation by advancing both the study and the practice of sustainability." The college strives to reflect innovation in the application and evolution of sustainability practices related both to the built environment and the management of College resources.

1. The President's signing of the American College and University President's Climate Commitment pledge in April 2009 included the goal of achieving carbon neutrality by 2020. Achieving carbon neutrality by 2020 requires a three strategy approach.
    a. The first strategy is to reduce building energy use by **20%** through conservation measures to include improved building systems scheduling, sustainability education and energy usage awareness, and encouraging behavioral changes throughout the college community.
    b. The second strategy is to reduce energy usage by **30%** through maintenance and renovation of building structures, electrical systems, mechanical systems to improve energy efficiency; and investment in technological improvements to reduce energy usage.
    c. The third strategy is to purchase or produce all electric energy through renewable energy sources and provide supplement heating through renewable energy technologies. The college plans to reduce its carbon footprint by **50%** through producing enough energy through renewable resources to offset the carbon footprint in other sectors such as the use of natural gas for heating and college related travel.

    Opportunities for achieving energy and water use reductions should be identified by design and engineering professionals in every construction or renovation project and considered for implementation based on life-cycle cost savings, impact on reaching carbon neutrality, and the importance of demonstrating social responsibility by supporting the college core values and taking a leadership role in nurturing the ethic of environmental sustainability.
2. The College's April 2009 signing of the President's Climate Commitment required initiation of tangible actions to reduce greenhouse gases. The College agreed to **"**establish a policy that all new campus construction will be built to at least the U.S. Green Building Council's LEED Silver standard or equivalent". **The College has established a High Performance Building Design Criteria program which exceeds the LEED Silver minimum prescribed requirements in order to meet its long range sustainability strategies for achieving carbon neutrality.**
3. New buildings, additions to existing buildings, or existing building renovations should minimize building life-cycle costs, direct and indirect, relating to energy use, maintenance, waste disposal and occupant health & productivity. Life-cycle costs should be based on a "whole-building perspective", rather than from the perspective of individual building systems or components.
4. Minimize environmental impacts throughout the building life-cycle, including product manufacturing, construction activity, use/occupancy, and demolition or renovation/reuse.
5. Purchasing of goods and services from manufacturers and vendors shall comply with the Colorado College Sustainable Purchasing Guidelines.
6. Optimize indoor environmental air quality.

B. Design Process

1. The Project Design Team is to evaluate sustainable design opportunities and strategies appropriate for project program, site and budget.

2. **Building performance design standards**: All new construction and renovation projects are to follow the Colorado College Facility Design Guidelines Manual, Colorado College Facility Design Guidelines , which contains expected **High Performance Building Design** requirements for new construction and renovations. The College's **High Performance Building Design Criteria** exceeding LEED prescriptive requirements, customized to meet Colorado College's sustainability goals, is to be used on all new building construction and existing building renovation projects over $1 million in cost**. The highest feasible facility energy use reduction goals will be attained based on each project's available funding, each building's optimum performance design potential, and each building infrastructure system's conditions, etc. Colorado College Facilities Services will provide the project design team with project specific high performance building design criteria to be used to develop the project design intent documentation**. The College has achieved Net-Zero Energy/Net-Zero Carbon buildings and strives to maintain that level of building design performance whenever appropriate. The following table highlights the **minimum** construction performance targets for Colorado College:

Performance Goal	Goal Quantification
Total Energy Use	20 KBTU/SF/YR or less
Water Use – Building	2.4 Gal/Building SF/YR or less
Water Use – Irrigation	14 Gal/Turf SF/YR or less
Total Building Power Factor	Not less than 0.95 lagging at the utility meter
Indoor Air Quality	700 PPM CO^2 or less during occupied hours
Artificial Lighting	0.30 W/SF or less
Lighting Levels	35 FC in classrooms

Note that the energy usage goal represents total building load including plug loads, not just HVAC and lighting. Predicted energy use shall be tracked during design using modeling and will be confirmed using utility billing data. Likewise the water usage goal represents both building use and irrigation.

3. Do not make project funding decisions based on first costs only. Evaluate life-cycle costs of design alternatives to reduce long term operating and maintenance costs of major building systems. **Life-cycle costs** should be based on a "**whole-building perspective**", rather than from the perspective of individual building systems or components.
4. Evaluate use of **renewable energy sources** for electric use or supplementing heating requirements to help reduce the carbon footprint and achieve the goal of carbon neutrality by 2020.
5. Use energy simulation/modeling software on projects greater than $1 million cost where feasible and within available funding resources.
6. Life-cycle cost saving strategies used should have **maximum payback period of 5-15 years**, or contribute significantly to the 30% reduction of energy use or carbon footprint goal by 2020.
7. Architectural/Engineering consultants are to include the above services in the Professional Services Agreement.
8. Architects and Engineers selected for the project should demonstrate proficiency and experience in sustainable design. Consultants with these qualifications should be included in the **earliest programming and conceptual design phases** to help identify and evaluate **high performance design** opportunities beyond the minimum LEED Silver certification feasibility, or feasibility of higher energy design standards attainability.

C. Design Guidelines

1. Energy Use
   a) Integrate Buildings with the Site: Consider local climate & site influences on building energy use. Utilize "free" energy sources where feasible, such as solar energy, daylight, exterior temperature variations and winds.

b) Optimize Energy Performance: Select building envelope, mechanical and electrical systems for improved energy efficiency. Where applicable, research products in order to meet Colorado Springs Utilities efficiency requirements for utility rebate savings. Typical strategies & technologies:
    1) Building Envelope
        - Control & utilization of solar heat gain
        - Daylighting of interior spaces
        - High performance windows/glazing
        - Energy efficient window coverings
        - Optimized insulation values
        - Reduced air infiltration
    2) Mechanical Systems
        - High efficiency equipment
        - Direct Digital Control System (DDC) for HVAC
        - Occupancy sensors/CO2 monitoring
        - Occupancy sensors
        - Heat recovery systems
        - Economizer cycle cooling
        - Zoning of HVAC system based on building orientations & loads
        - Variable speed drives on motors and fans
        - Low flow plumbing fixtures
        - Time of day scheduling
        - Separate controls for individual spaces, where feasible
    3) Electrical Systems
        - High efficiency lighting fixtures (no incandescent)
        - Occupancy sensors
        - Daylight sensors
        - Separate ambient and task lighting
        - Lighting dimmers
    4) Energy and Water Metering
        - Every building or energy and water using facility should have sub meters monitoring energy and water use. Where possible high energy or water consuming operations within buildings or facilities should be sub-metered locally to identify, monitor, and control energy and water use.
c) CFC/HCFC/Halon Reduction: Avoid use of these products in HVAC refrigerants and fire suppression systems.
d) Building Systems Commissioning
    1) All projects shall implement a Commissioning plan, with the scope to be determined by the project team.
    2) Key mechanical & electrical systems are to go through a Commissioning process, which includes the following:
        - Inspection & testing for functional performance in accordance with project objectives & the Colorado College Facility Design & Construction Guidelines.
        - Documentation of criteria, inspections/testing & acceptance.
        - Training of Colorado College operations & maintenance staff.

3. Water Use
    a) New low flow water devices are required for new construction by current building codes. Opportunities for achieving water-use reductions should be identified in the course of routine maintenance improvements and renovation projects. Older water faucets typically having flows of approximately 2.5 gpm and should be replaced with 1.5 gpm or .5 gpm flow devices depending on the applications. Older toilets have flush volumes of approximately 3.5 to 4.5 gpf and should be replaced with dual-flush toilets, or 1.6 gpf toilets, which tend to be equivalent to the dual-flush toilet flows on average.
4. Building Materials
    a) Recycled Content Materials: Use materials with post-consumer or post-industrial recycled content where feasible. Common products with recycled content include structural steel,

aluminum windows, gypsum board, acoustical ceiling tiles, rubber floor tiles, carpeting, and toilet partitions.

b) Durable & Flexible Materials: Utilize components and systems which are durable and easy to maintain. Where feasible, use materials which provide flexibility for future changes and modifications to occur.
c) Renewable Materials: Consider use of products that are comprised of raw materials that are in abundant supply or come from renewable sources. When feasible, obtain wood products from suppliers certified as utilizing sustainable harvesting methods.
d) Local Materials: Use products produced regionally where possible.
e) Construction Waste Management: Contractors are to develop a plan for sorting, storing & recycling of waste materials on projects. A waste minimization specification is to be used as guidance for this work. All projects shall implement a Construction Waste Minimization Plan, with the scope to be determined by the project team. A minimum of 50% of construction waste is to be salvaged, recycled or otherwise diverted from landfill or incineration.
f) Recycling Facilities: Plan for convenient areas to be designed in new buildings and building renovations for sorting & storage of recyclable items by the building occupants.

3. Indoor Environmental Quality
   a) Design for Human Health: Consider environmental needs of people in terms of daylight, ventilation, exterior views and thermal/acoustic/visual comfort for interior spaces. A direct line of sight to exterior vision glazing from 90% of all regularly occupied spaces is a long term goal.
   b) Ventilation Requirements: Optimize the amount of fresh air provided to building spaces. Connect occupancy sensors & carbon dioxide monitors to HVAC systems, where feasible.
   c) Low Emitting Materials: Utilize materials which have low levels of volatile organic compound off-gassing. Minimum requirements for 45% of materials (by cost):
      - Adhesives & sealants: VOC content less than established limits.
      - Paints & coatings: VOC emissions that do not exceed Green Seal's Standard GS-11.
      - Carpet: Comply with CRI Green Label Plus Testing program.
      - Carpet cushion: Comply with CRI Green Label Testing program.
      - Composite panels: No added urea formaldehyde resins.
   d) Construction Air Quality Management: Protect ductwork and equipment from contamination during construction. At a minimum:
      - During construction, comply with SMACNA IAQ Guideline for Occupied Buildings Under Construction, 1995, Chapter 3.
      - Protect stored on-site or installed absorptive materials from moisture damage.
      - If air handlers are used during construction, filtration media with a MERV value of 8 are to be used at each return grille, per ASHRAE 52.2-1999.
      - Replace all filtration media immediately prior to occupancy.
      - Conduct a 2 week building flush-out with new filtration media with 100% outside air after construction ends & prior to occupancy. After flush out, replace filtration media.

      or

      - Conduct a baseline indoor air quality testing procedure to demonstrate that concentration of air contaminants are below specified levels. Meet the testing requirements listed in LEED IEQ Credit 3.

4. Site Work
   a) Building Siting and Landscaping: Use the Colorado College Campus Master Plan design guidelines as a guide for design decisions.
   b) Minimize Site Disturbance: Consider the impact of project on the surrounding ecosystem. Investigate methods to minimize impacts on natural habitats and watersheds.
   c) Stormwater Management: Limit off site storm water runoff and employ methods to increase on-site infiltration.
   d) Alternative Transportation: Provide site facilities to encourage pedestrian, bicycle and bus transport, where feasible.
   e) Light Pollution Reduction: Minimize site lighting levels & off-site light spillover/ glare, while providing for adequate levels for security and way finding.

f) Water Efficient Landscaping: Utilize drought resistant plant materials and low flow irrigation techniques, where feasible. Consider use of native plant species.
g) Erosion & Sedimentation Control: Employ techniques such as silt fencing, sediment traps/filters, topsoil stockpiling and slope stabilization to minimize erosion of soil during construction. At a minimum, comply with EPA Document No. 832/R-92-005 (1992) Stormwater Management for Construction Activities, Chapter 3: Sedimentation & Erosion Control.

D. References

General

- US Green Building Council- LEED Green Building Rating System, www.usgbc.org.
- Colorado College Campus Master Plan
- Colorado College Facility Design Guidelines
- Colorado College Sustainable Purchasing Guidelines
- American College and University President's Climate Commitment
- CC Goal to Achieve Carbon Neutrality by 2020

Energy Use

- ASHRAE Standard 90.1-1999 Energy Standard for Buildings except Low Rise Residential Buildings US DOE/EPA Energy Star Guidelines.

Building Materials

- EPA Comprehensive Guide for Procurement of Products Containing Recovered Materials; Recovered Materials Advisory Notice III; Final rule (1/19/00) 40 CFR Part 247.
- Forest Stewardship Council Guidelines.
- Triangle J Council of Governments, "Waste Spec"- Model Specification for Construction Waste Reduction.
- Green Seal Paints and Coatings Requirements- Paints (GS-11), First Edition, 5/20/1993.
- Carpet and Rug Institute Green Label Indoor Air Quality Test Program.

Indoor Environmental Quality

- ASHRAE 62-1999: Ventilation for Acceptable Air Quality.
- ASHRAE Standard 55-1992, Addenda 1995- Thermal Environment Conditions for Human Occupancy, Including ANSI/ASHRAE Addendum 55a-1995.
- Sheet Metal & Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings Under Construction, 1995.

Site Work

- EPA Storm water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices.
- IESNA Recommended Practice Manual: Lighting for Exterior Environments (RP-33-99).

Colorado College
Facilities Services

Sustainable Operations & Maintenance Guidelines Manual

Principles and Guidelines for Sustainable Operations and Maintenance of Colorado College Buildings and Infrastructure

November 24, 2015

Purpose

The purpose of these sustainable operations and maintenance (O&M) guidelines is to provide the Facilities Services operations and maintenance shops with basic principles and guidance as a framework from which staff may develop and update their own enhanced O&M best management and sustainable practices over time.

These guidelines will provide Facilities Services staff with clear and consistent sustainable operations and maintenance principles intended to achieve high performing indoor and outdoor environments at the college as specified in the **Colorado College Facility High Performance Design Guidelines Manual, October 2014**.

According to the U.S. Green Building Council (USGBC) the built environment has a profound impact on our natural environment, economy, health, and productivity. In the United States alone, buildings account for:

- 72% of electricity consumption
- 39% of energy use
- 38% of all carbon dioxide (CO2) emissions
- 40% of raw materials use
- 30% of waste output (136 million tons annually)
- 14% of potable water consumption.

Implementation of sustainable building operations and maintenance practices directly impacts ongoing building costs and the internal occupant comfort and external building environment. **Successful campus-wide implementation of these O&M guidelines can therefore lead to substantial economic, social, and environmental benefits.**

Maintenance Practices & Approaches

Operations & Maintenance comprise the day-to-day activities necessary for built systems to perform their functions. O&M has developed into one term because a system cannot operate without being maintained. The enhanced guidelines in this document differ from typical O&M practices because of the underlying goals of sustainable practices mentioned above. **A shift from reactive to preventive maintenance focus has already happened in Facilities Services shops.**

Reactive Maintenance is sometimes referred to as breakdown maintenance or "replace on failure." ***It is not a desirable approach as it guarantees interruption of service.*** Equipment life may be significantly shortened due to the lack of regular maintenance, and costs end up higher in the long run.

Preventive Maintenance refers to ***performing regularly scheduled tasks and equipment replacements to avoid problems before they occur.*** Examples of preventive maintenance include replacing fan belts annually or replacing air conditioning units every ten years. It is possible that the replaced equipment could operate longer, but the odds of a failure and

the frequency of repairs increase as the equipment gets older. **Replacement decisions must balance with the operational risk of equipment failure and resource efficiency of utilizing a material or system beyond end of projected useful life.**

Predictive Maintenance relies on monitoring or testing to predict problems and deal with them before they become too big. Predictive maintenance tasks can include measuring vibration, temperatures, efficiency or other characteristics and comparing them to engineering limits. ***Equipment is repaired or replaced when results exceed limits.***

How to Use This Document

The intent of this document is to provide general guidance on O&M procedures applied in all college facilities, to achieve high performance and sustainable practices in the operations and maintenance of buildings and infrastructures. The guidelines herein are meant to work alongside, or to replace already existing practices. Facility staff can identify and select to implement any or all of the guidelines as they apply. Exactly how this document is to be used is up to the discretion of facility staff and depends on the effectiveness and sustainable impacts of practices and requirements already in place. There are references to frequencies of actions that may not be applicable or possible for certain buildings, facilities, or assets. Consider the frequency that is most appropriate for the conditions of such facilities.

This is a "working" document that will be updated over time. Future versions will likely include additional chapters, including minor remodel strategies.

Use the Table of Contents hyperlinks to jump directly to any of the Sections 1- 9.

Sustainable Operations & Maintenance Guidelines Manual

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Retro-Commissioning Guidelines

Retro-Commissioning Introduction

Improving building comfort and achieving energy savings in the college buildings begins with a process for identifying existing building energy performance. Retro-commissioning, also known as existing building commissioning, is a systematic investigation process for improving and optimizing a building‘s performance according to the owner‘s desired operating requirements. Retro-commissioning typically focuses on energy-using equipment such as lighting, HVAC, and building controls with the goal of identifying maintenance and operational changes to improve building comfort and energy savings. Retro-commissioning can increase the energy efficiency of buildings by 5-10% or more.

Depending on the project scope and owner‘s desired outcomes, retro-commissioning can include a range of actions from small scale efforts such as building scoping, equipment repair and tune-up activities to more comprehensive efforts which include functional testing of equipment and systems, analyzing test results, repairing equipment, replacing failed parts, adjusting equipment schedules and tuning operation, and re-testing equipment and systems to verify results.

The question of the scale of the effort and who should conduct retro-commissioning can be addressed once the objectives and budget have been established. Some facilities have in-house capability to successfully retro-commission their own equipment, while others will need the assistance of a service provider (e.g., mechanical contractor) or commissioning agent. Service providers have different approaches to improving energy performance.

Whether small or large, retro-commissioning activity is critical to ensuring energy efficient operation. If executed properly, it can result in:

- Substantial cost savings from extended equipment life;
- Increased occupant satisfaction through improved space comfort;
- Substantially better energy performance;
- Improved indoor air quality; and,
- Fewer O&M emergency calls.

A building investigation looks for opportunities to reduce energy waste in many ways, including:

- **Equipment Scheduling** – Equipment runs when it is not needed, including lighting that is on when it is not needed.
- **Sensor Error** – Erroneous sensor data causes increased heating, cooling, or equipment operation, which can affect occupant comfort.
- **Simultaneous Heating and Cooling** – The same air gets heated and cooled, or hot and cold air streams get mixed together to make warm air.

- **Outside Air Usage** – Economizer does not function optimally, or excessive outside air causes increased heating and/or mechanical cooling, and sometimes too little air compromises indoor air quality.
- **Air filtration –** Infrequent filter changes may result in fan energy demands to compensate for excess pressure that are more significant than the cost of changing the filters.

Retro-Commissioning Additional Guidelines

Establish **key performance indicators (KPI's) for the building equipment and systems** identified in the operation manual, or work order preventive maintenance system. Routinely track the indicators to ensure performance is being met.

Conduct annual occupant surveys to assess satisfaction with building energy performance. Suggested categories of inquiry, among others, could include thermal comfort, lighting, and air quality.

Conduct an investigation of the building's energy-using systems performance and energy-monitoring systems, such as:

- HVAC Equipment and Systems-Packaged Air Conditioning Systems: Fan coils and unit ventilator, VAVs, chilled water systems, hot water systems, air filters, ducts and economizers.
- Lighting equipment and systems: Lamps, luminaries, exit and emergency lighting and controls including occupancy and motion sensors, timers, time clocks and day lighting controls.
- Controls Equipment and systems: Building energy management control system (BMS), individual building management control systems and all of their components.
- Conduct a building scoping walk-though to identify maintenance and operational improvement opportunities, including related landscape management and irrigation, waste collection and management, and air quality conditions. Prepare a scoping report that identifies needed repairs, basic maintenance problems and operations improvements such as scheduling and optimization.

Landscapes

Landscaping O&M Plan

The first influential step toward green landscaping is creating a green landscaping O&M plan. A green landscaping O&M plan helps to fully realize the intended state of a building's landscaping while also protecting the local and regional ecosystem and human health. Landscaping should be maintained to maximize the health of plants and people, while also reducing impacts on the planet and budget. Additionally, a well-executed O&M plan will improve the beauty and life of the plantings. **The ultimate goal in developing this plan is to create an effective maintenance program that keeps plants healthy while reducing needed resources.**

Prepare or update the landscape O&M plan of our facility. Include strategies to reduce the need for pesticides, fertilizers, water, and maintenance, and to preserve natural resources. The plan should cover all aspects of grounds maintenance including plant care, turf management, irrigation, integrated pest management (IPM), and hardscapes. The plan should include the following sections:

- Landscaping maintenance goals
- Responsibilities
- Landscape documentation
- Maintenance task list and schedule
- Evaluation task list and schedule
- Recordkeeping process
- Maintenance system audit

Implement plan in conjunction with staff training and goal-setting.

General Landscaping O&M Guidelines

The goal of routine maintenance in **natural areas** is to protect, conserve and enhance native plants, water quality, soil, sensitive areas, and wildlife (including fish). The goal of design and routine maintenance in **formal landscapes** is to promote the health, safety, and longevity of landscapes that enhance the aesthetic beauty of college facilities with a minimum of resources used.

General Landscape Operation and Maintenance Guidelines include:

- Increase the use of native plants, increase irrigation efficiency to reduce water use, give better plant care in order to reduce pests and diseases and thereby minimize pesticide use.
- Follow the best management practices (BMP) related to IPM, turf placement and maintenance, species selection and care, irrigation systems and schedules, and maintenance guidelines.
- Identify and assess the components and layout of the landscape, assess the geographic location and microclimates, inventory the plants, and identify soil types.

Integrated Pest Management (IPM)

Action Thresholds:

- Pests – the recommended insects per square foot, or per plant, will be used to establish the need for treatment.
- Monitoring – monitor for pests, disease and general health on a regular basis.
- Prevention – proper and frequent inspections are needed for the overall health of the plant.
- Control – proper cultural practices are used as well as disease resistant landscape material, biological controls and the use of the least toxic yet most effective material.
- Environmental conditions - moisture, temperature, wind speed and other related conditions will be considered before a decision is made to determine the best course of action.

Well-chosen plants and a well maintained landscape dramatically reduce the need for pest control. Appropriate selection of plants, irrigation, application of mulch and/or fertilizer, mowing and other practices all help landscapes withstand pest pressures and support natural predators.

Training of staff how to identify pests and work with an IPM Program is recommended. All staff associated with the design, construction and maintenance of the grounds, landscaped building, facilities, and other areas where pests must be controlled, or vegetation managed, receive an orientation/training to the IPM policy and its guidelines.

Use pesticides only as a last resort. When they are used, select the least-toxic product. Collect and maintain pest management records. Include date, specific location, name, reference used for identification, corroborating expert (as needed), stage of lifecycle, extent of pest presence and other pertinent information. Include any control methods implemented, details about pesticide application and on-going monitoring.

Native and Drought-Tolerant Plants vs. Invasive Plants

The key to reducing maintenance needs is to choose the proper plant for the site. Select native plants and/or drought-tolerant plants that have proven their toughness and ability to thrive with minimal care.

Preferably, do not plant any species listed as noxious weeds on college properties.

Select plants on the basis of their function and adaptability to the site, resistance to diseases and pests and the amount of care required.

Integrate native and/or drought tolerant plants into existing landscapes as appropriate for the area and landscape design.

Determine if noxious or invasive species should be removed from the site.

Turf

Turf areas vary widely in grass type and function from highly maintained athletic fields to courtyards and each type of turf requires distinct maintenance.

Manage turf pests, including weeds, through good practices.

Do not seed turf grass within one foot of a fence line or structure. Replacing turf with a properly installed gravel/concrete strip or equivalent minimizes landscaping maintenance by simplifying the mowing process. Avoid using pesticides and opt for manual removing any weeds from this strip.

Determine and follow best practices in the O&M plan for turf mowing, edging, and fertilizing, reseeding, irrigation and, based on use, top dressing, dethatching and aerification.

Trees

Selecting healthy trees, planting them in appropriate sites, and nurturing them when young will prolong their life and reduce the maintenance needed to keep them safe and healthy for humans to enjoy.

Review landscape designs to insure that the selected trees are **properly sited**, and can achieve the design goal with minimum care, before the design is approved.

Promote training of tree care specialists with proper training and/or certification.

Tree management priorities should emerge from the maintaining a college tree inventory and providing regular monitoring of trees on the inventory.

Maintenance schedules and procedures shall be based upon **priorities** established in the landscape O&M plan for the college.

Plant Beds

Plant beds are generally designed as focal points or visual frames in more formal areas around the buildings. As such, plant beds require a high level of maintenance and can include both native and ornamental species. These beds may contain trees, woody shrubs, and herbaceous perennials that die down in the winter. Maintenance should focus on ensuring the right plant is the right place and enhancing existing soils by mulching for

water retention and weed control. Actual maintenance given to a plant bed will vary depending on location, type of site, design goals, and species.

Shrub bed designs should be reviewed by a staff horticultural professional familiar with the site, soils, and species selected before the designs are approved. The goal is to install a shrub bed that can achieve the design goal with a minimum of care.

Irrigation

Drought resistant landscaping should be utilized as much as possible: However, inevitably some landscaping will require irrigation. A wide variety of college properties use automatic irrigation systems to maintain their turf, shrub beds, annuals and plantings. **The goal of landscape management must be to provide suitable water to plants, but not enough to provide runoff and waste.**

The irrigation system is a management tool and cannot replace the sound judgment of trained professionals. The best designed irrigation system will fail without regular maintenance.

Update and retrofit existing irrigation systems and equipment to take advantage of new water saving technology, such as rain shut off devices and drip irrigation.

In order to conserve potable water, continue to move toward using reclaimed non-potable water to operate irrigation systems where feasible.

Report irrigation leaks and shut off the water as soon as possible to prevent water waste. Make repairs as soon as feasible to maintain plant health.

Include the following features with irrigation controller and systems:

- Use a flow sensor to monitor how much water is being used.
- Use a rain sensor to shut off the controller due to rain.
- Use moisture sensors to determine amount of water application needed.
- Use a remote hand controller as a tool for sprinkler head and maintenance inspections.
- Use a central control irrigation controller and insure the maintenance staffs are properly trained in its use.

Periodically verify that plant material is healthy and that the soil moisture is adequate. Use a soil probe to visually inspect root depth, soil structure and moisture.

During the dry season, water deeply but infrequently. Do not exceed one inch per week (including rainfall).

Perform regular inspections to optimize irrigation equipment.

Equipment maintenance should be performed on a weekly basis, which includes checking equipment for damage, leaks, or needed adjustments; and then performing the adjustments or repairs as necessary.

Prioritize future irrigation system improvements by maintaining a record of repairs that are required.

Sub-meter landscape areas, if possible, for water budgeting purposes and leak detection.

Adjust water pressure as needed. Set water pressure to minimize wind effects. Make sure supply and pressure meet design specifications.

Bio-Swales/Rain Gardens

Rain gardens are shallow depressions that can hold and soak up water runoff from roof tops, driveways, patios and other impervious surfaces. Rain gardens have deep, compost amended, high infiltration rate soils and are landscaped with native or adapted plants. By holding and naturally infiltrating runoff, rain gardens filter oil and grease from driveways, pesticides and fertilizers from lawns as well as other pollutants before they reach the storm drain and eventually streams, wetlands, lake and other marine waters.

- Mulch as much as needed to prevent erosion and weeds.
- Regularly inspect and keep water runoff inlets and outlets well protected with rock and clear of debris.
- Water as needed until native or adapted plants are well established.

Hardscapes

Hardscapes O&M Plan

Hardscape describes the non-living parts of the landscape, such as pavement, walls, fences, pavers, decks, flat roofs, and driveways. Hardscapes provide some of the most visible utilitarian areas on facility sites. However, they also contribute to increased storm water flows and sediment/contaminant loads, and can promote heat island effects unless they have a high Solar Reflectance Index (SRI). Minimizing the amount of impervious hardscape can improve local hydrologic cycling.

Proper hardscape use and care can minimize their negative impacts, and keeping them clean and well maintained is important for safety and aesthetics. Hardscape maintenance includes garbage and recycling, graffiti removal, cleaning, repairs, and sealing.

- Include hardscape maintenance in the landscape O&M plan that includes routine maintenance, cleaning, sealing, inspections, graffiti removal, trash and recycling.
- Avoid graffiti removal systems that contain phosphates, chlorinated hydrocarbons, xylene or other products known to cause health or disposal problems. Rather, use products that are biodegradable and meet EPA standards for VOCs.
- Conduct daily inspections of hardscape for hazardous materials and waste pickup.
- Schedule routine cleaning.
- Conduct daily inspections for graffiti and immediately submit request for removal.
- Inspect landscape irrigation systems frequently to reduce water runoff and prevent hardscape damage.
- Minimize the use of potable water to clean hardscapes.
- Install recycling receptacles adjacent to exterior trash receptacles to encourage recycling. Dispose of trash and recycling on a regular basis.
- Minimize the use of blacktop and dark-colored hardscapes.
- For new work, specify a high Solar Reflectance Index concrete when possible.

Snow and Ice Removal – Inclement Weather

All Facilities Services essential personnel will be involved in snow and ice removal. Mechanical and hand equipment will be used to clear roads, sidewalks, ADA ramps and parking lots in order to reduce the need for deicers. Our goal is to have clear access to all buildings and events while campus remains open. If deicers are used, only the most non-toxic/corrosive and minimum amounts are to be used. Apply deicers carefully to adequately remove ice, while avoiding excess over-application onto adjacent landscape areas, or onto building materials such as wooden doors and exterior walls.

Building Envelope

Introduction

The building envelope separates the conditioned inside occupied space from the outside natural space (or from unconditioned spaces). From an energy standpoint, mechanical systems only exist because of deficiencies in the envelope. The degree to which heat, water (liquid or vapor), and air can transfer between the inside and outside dictates the amount of energy inputs required by mechanical equipment. Minimizing the use and maintenance of HVAC equipment is therefore directly related to the quality and upkeep of the envelope. Ideally, the envelope has been properly designed and built, but this opportunity rarely exists in reality. Therefore, **proper maintenance and potential retrofits are critical to optimizing the building envelope.**

Maintaining the building envelope is essential to ensuring continued energy efficiency, indoor air quality, and occupant comfort. A proper inspection program is an important aspect of maintenance and can help identify problems before they impact energy use and occupants' health. Effective building O&M requires regular inspections, cleaning, and early detection of problems such as water penetration, air infiltration, structural damage, or insect infestation, all of which should be addressed in the building envelope O&M Plan. The building envelope O&M Plan should include provisions for regular building inspections, and prescribe the frequency of inspection for each building component. Cleaning practices for the building exterior and site maintenance duties should also be identified. The plan should include procedures for reporting problems, tracking the resolution of problems when they occur, and achieving goals identified by Facilities Services trades shops staff.

Wall Maintenance

Identify and schedule regular inspections and maintenance for each exterior wall type. Create an annual schedule that includes inspection, caulking, painting touchup, tuck-pointing open mortar joints, and cleaning/refinishing vertical wall surfaces. Ensure that the ground slopes away from building foundation and water drains away from the foundation.

Roof Maintenance

Identify and schedule regular inspections and maintenance based on roofing type and weather conditions. If necessary utilize an outside qualified contractor to check for leaks or damage through advanced technology inspection techniques.

Perform both preventive and regular maintenance on all building roofs to ensure the reliability of the roof, the durability of the structure, and the efficient use of heating and cooling.

Keep a record of all roof work completed as well as an inspection checklist report.

The checklist should include and address the following inspection items: worn spots, holes, deteriorated sections, adequate drainage, flashings, fasteners, cracking or weather aging of sealants, open joints, penetrations, and exhaust flashings.

Roof & Gutter Cleaning

Cool roofs should be cleaned at least once a year with a medium pressure spray and following the manufactures recommendations. Clean all debris from the surface of the roof including anything gathered behind HVAC units, under PV Solar installations, at pipes and pitch pans and any other roof penetrations. Inspect, clean, & repair gutters and downspouts twice annually in the fall and spring. Debris has tendency to hold water, and water will expedite roof and gutter deterioration especially if the roof is asphalt based such as built-up plies, or asphalt shingles.

Roof Retro-fit Opportunities

If the existing roofing is determined to be beyond repair, or it is not economically feasible to continue maintenance activity, the roofing will need to be replaced.

TPO/PVC single ply roofing is a popular and low first-cost choice for re-roofing depending on the type of building and equipment to be worked around, however, **a four-ply built-up asphalt roof system may have lower life-cycle cost, better durability, and better reliability; especially for mounting solar systems.** Cool roofs are recommended for low-sloped roofs. Cool roofs will not only lower cooling loads, but will also reduce thermal stresses due to daily temperature cycles. **Roof retro-fits provide an opportunity to add considerable R- value to the roof, which can drastically reduce energy use in all seasons.** Consider the energy benefits when designing and specifying roof retro-fits.

Windows and Doors

Windows provide views to the outside, daylight to the inside, and fresh air if they are operable; however, they can also act as big holes in the envelope and contribute to significant air infiltration, heat loss, and moisture flows. **It is critical to ensure that windows are functioning optimally and that related problems are minimized through proper maintenance.** Windows should be checked for air-tightness. Condensation within the airspace of dual-pane windows is indicative of a failed seal. Condensation on the interior face of windows is typically the result of extreme temperature differential between the inside and outside and sometimes an indication of excess humidity inside (though not always). Reports of drafts also may be an indication of a problem.

Schedule annual inspections of all existing windows and doors and identify conditions and maintenance needs for each window and door.

Cleaning and maintenance should include the following:

- Clean with environmentally preferable cleaning products.
- Keep sill and track areas clean and fee of dirt and other debris.
- Keep weep holes clear.
- Clean frame surfaces avoiding petroleum based cleaner and solvents.
- Check for air infiltration through the doors and windows.
- Make sure corners of mechanically joined frames are caulked to prevent water penetration.
- Check weather stripping around doors and windows and replace as needed.

Window and Door Retro-fit Opportunities

Window replacement with double-paned windows and low-e coatings will lower both the cooling and heating costs and should be evaluated as part of building renovations. New windows provide better weatherization and energy savings for the facility. Consider opportunities for improving the envelope through use of energy efficient glazing, exterior door replacements, and increased wall and roof insulation values.

HVAC Systems and Indoor Air Quality

Introduction

Heating, ventilating and air conditioning (HVAC) systems account for approximately 39% of the energy used in commercial buildings in the United States. Significant energy savings can be realized by improving control of the HVAC operations and improving the efficiency of the individual system components. Improvement in controls can also remedy indoor air quality concerns. Achieving the best results in energy efficiency, system effectiveness, and indoor air quality demands an integrated systems design approach that considers interactions between all building systems.

Colorado College Facility High Performance Design Guidelines Manual, October 2014 goals include a net reduction in the energy intensity (KBTU per square foot) in campus buildings. These goals should drive both development of new operations and maintenance plans, and the updating of existing operation and maintenance plans for all college facilities.

The challenge is to optimize the balance between occupant comfort and productivity with energy savings; two forces that occasionally are in direct conflict with each other. It is important to remember that most buildings exist solely to enable humans to complete tasks. The financial benefits of improvements in productivity can sometimes far outweigh the incremental costs of workspace HVAC improvements and retrofits. **The O&M staff is tasked with finding the precious balance between optimizing HVAC systems to conserve energy, and to provide education and buy-in for the building occupants.**

Indoor Air Quality

HVAC O&M staff can influence indoor air quality (IAQ) in several ways, but their most important task is ensuring proper ventilation. Proper ventilation consists of a continuous supply of outside air at a rate that varies based on the space type and occupancy conditions. IAQ is a constantly changing interaction of a complex set of factors. The indoor environment in any building results from the interaction between the site, climate, building system, construction techniques, contaminate sources, and building occupants. The following elements may contribute to indoor air quality problems. All must be considered to prevent, investigate, and resolve indoor air quality problems:

- **Source:** a source of contamination causing discomfort could be indoors, coming from outdoors, or found within the mechanical systems of the building.
- **Pathways:** one or more pollutant pathways could connect the pollutant source to the occupants, and a driving force could exist to move pollutants along the pathway(s).
- **Occupants:** building occupants which are present.

Optimizing the ventilation can be equally challenging with regard to providing for human productivity and comfort, and managing energy use. Energy systems operation and effects on occupants should be closely monitored.

The guidelines provided should help facilities O&M staff develop a combination of building O&M practices and schedules that best serve occupant needs and productivity, reduce energy consumption and environmental impacts, and maintain good IAQ.

HVAC O&M Plan

HVAC operation and maintenance practices vary depending on the type of equipment, building types, and the existing building envelope conditions, as well as building location, size, use pattern, and purpose. **A building specific O&M plan helps to fully realize the intended reliable, effective, and efficient and healthy operational state of a building's HVAC system, as well as lengthen the system's useful life**.

The Facilities Services HVAC O&M plan for college buildings addresses the following topics:

- **Include and clearly state the critical goals of operating and maintaining indoor air quality, comfort, and energy efficiency in the building O&M plan. Set up the operating parameters and maintenance tasks with these goals in mind.**
- HVAC maintenance goals. Provide training in energy-efficient and indoor air quality O&M strategies.
- Setting and maintaining building performance goals on both a daily and ongoing basis.
- Communicate responsibilities of O&M staff. Provide the training or skill set involved with each task to best equip the responsible staff.
- System condition, useful life expectation, and performance documentation **(Update VFA Capital Planning Program records annually)**.
- HVAC O&M task list, schedule, and evaluation criteria **(TMA PM Program Updates)**.
- Performance measurement so that the building can be benchmarked against previous performance and compared other similar buildings (Energy Management KPI's).
- **Assess changing occupant needs and system adjustments** (in concert with lighting, electrical, telecommunications, safety, housekeeping, and building automation control systems).
- Repairs, upgrades, and re-commissioning of building systems.
- Preventing disruptive failures in the building and its systems.

HVAC O&M Goals

One goal is compliance with regulations. Another maintenance goal is making sure that the HVAC system does not become a source of indoor air contaminants. Inspection and periodic cleaning of the system, as well as the environments around outside air intakes, are important tasks to avoid potential problems. Conditions to avoid include: standing water and idling vehicles around outside air intakes and entryways.

Include and clearly state the critical goals of operating and maintaining **indoor air quality**, **comfort,** and **energy efficiency** in the O&M plan. Set up the operating parameters and maintenance tasks with these goals in mind.

Communicate the goals to all maintenance staff to provide them with guidance for their day-to-day maintenance decisions.

HVAC Develop O&M System Components Maintenance Task List and Schedule (Preventive Maintenance)

Conduct a building O&M-focused preliminary energy audit and site assessment. Prioritize operation and maintenance tasks and adjust schedules to fit available staff time. When setting priorities, keep in mind the **goals of indoor air quality, comfort, and energy efficiency** to make sure they are not overlooked. Then create a list with specific maintenance tasks for the following system components, and indicate how often they need to be carried out:

- Air delivery systems
- Outside air delivery
- Ducts
- Hydronics
- Controls

The type of information to be included for each PM maintenance task includes:

- Task description
- Detailed instruction or reference to location of instructions
- Appropriate corrective action for typical problems (clean lubricate, replace, adjust, tighten, program, schedule
- Tools required
- Notes about why the task is important or how it helps meet the goals
- Location of related system documentation
- Shutdown/start up issues
- A description of what, where, and how the records resulting from the task will be stored **(TMA PM Program Updates)**.

HVAC System Components Condition Evaluation Task List and Schedule

- Investigate opportunities for automatic controls.
- Develop a space use-based operations schedule in the BMS control system. **Automate system operations with control sensors located in spaces where feasible.**
- In addition to regular inspection, include performance monitoring and system testing in the HVAC O&M plan, to ensure that the HVAC systems are meeting the performance goals. This part of the plan should include the following performance characteristics:

    - Air quality
    - Thermal comfort
    - Energy efficiency
    - Noise

HVAC Systems Components O&M Audit Approach

Include an audit process to periodically review how well the HVAC O & M Plan is working. Stay current on routine maintenance practices.

The audit should include the following:

- Completeness of procedures and checklists
- Ensure availability of procedures and checklists for the O & M staff.
- Provide adequate training for O&M staff.

Additional Factors: Uncontrolled Appliances or Special Individual Needs of Occupants

Additional factors can impact HVAC performance in buildings, such as devices brought in by building occupants and fluctuating building conditions during the day. Occupant devices range from desk lamps, electric fans, and space heaters, to other devices. At best, these devices help provide occupants with the additional environmental controls that modern buildings have taken away. At worst, they are a nuisance, if not a fire hazard.

Address ways of dealing with devices brought by employees/staff/students in the plan. External factors would include:

- Conduct periodic building surveys to identify heating or cooling devices brought by building occupants, which may indicate the occupants have additional heating or cooling needs.
- Develop a sustainable program to identify individual devices that work and are energy efficient.
- Set sustainable guidelines for employees regarding personal plug-in devices.

- **Use the TMA work order system to identify, track and monitor devices used by occupants; and to track any special individual needs of occupants beyond the normally provided building environmental controls and systems.**

Additional HVAC Systems Guidelines for Balancing Sustainability & Occupant Comfort

General Guidelines for HVAC Systems includes:

- When possible, provide temperature for zones/spaces according to their function to reduce HVAC loads (e.g., hallway can be cooler in the winter and warmer in the summer than office areas).
- Allow occupants to self-regulate temperature within a predetermined range through better access to vents and thermostats when feasible.
- Install blinds, window shades, and other devices to control HVAC loads in areas with load factors not controllable through in the HVAC controls (e.g., leaky windows, heat gain in east, south, and west facing offices, poorly insulated walls).
- **Look for low cost or no cost system modifications, such as changing operation procedures or automating system settings.** An example of this is the practice called “night-flush” where maximum cool outside air is brought into buildings late at night and early morning in hot seasons, to pre-cool buildings and maximize fresh air, when it is energy efficient and comfortable to do so.

The following sections highlight example types of HVAC systems and associated guidelines that should form a basis for customizing O&M manuals for each facility.

Air Delivery Systems

Packaged Air Conditioning Systems

Replacement of packaged air conditioning units is not usually cost effective based on energy efficiency alone. When units are to be replaced at or near end-of-life, it is important to seal and insulate ducts and check for airflow constrictions. It is also critical to perform cooling load calculations to check whether a smaller capacity is appropriate as is might cost less and perform better.

Packaged air conditioning systems are exposed to outdoor elements and require regular maintenance to ensure efficient operation and reliability. Regular maintenance to this equipment would include the following: replace air filters, inspect and test economizer dampers, check fan, belts, and bearings, check coils and condensate drain pan, control settings, compressor maintenance, cabinet and ductwork for air leaks, inspect piping insulation, inspect electrical connections, measure supply air flow if needed. Refer to the manufactures recommendations for each piece of equipment and modify the maintenance tasks as necessary.

Fan Coils and Unit Ventilators

These units consist of a fan and one or two coils. In some cases a single coil is used for both cooling (with chilled water) and heating (with hot water). In other cases the unit has two coils, one for cooling and the other for heating. These units also include filters and may have outside air economizers.

- Confirm appropriate set points and control points.
- Implement supply air pressure reset controls to save fan energy.
- Reduce the supply fan minimum speed set point. Often this is set higher than necessary due to the default setting of the variable speed drive.
- Analyze space use to determine best setting or strategy for conditioning (i.e., shade glazing to reduce loads on unit).
- Maintenance of fan coils and unit ventilators (notably filter changing and cleaning) is similar to Package Air Conditioning systems.

Variable Air Volume Systems

Variable Air Volume (VAV) systems serve multiple zones with a single air handler. The amount of air supplied to each zone is controlled by a damper within a terminal unit (VAV box). These dampers, one for each zone, vary the airflow to maintain the space temperature set point. The supply air temperature leaving the air handler is held relatively constant, but is usually varied within a limited range ("reset") either automatically or manually depending on the amount of cooling required. Each VAV box usually has a minimum damper position or minimum airflow rate (if the box contains an airflow sensor) that ensures adequate ventilation is provided to each space. If a zone requires heating or has low cooling loads, then too much cooling may occur at the minimum airflow rate. Therefore, many VAV boxes include reheat coils, either hot water or electric, that increases the temperature of the air supplied to the zone to prevent overcooling.

As cooling loads drop and the VAV box dampers close, the total supply air flow through the central fan also drops. Without any controls, the pressure within the supply ducts would increase. To save energy, the central fan is usually controlled with a variable speed drive or inlet guide vanes to maintain a constant pressure within the supply duct. Therefore, as the VAV boxes close down, the central fan speed will drop or the inlet guide vanes will begin to close.

VAV systems typically have either a chilled water coil or a refrigerant coil to provide cooling. Heating may be from a hot water coil or a gas furnace, or in many applications, electric resistance heating may be applied at the VAV box (called terminal reheat). The appropriate list of maintenance tasks varies depending on the type of cooling and heating and on the type of control system. Older systems often have pneumatic controls, which use the pressure in compressed air lines to control dampers and valves. Newer systems typically have direct digital control (DDC) systems that use electrical connections between sensors and actuators and a digital controller. Dampers and valves are moved by electric motors.

Control measures for VAV systems typically include the following:

- Reduce minimum airflow settings for VAV boxes to the minimum required for ventilation.
- Retrofit pneumatic VAV box controls with a DDC system including zone temperature sensors and electric damper actuators.
- Implement supply and pressure reset controls to save fan energy.
- Identify “rogue” zones that have either excessive cooling loads, undersized VAV boxes or other control problems that prevent the system from resetting either the supply air temperature or supply air pressure. These zones may not be meeting their temperature set points, requiring the supply air temperature to remain low, even though all of the other zones could be satisfied with a higher supply air temperature.
- Malfunctioning VAV boxes can result in thermal discomfort and fail to prevent buildup of indoor air contaminants. It is important to insure that VAV box minimum settings (e.g., 30% of peak flow) combined with the outdoor air fraction provides enough supply air so that sufficient outdoor air enters the space at partial loads.
- Maintenance tasks should include those listed for Packaged A /C systems as well as:

    - Determine the appropriate control sequences: and,
    - Verify VAV box operation, fan start/stop controls, supply air static pressure control, supply air temperature control.

Outside Air Delivery

Filters

An integrated indoor air quality approach includes outdoor air ventilation, pollutant source control, and air filtration. Filtration's first priority is to protect the HVAC system, keeping the fan, coils and ducts clean. Clean components perform better and are less likely to harbor mold or bacteria growth. **Additionally, HVAC air filters reduce concentrations of particles in indoor air. Standard low-cost filters provide little benefit in this regard.**
There are two commonly used filter performance ratings: **dust spot (or particle-size) efficiency** and **MERV (minimum efficiency reporting value**). These ratings indicate the amount of particulate removed from the air stream. A higher efficiency filter removes more material. The dust spot efficiency is more common because it has been around longer, but the MERV rating provides a better indication of performance. See ASHRAE Standard 52.2-2008 for details on dust spot (particle-size) efficiency and MERV ratings.

Several types of air filters are used in HVAC systems, including flat panels, pleated panels and bag filters. **Bag filters** are used only in larger air handlers with adequate space. Therefore, pleated panels are the appropriate choice for most air handlers. **Pleated panel filters** usually provide better filtration with lower air pressure loss compared **to flat panel filters**, because of increased surface area.

Other less commonly used products include electronic polarization filters and electrostatic filters. The **electronic polarization filters** create a high voltage electrical field to statically charge the particles, which then are more likely to collect on the filter medium. **Electrostatic filters** (also called electrostatic precipitators) charge the particles as they pass through and collect them on metal plates. Both of these types of filters require a small amount of electric energy. Both are also more efficient at removing particles when new, and their performance degrades over time. This is in contrast to a standard filter, which tends to filter more particles as it gets loaded (sometimes with adverse energy impacts). However, the electronic polarization and electrostatic filters typically create less pressure loss and may require less fan energy.

- **Select filters that provide up to 85% or MERV 13 efficiencies if the system is compatible.** Check with the equipment manufactures or HVAC designers to determine the proper filter system to maximize for filtration and energy efficiency.
- Inspect and replace filter regularly, as described in the maintenance recommendations for specific systems used. **Generally, a change of filters should be from 2 to 4 times a year.**
- **Select and use pleated panel filters whenever possible.**
- **Make sure that filters are properly fitted to prevent air from bypassing the filter and check filter seals.**

Economizers

An economizer is a set of automatically controlled dampers that can open to draw 100% outside air when conditions are favorable for free cooling. Otherwise, when the outdoor air temperature is higher than indoors or when outdoor air is very cold, the outside air damper closes to a minimum position (for ventilation) and the return air damper opens up.

Colorado‘s climate is ideal for economizers. It's often cool enough outside for an economizer to be used frequently. The savings from this "free cooling" can be big. Some HVAC systems enable this function very easily. **Even when adding more equipment and controls, an economizer can pay for itself in two to five years.** They usually do require maintenance to work over the long term. An outside air economizer can be part of any air handler, from small packaged air conditioners to the largest VAV systems.

- Determine the type of economizer in use and verify proper operation, inspection, cleaning and lubrication of economizer.
- Perform periodic testing of economizer operation and make adjustments or repairs as needed.
- Regularly inspect, clean, and lubricate the systems.

Duct Work

Sealed duct systems with a leakage rate of less than 3% will usually have a superior life cycle cost analysis and reduce problems associated with leaky ductwork. Duct leakage can cause or exacerbate air quality problems and waste energy. Common leakage problems include:

- Loose fitting joints.
- Leaks around light Troffer-type diffusers at the diffuser light fixture interface, when installed in the return plenum.
- Leaks in return ducts in unconditioned spaces or underground can draw contaminants from these spaces into the supply air system.

A small amount of dust on duct surfaces is normal. Parts of the duct system susceptible to contamination include areas with restricted airflow, duct lining, or areas of moisture or condensation. Problems with leakage and biological pollutants can be prevented through proper installation and ongoing maintenance inspections.

- Isolate HVAC during construction or remodeling of specific areas. Enclose work area and tape over or seal all return diffusers within area. Change air filters after completion of work.
- Ensure each section is pressure balanced to ensure adequate flow.
- Provide flush out period after installing new flooring or painting.
- Check the spread and throw of diffusers to ensure effective air mixing at point of use, and ensure comfort of occupants that are located near diffusers.
- Periodically perform a complete duct inspection. Identify if ducts need sealing and whether cleaning is required.
- Minimize dust and dirt build-up (especially during construction or renovation).
- Promptly repair leaks and water damage to keep system components dry (that should be dry).
- Routinely clean system components such as coils and drip pans.

Chilled Water Systems

- Replace standard efficiency with premium efficiency motors for pumps with long run hours.
- Wherever practical, replace single-pass water cooling schemes in chiller systems with other methods of heat rejection – they are very wasteful of water and energy, and are accordingly also expensive to operate.
- Implement condenser water reset strategies to allow the water temperature to drop when this can result in efficiency gains: check with manufacturer to ensure the chiller can operate properly at lower temperature.
- Trim the pump impeller rather than using a balancing valve to reduce flow in constant pump speed applications; this may reduce pump power significantly.

- Replace 3-way valves with 2-way valves on cooling coils and implement variable flow control on the chilled water loop.
- Install variable speed fan controls on cooling tower to reduce fan energy consumption.
- Implement a performance monitoring system to verify that controls are operating properly and to track chilled water plant efficiency.
- Review chiller sequencing controls for plants with more than one chiller to determine the optimal strategy for efficiency.
- Address operations and maintenance tasks for chillers, cooling towers, pumps, chilled water piping, and valves in the HVAC O&M Plan.
- Typical maintenance tasks for chilled water systems should include:

    - Chiller maintenance
    - Cooling tower maintenance
    - Pump maintenance
    - Piping maintenance
    - Air release valve and strainer maintenance
    - Set up performance monitoring
    - Refer to manufacturers' recommendations for equipment maintenance tasks.
    - Consider adding a condenser water conductivity controller for bleed-off water. In some systems, this controller can save enough water for a 1-year payback.

Hot Water Systems

Possible approaches to increase boiler/exchanger efficiency include:

- **Reduce "on" time** – enable seasonal shut-down, if possible;
- **Reduce load** – eliminate unnecessary loads from the system;
- **Just meet loads** – lower steam pressure or water temperature to meet the actual load conditions.

Increase boiler efficiency by reducing load (eliminate unnecessary loads from system); and just meet loads (lower steam pressure or water temperature to meet actual load conditions).

Replace standard efficiency with premium efficiency motors for pumps with long run hours.

Perform boiler tune ups once per year using combustion efficiency and emissions monitoring equipment.

Replace three-way valves with two-way valves on cooling coils and implement variable flow control on the hot water loop.

Pressure or temperature settings should be set no higher than required to avoid short cycling, or rapid on-and-off of the equipment. The system should be balanced to avoid this. When adjusting fuel/air ratios, check efficiencies and monitor stack temperatures.

Automate oxygen trim to operate with boiler controls.

Identify and implement opportunities for reducing pump power (with VFDs or control strategies).

Maintenance tasks for hot water systems should include:

Preventive maintenance:

- Boiler Maintenance
- Pump Maintenance
- Regular inspections
- Record keeping
- Accurate water treatment
- Blow-down continuously, daily or weekly
- Clean heat exchanging surface

Controls

Controls are a sustainable retrofit option in existing buildings enabling increased energy efficiency and cost savings. The most basic function is connection to a central Building Energy Management System (BEMS) for start/stop control of building energy systems. **Energy savings will vary depending on how the existing building control system is being operated.** The BEMS control system is also used for monitoring of the different energy systems. **Central BEMS control systems save staff time by allowing staff to monitor operations and performance of energy systems in many buildings. Metering of energy systems is required along with adequate control points in order to derive the maximum benefits and energy savings from the buildings.**

A comprehensive BEMS control system can be considered the most important key to sustainable operations and maintenance of buildings when properly used for energy performance monitoring and energy use benchmarking.

Basic Building Energy Management System (BEMS) maintenance guidelines:

- Check set point versus actual control point.
- Verify that proper control strategies and set points are being implemented.
- Check controls periodically, as they often drift out of calibration.
- Ensure controls adequately reflect the actual building conditions and needs.

Electrical and Lighting Systems

Introduction

Lighting operations and maintenance practices significantly impact building energy use and can affect occupant productivity. Building's lighting systems - illuminating offices, hallways, reception areas, etc. - constitute the largest energy use in most office and commercial buildings. **Energy used for lighting accounts for about 17% of all US electricity use, and this proportion can increase to 22% or more when adding the energy used to cool the heat generated by standard lighting systems (LED lighting systems greatly reduces heat generation).** Appropriate lighting quality can improve employee productivity, and the increase in employee output can outweigh the incremental costs of workspace lighting improvements and retrofits. Interior and exterior lighting can also contribute to light pollution. These lighting guidelines offer best practices for ongoing operations and maintenance associated with lighting.

Electrical equipment and appliances in facilities also use significant amounts of energy. Building operators can achieve energy conservation and cost savings from various electrical systems through sustainable equipment selection and/or equipment upgrades, maintenance, and encouraging occupant behavior changes related to the operation of electrical equipment.

Systematic lighting maintenance can help to extend product life, saving replacement effort and costs. Planned lighting maintenance can also significantly improve quality of light, by reducing recoverable light loss factors of:

- Lamp burnout;
- Lamp lumen depreciation (reduction in lamp light output over time);
- Luminaire dirt depreciation; (dirt on lamps and fixtures blocking light);
- Room surface dirt depreciation (reduction in room surface light reflection from dirt).

Many lighting systems are overdesigned to account for light loss, thus another benefit of planned maintenance is reduction in the number or output of luminaires required in a space.

The actions discussed in the section below allow facilities O&M staff to balance operational efficiencies with occupant lighting needs, and reduce cost.

Lighting System O&M Plan

Implementation of an electrical and lighting O&M plan is fundamental to achieving energy efficiencies in existing buildings. A successful and effective O&M plan schedules regular audits, encourages feedback from custodial cleaning staff and building occupants and identifies any area that does not provide intended results.

The O&M plan should consider upgrading lighting systems with newly-available lighting technologies to achieve improved and flexible lighting with intended energy savings. O&M staff will need to be informed and trained in how to maximize the efficiency and output of the new systems.

The electrical and lighting O&M plan should include the following elements:

- Assess the scheduling of lighting systems….does the scheduling match the occupancy? Or should occupancy sensors be considered?
- If a digital scheduling system is not used, communicate responsibility for turning off lighting to appropriate parties, or install occupancy sensor controls.
- Are cleaning staff responsible for turning off lighting? Coordinate with cleaning staff.
- Inspection, repair, and recalibration of lighting systems and controls should be conducted at regular intervals.
- Re-lamping schedules and specific procedures for both group and spot re-lamping for each luminary type in a building.
- Procedure for identifying and dealing with unexpected light inhibitors (such as a tree or shrub that has grown to block the light).
- Recycling and disposal plans for used lamps and ballasts, including toxic waste procedures.
- Scheduled audits and feedback of the implementation and effectiveness of the maintenance plan, to identify any additional areas which need periodic or special lighting system corrections, repair, or upgrades.
- Consider purchasing Energy Star Equipment labeled whenever possible.

Scheduling Group Re-lamping and Cleaning

Proper planning of a group re-lamping schedule is critical. Waiting too long could result in higher number of burnouts and increased maintenance costs. Setting the schedule requires a review of manufacturer information and coordination with the cleaning staff. Facility O&M staff should work together with cleaning staff to estimate optimal group re-lamping frequency, and then adjust schedules as actual operating conditions dictate the actual bulb burn-out rate.

Clean luminaries at the time of re-lamping. Use best practices procedures to accomplish this task.

Exit and Emergency Lighting

Exit signs typically operate at all times, representing a significant cost and energy savings opportunity. LED's should be the first option at retrofitting and purchasing of new units for replacement.

Create a regular schedule for emergency lighting routine maintenance, including periodic testing and replacing failed components.

Perform a life-cycle cost benefit analysis to determine if group battery replacement is cost effective.

Lighting Controls

Lighting controls exist in many forms. The following options should be explored to help reduce the total energy load on campus.

- Occupancy and Motion Sensors (Infrared, Ultrasonic and Dual Technology sensors).
- Timers and Time clocks.
- Day-lighting controls.

Plumbing and Mechanical Systems

Introduction

Between 1950 and 2000 the national public demand for water more than tripled while the population doubled. **Americans now use an average of 100 gallons of water each day.** This increased demand has put additional stress on water supplies and distribution systems, threatening both human health and the environment. By using water more efficiently, we can help preserve water supplies for future generations, save money, and protect the environment.

Operations & maintenance of plumbing systems involves selecting efficient and durable systems & fixtures, repairing stoppages and leaks, and detailed maintenance of all plumbing systems including steam and gas lines, kitchen appliances, waste systems, and irrigation system supply mainlines. Plumbing maintenance staff may also be in charge of maintaining water supply lines for HVAC equipment, such as water source heat pumps.

Plumbing O&M Plan

A plumbing O&M plan usually establishes operating and performance standards for domestic water lines, sanitary lines, and gas lines; and includes information on building equipment, inspection procedures, schedules and reporting requirements for repairs and maintenance. The plan should include an assessment and timeline for the conversion of plumbing fixtures to high-performance plumbing fixtures and fittings as part of any future renovations, as well as a list of scheduled preventive maintenance tasks, frequency the tasks will be performed, the personnel or level of skill required to perform the task, and the time required. A good plumbing O&M plan will ensure the expected life of equipment is extended, that pollutants do not enter the system, and that the systems are maintained for optimum performance and safety. Additional specifications to consider including in the plan are water heater storage temperatures, control of mixing valves, operating pressures, and flow rates.

General Plumbing Fixtures and System Guidelines

Water systems should be reviewed for sustainable retro-fit opportunities.

Periodically check safety and shutoff valves for proper operation. For faucets, clean aerators if the flow appears restricted or irregular. Inspect showerhead for deposits, debris, or build-up.

Test pressure relief valves and checks for trapped air.

Check manual or automatic bleeder devices for operability.

Check pumps and motors for circulation pumps for leaks, noise or vibrations. Test for proper pressure.

In areas where water quality is a problem, perform routine testing of water quality. Water quality testing is important for both public health and for the maintenance of the piping system.

Check domestic water circulator pumps for proper operation. Periodically check the flow rate through domestic water lines.

Fixtures

Toilet and Urinals

- When replacing tank-type toilets, specify toilet with the Water Sense label. (1.28 gallons or less).
- When replacing urinals, replace with high efficiency models designed to use 0.5 gpm or less.

Replace worn part and adjust mechanisms to ensure that the water consumed per flush meets manufactures original equipment specifications.

Correctly adjust and maintain automatic sensors to ensure proper operation (if used).

Faucets and Showerheads

Install low-flow aerators on lavatory faucets to reduce water use, or replace with code-compliant low-flow sensor faucet.

Encourage users to take shorter showers.

Replace all showerheads with high-efficiency fixtures or install flow restrictors in existing fixtures.

Water Heaters

Modern buildings typically require hot water at 60°C (140°F) for heating, and may use 140°F–180°F water for sanitizing or automatic dishwashers. The expected useful life of commercial electric water storage tanks is around 10-15 years, or less for gas heated tanks. Corrosion is the primary cause of premature failure of storage tanks.

The cost of maintaining water heater storage tanks is low, but standby energy losses may be significant. Instantaneous heaters cost more than conventional storage units; however, these costs are offset by lower operating costs (due to the elimination of standby energy losses) and a longer expected useful life (over 20 years, in comparison to the 10–15 year life of storage tank heaters). In certain areas with extensive distribution piping, electric instantaneous water heaters may be a good option, but this depends on the design needs of the building.

Instantaneous or "on-demand" water heaters can provide a continuous supply of hot water. Instantaneous water heaters are sized for maximum flow rate through the fixture. They are also used as booster devices, to raise the water temperature to that required by automatic dishwashers. A modulating control that provides a constant outlet temperature, regardless of the flow, is preferred. A minimum flow rate is also required for heating to turn on.

Automatic timers can be used to control circulation of hot water based on demand. These are inexpensive and work well where schedules are predictable. Timers will significantly decrease the distribution losses from systems.

Evaluate each point of use in the facilities for hot water needs and determine if a tank-less water heating system can be employed to reduce stand-by heat losses from existing tank heaters.

Perform routine flushing to remove mineral deposits and extend the useful life of water tanks.

When possible, look at Solar Thermal Systems and compare the efficiencies and over all life-cycle costs.

Steam and Gas Lines

Proper operation and maintenance of boiler and furnaces by trained staff is essential for occupant safety and efficiency.

Provide proper training for all staff that operate or maintain boilers and furnaces.

Establish written checklists for startup and shutdown of boilers.

Replace older inefficient boiler(s) when possible.

Check piping and periodically test pressure relief valve.

Check temperature and pressure controls.

Inspect, clean and adjust boiler according to manufacturer’s specifications. Inspect the combustion chamber for cracks, deterioration or sign of incomplete combustion. Clean soot or condensate off of the exterior heat exchanger surface according to procedures recommended by the manufacturer.

After cleaning or maintenance of any repairs, check all connections for leaks after initial firing.

Check steam traps as scheduled.

Check all gas appliances for possible leaks.

Green Cleaning Practices, Equipment and Products

Introduction

Green cleaning is a holistic approach to janitorial/housekeeping services. It takes into account the health, safety and the environmental risks of product and processes associated with cleaning, and balances this with need of the facility. Green cleaning involves the use of alternative products, application of the product in different ways, and evaluation and/or behavior shifts associated with how buildings are used to reduce risks, while maintaining a satisfactory level of cleanliness and disinfection.

General Green Cleaning Best Practices

Colorado College custodial services contractor, Sodexo Environmental Services is Green Seal Certified, practicing Green Seal Standards for cleaning methods and using Green Seal products for cleaning. All effective green cleaning programs are built on using best green cleaning practices along with effective product, equipment and green cleaning methods. The following best practice applies for general green cleaning purposes across a variety of facilities:

- Reduce the need to clean. Use effective entrance matting systems to prevent soil, moisture and other contaminates from entering the facility. This reduces the need to clean, eases cleaning, protects floor from damage, and makes floor safer by reducing slipping.
- Follow instructions and precautions provided by the manufacturer. All products should be used following instructions or precautions provided by the manufacturer. Follow the instructions for diluting and mixing products before use, to avoid damage to surfaces being cleaned and/or leaving residues or hazardous gases.
- Clean first, and only use a disinfectant or germicide if needed. Surfaces must be cleaned thoroughly, whether or not disinfectants are used. If any product claims to be a disinfectant or sanitizer, then it must be listed as an approved antimicrobial product. If the decision is made to use disinfectants, then personnel must be trained in the proper use of these products and label direction must be followed.
- Minimize the use of products that leave a scent in the room. Fragrance formulations often are a complex mixture of chemical ingredients and often added purely for aesthetic reasons. Avoid using these products unless it is a natural fragrance used to improve cleaning performance or to counter-act objectionable odor from the product or the environment being cleaned.
- Purchase quality floor finishes. A quality product finish handles wear and tear, requires minimal burnishing, is long lasting and facilitates easier removal of soil by dust mopping and daily cleaning. Floors should reach 5 to 10 years without needing to be stripped. Consider the impact and life-cycle cost of maintenance in choosing floor products.

- Use Cold Water. Experiment with green cleaning products that work with cold water. Products certified by Green Seal, Inc. are designed to work with cold water. This saves money and eliminates the risk of burns from cleaning with hot water.
- Vacuum carpets frequently prior to considering the use of any carpet cleaning products. This helps maintain indoor environmental quality and extends the useful life of the carpet along with reducing the use of chemical and water based shampoo extraction products.
- Properly train all custodial and maintenance personnel. Conduct periodic monitoring to ensure personnel are properly following established procedures.
- Investigate the use of new cleaning technologies and equipment. New products often offer opportunity to conserve energy, improve safety, and reduce resource use and waste, and eliminate toxics.
- Purchase universal mounted dispersing/proportioning systems. These dispense chemical concentrate diluted with the right amount of water, to provide a ready to use mixture to spray bottles, mop bucket, auto scrubbers or any other receptacle.

Green Cleaning Plan

Colorado College custodial services contractor, Sodexo Environmental Services, has developed a green cleaning plan for the campus and trains custodial staff on use of new products and practices.

Evaluate current cleaning products, methods, and equipment. Evaluation checklists are available at the US Department of Interior's website:

http://greeninginterior.doi.gov/buildings/index.html

Refer to the" Green Seal "Products standard for all cleaning supplies:

http://www.greenseal.org/GreenBusiness/Standards.aspx

Identify which products contain hazardous substances that can be replaced by healthier alternatives. Phase in the selected new green cleaning products after current products are depleted.

Monitor progress and continually improve the program.

Keep a log of all cleaning chemicals used or stored on campus and attach MSDS and technical bulletins from the suppliers.

Green Cleaning Product Selection

The following green cleaning product characteristics were developed and adapted from Green Seal, Inc. and should be referred to as guidelines for product selection:

- The undiluted compound shall not be hazardous to humans.
- The undiluted product shall not contain any ingredients that are known carcinogens or known to cause reproductive toxicity.
- The undiluted product shall not be a skin sensitizer.
- The undiluted product shall not contain substances that contribute significantly to the production of photochemical smog, tropospheric, ozone, or poor indoor air quality.
- The product used shall not be toxic to aquatic life.
- All organic ingredients in the product as used shall exhibit ready biodegradability.
- The product as used shall not contain more than 0.5% weight of total phosphorus.
- The primary packaging shall be recyclable.
- The product manufacture shall identify any fragrances on their MSDS.
- The manufacture‘s label must clearly and prominently state recommended dilution levels with cold water.
- The manufacture must also include detailed instruction for proper use and disposal, and for the use of personal protective equipment.

All-purpose cleaners

- Use cleaners with a neutral pH instead of those with extreme pH factors.
- Use cleaners that are readily biodegradable.
- Use product with no or low levels of dyes and fragrances.
- Use products that have no or low VOC’s.

General Degreasers/Disinfectants

Degreasers: Choose products with D-Limonene (derived from citrus fruits) and methyl esters from soy and corn when possible.

Disinfectants: Choose products containing hydrogen peroxide when possible.

Bathroom Cleaners/ Disinfectants/ Urinal Deodorizer.

Prefer products with a more neutral pH (green bathroom cleaners may fall more in the range of pH 4 as compared to a pH below 1).

Use products that readily biodegrade and have no or low levels of dyes and fragrances.

Bathroom cleaners: surfactants, contains terms such as lauryl, amides, glycosides, citric or acetic acid.

Prefer antimicrobial ingredients that have a lower potential for persistence in the environment and to accumulate in living tissue compared to those with greater potential.

Lime and Scale Remover

Choose environmentally preferable lime and scale remover with a pH in the range of pH 4 as compared to traditional products that may have a pH below 1.

Preferred ingredients: citric or acetic acid.

General Carpet Cleaning

- Do not allow carpets to become too wet.
- Use general purpose cleaner whenever possible and reduce water use.
- Use equipment that provides maximum extraction of moisture from carpets.
- Use blower/dehumidifiers when needed.
- Waste, Energy and Water Reduction.
- The green cleaning program should focus on the 3 R's: reduce, reuse, and recycle.

Recycling and Waste Management
(Practice the 3 R's: Reduce, Reuse, and Recycle)

Introduction

The disposal of solid waste is expensive, polluting to transport, and produces greenhouse gas emissions in landfills. Reusing materials and extending equipment life can preserve natural resources while saving budgetary dollars for other needs. Disposal of solid waste should always be considered a last resort.

Reuse Expansion

Work with non-profits/Habitat for Humanity/school districts/local community recyclers for reuse of reusable building materials/products. Try to eliminate the use of fuel and other costs for disposal or reuse of products with minimal recycle content.

Expand collection of polystyrene peanuts, air bags, and other shipping packing materials for reuse. The college mail services recycling program saves a supply of packing materials for reuse by students.

Waste Minimization/Recycling Collection

Educate staff and students about recycling opportunities and recycling best practices to achieve waste minimization in the near term, and ultimately achieve Zero-Waste over the long term to reduce the college's carbon footprint.

Increase paper and compost recycling.

Work directly with the waste removal vendor for paper recycling and other basic recyclables to resolve any contamination problems. Facilities Services recycling coordinator monitors contamination and works with stakeholders to reduce contamination.

Increase the amount of scrap metal recycled.

Increase the collection of yard waste for composting.

Decrease the amount of construction waste and increase the amount of construction materials recycled.

Buying Recycled Products

Increase the overall purchases of environmentally preferable products.

Increase the purchase of environmentally preferable products for college construction projects. Use the LEED standard guidelines to define environmentally preferable products.

Greenhouse Gas Emissions Reduction Program

Waste minimization will result in a reduction of greenhouse gas emissions from recycling reduction and avoidance of waste going into the landfill.

The goal should be to practice Zero-Waste.

Reduction of consumable goods including office supplies, fuels, and mechanical/electronic equipment is the primary strategy for preserving natural resources and keeping material out of the landfill. Reducing overall consumption offers the most benefit for lowering carbon emissions when compared with other waste management strategies, and therefore should be a priority of focus.

Residence Hall move-in and move-out Waste Reduction Program

Encourage students and staff to reduce waste by being proactive.

Educate staff and students about recycling opportunities and recycling best practices to achieve waste minimization in the near term, and ultimately achieve Zero-Waste over the long term to reduce the college's carbon footprint.

During move-in and move-out at the beginning and end of the school year, large landfill waste collection containers are placed near student residences. Student Housing staff should monitor the flow of materials going into these containers to sort out recyclables. The college works with local non-profit groups and local community recyclers to recycle materials and identify items that might have reuse value to fill a need elsewhere.