Best Practices to Support Operation and Maintenance in Cold Climates

Latest Update: January 2, 2023

Introduction

This document is a culmination of the knowledge provided from various Operation and Maintenance Best Practices workshops that have been completed throughout the State of Alaska over the last several years. In all, it includes input from over 200 professionals including Facility Managers, Designers, Project Managers, Contractors, Manufacturers and Building Owners. It is a living document and will be updated periodically as more information is made available.

This document is Dedicated to the Public Domain. You are encouraged to share it with peers, clients, consultants, contractors, and the general public. The intent of the document is to improve Operation and Maintenance in Alaska and communities across the Arctic. However, the document and verbiage included cannot be duplicated or used for profit.

Document Layout

This document is separated by major construction systems including:

- General Building Operation (items that apply to all construction trades)
- Site and Landscaping
- Building Envelope
- Finishes, Furnishings, and Floor Plan
- Structural Systems
- Mechanical Systems
- Electrical Systems

Within each construction system, the document is further broken down into three subcategories:

- Scheduled O&M Tasks: This section focuses on the daily tasks of the Facility Operations Team. These are the regularly scheduled activities that will prolong the life of the systems, reducing both short term and long term operational costs. An example of a recommendation within this section is daily walk-throughs of the mechanical spaces to identify leaks or unusual noises.
- Capital Improvement Tasks: This section highlights where capital funding is best applied to reduce operational costs. An example of a recommendation from this section is the replacement of fluorescent light fixtures with LED light fixtures.
- Design Practices to Support O&M: This section is directed at designers and includes recommendations on how to design and specify products and systems in a way that will facilitate maintenance and reduce

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the long term operational costs of the facility. An example of this section is the inclusion of commissioning to ensure constructed systems are operating as intended and in an energy efficient manner.

Expanding the Body of Knowledge

We would greatly appreciate any additional recommendations for this document. If provided to you as a PDF, the document can also be provided in Word format to facilitate editing. We request that you turn on "Track Changes" to make it easier for us to identify the additional information and incorporate it into the master document. Please send all edits to Craig Fredeen at cfredeen@coldeng.com.

A 'How-To' Workshop Guide is also available to guide you and your organization through having your own O&M Best Practices Workshop. This can be a great team-building exercise to share knowledge among your team members. We recommend inviting your clients to participate or hold the workshop at your client's organization to make it easier for their Facility Personnel to partake. This will help you identify what O&M Best Practices are important for your clients. This is also a fantastic work-shop to hold during a monthly professional society meeting or conference where you have a diverse group of professionals sharing their knowledge.

If you are interested in hosting a workshop, contact Craig Fredeen. He will send you the most current version of this document to make available to participants at the workshop. When done, email photos of the resulting lists of best practices that were generated at the workshop to Craig. He will then update the master document with the new information and send an updated version of the document back to you for dissemination to all of the participants.

Not all recommendations apply to all situations. If you or a workshop participant take issue with something noted in this document, include that in your edits/recommendations and describe why/where you take issue with a recommendation so that too can be included in the Body of Knowledge for others to take under consideration. It is just as important to have caveats and counterpoints to recommendations to ensure the reader applies them appropriately.

Waiver

There are always exceptions. Every building and every system is different. As such Craig Fredeen, Cold Climate Engineering, LLC, and the various authors who have added information to this document do not endorse, warranty, or guaranty the information provided within this document. Always seek the advice of a professional who is familiar with your specific facility and systems before enacting the recommendations within this document.

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GENERAL BUILDING OPERATION

Scheduled O&M Tasks

- Communication is the key to proactive rather than reactive maintenance.
  - Speak to Users (Teachers, Operators, etc.) daily and ask about changes in systems you may not notice.
  - Encourage Users to contact Facility Staff immediately once they identify an issue.
  - Ensure that Users know how to contact Facility Maintenance Staff.
- For distributed campuses like School Districts, provide a high-speed Wi-Fi network that can support live video streaming services. Remote site personnel can use a smart phone or tablet to show remote technicians an issue. The remote technician can either walk the onsite personnel through how to fix the issue or be able to use the information to trouble shoot the problem and identify what materials/spare parts and tools they need to bring to the site to complete the repair.
- Documentation
  - Use District's/Organization's web page to share information, Operation and Maintenance (O&M) manual information, and training manuals and videos.
  - Keep record drawings and O&M manuals electronically. Scan existing paper documents so that they don't get lost.
  - Update O&M manuals, both physical sets and electronic sets, as equipment is replaced or renovations (in-house and contracted) are completed. Remove outdated material or note it as no longer applicable.
  - Update cleaning training as new cleaning chemicals are implemented.
  - Have a 360 camera documentation of the facility, particularly for mechanical and electrical spaces, for reference by remote operators and future designers.
- Training
  - Train Users on how to utilize the systems in the building (i.e. thermostats) as well as how to convert multi-functional furniture.
  - Provide training for all new facility staff as well as Users.
  - Provide regular refresher training for all Users. For schools, complete it annually as part of the before-school in-service days as there are always new teachers.
    - Develop a Users' training packet/handout on how to operate the thermostat or other controls. Have Facility's contact number prominently displayed.
  - Provide annual training for all O&M personnel.
    - As budget allows, send staff to local and national conferences. Require the individual to provide training sessions to local staff on what they learned.
  - After each training session, document how the training can be improved. This may include covering the questions that were asked, or where follow-up training was required. Review and update training manuals every couple of years.
    - Consider bringing in a "fresh" training team to identify existing deficiencies that may have been previously overlooked.

- Work Orders
    - Develop Standard Operating Procedures (SOP) for regular maintenance activities.
    - Generate annual maintenance checklists for the facility that include the inspection/maintenance task, the frequency, and ways to identify who and when the task was completed. This is often integrated into maintenance software packages.
    - Include all preventative maintenance tasks noted in this paper including filter changeouts and lubricating bearings.
    - Include all scheduled testing noted throughout this paper (generators, fire pumps, emergency lights, etc.).
    - Schedule inspections as noted throughout this paper.
- Daily Walks
    - Walk mechanical room daily looking for leaks and unusual sounds.
    - Place carbon monoxide detectors throughout the facility, especially in mechanical rooms, and check them during each walk through.
    - Have checklists of system operating conditions that need to be filled out.
- Cleaning and Upkeep
    - Keep facility free of clutter and materials being stored/stacked where they should not be. This will help ensure that tools, materials and spare parts will be able to be easily found when needed.
    - Schedule an annual “deep-clean” of the facility once a year during a regularly slower time of year.
- Track Energy Usage
    - Review monthly fuel, electricity, and water usage and compare to previous years. Some issues, such as broken outside air dampers or fans left manually on, may first show up as anomalies in utility usage.
    - Send monthly bills to Facility Staff and Principals/Managers. Knowing the energy usage keeps operational costs on their minds as they complete their daily duties.
- Develop Emergency Preparedness manual. Review and update annually with staff. Recommended categories include:
    - Power Outage:
        - Location and information about the standby generator (i.e. if you have one).
        - Instructions on how to operate the standby generator including transfer switch.
        - Note what systems the generator is sized to operate (not all electrical systems are typically on a standby generator).
    - Prepare for Water Emergencies:
        - Have maps in multiple locations that clearly locate where all water entrances and sprinkler risers (if in different locations) are in the building.
            - Recommended locations include at the fire panel, in mechanical rooms, a central operators room or reception desk, and in each riser room (if multiple rooms exist).

- This can be expanded to show where all fire extinguishers, AEDs, and other life/safety equipment is stored in the building.

- In water entrance rooms and sprinkler risers/water entrances into the building, have clearly labeled step-by-step procedures on how to isolate the system if a sprinkler system was accidentally discharged.
  - Note that some sprinkler isolation valves are chained and padlocked open to ensure they are not accidentally left closed and therefore not available during a fire. Consider providing bolt cutters in the room if that is the installed system.
- Ensure that all local maintenance staff and managers/principals as well as remote supervisors know where the water entrances are and they know how to shut off the water. These are likely the people who will be called if there is a water emergency.

- HVAC
  - Process on how to startup the heating system after an event.
  - How to change dual-fuel boilers to standby fuel source.
  - What systems are designed to work with a standby generator. Ventilation systems may not be intended to be used after an event.
- Fuel Spills
  - Have a fuel spill response plan in place. Coordinate the plan with State of Alaska DEC regulations. Keep response plan readily available on site and electronically for remote access.
  - Provide training for supervisors on the plan. Include training on penalties and fines associated with not reporting spills. Spills that are not properly remediated can result in significant future costs as well as potential health impacts.
- Earthquake
  - Inspection checklist for structural elements within the building including roof trusses and foundation. Check for cracks that may indicate failed structural elements.
  - Identify if seismic-activated gas valves have been installed on the building on the natural gas utility entrance.
  - Provide instructions on how to inspect the system for leaks and how to reset the valve.
- Contact list of who to contact after an event such as management, utility technicians (not just general customer service number), engineers/inspectors, etc.
  - Consider having in place contracts with local engineering firms for inspection services on T&M basis. This will expedite getting critical inspections (structural) completed immediately after an event.

Capital Improvement Upgrades

- Develop a Master Plan for the future development and renovation of the facility and site. Include all stakeholders in development of the plan.

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  - Regularly update the Master Plans to keep them relevant to the needs of the school and District.
- Financing and Grants
  - Educate decision makers on the importance of funding preventive maintenance verses the higher cost of reactive maintenance.
  - Designate a staff member to research and track various grants that can be used to replace, renovate, or upgrade the existing facility. Energy efficiency upgrade grants can be used to replace older and higher maintenance equipment.
    - For Alaska, the Alaska Energy Efficiency Partnership (AEEP) maintains a list of available grants. They are found at www.akenergyauthority.org
  - Obtain the grant scoring matrix immediately, do not wait until the application submission window is open.
  - Invest in a grant research and writing resource. A professional grant writer will typically have a much higher winning percentage than using in-house staff.
  - Track exact data of O&M issues (number of days without water, etc). This information is helpful in scoring and prioritization of grants.
- Develop a five-year Capital Improvement Plan (CIP) for each facility
  - Integrate escalation costs into CIP plan for inflation, bid market, etc.
  - Staff writing and approving grants need to consult with proper Facility Staff prior to submission.
    - Facility staff to have input and help prioritize Deferred Maintenance funding and projects.
  - Make and keep good communication with the Districts and schools for ongoing issues they need to know about and as changes in status occur.
  - Keep a register of all major pieces of equipment and their expected life cycle. Recognize that different equipment has different life spans. References for where this information can be found is located in the Resources section.
  - Proactively schedule the replacement of critical infrastructure such as roofs, boilers, pumps, and generators on a predictive life-span based cycle.
- Purchasing
  - For School Districts, create state-wide purchasing agreements with suppliers to improve buying power and reduce costs.
  - Collaborate with other facilities in the region to share:
    - Regularly scheduled maintenance (i.e. generator overhauls, boiler tuning). Schedule the technician to complete maintenance to the equipment in multiple facilities within a community/village. Share the travel costs.
    - Regional maintenance service providers for immediate or even planned maintenance. May be less expensive to have someone fly in from nearby village than from hub-city.
    - Parts availability.

- Have an energy audit completed at the same time as an inventory and condition survey. Integrate results into CIP plan.
    - For smaller communities, prioritize upgrades that lower fuel consumption. Savings from reducing electrical power usage in large facilities like schools are often offset by immediate increases in electrical utility rates by local electrical provider to cover operational costs of local power plant.
    - Weigh all energy efficiency gains with additional maintenance costs. Many higher efficiency systems/equipment are more complicated and harder/costlier to maintain.
- Develop a Facility Design Guide and Equipment Standards
    - For larger organizations, it is beneficial to develop a Facility Design Guide that all designs and construction is expected to follow. The Design Guide is usually separated by construction discipline or CSI specification section. It is recommended that the Design Guide include items that will affect long term operating costs such as:
        - Minimum building envelope R values. Values higher than code minimums can result in significant reductions in utility costs. If these are not documented in the Facility Design Guide, the designers may only use code minimums.
        - The inclusion and location of items such as isolation valves that will make maintenance easier.
        - Lessons learned from previous projects and systems.
        - Anything that you want to ensure every project includes.
    - An Equipment/Material Standard documents standardized equipment and materials.
        - This will reduce spare part inventory as well as focus training to one or two manufacturers.
        - Additional items that should be included in a Standard are noted throughout the document.
        - If a standard is not already in place, complete a survey of what has been used at other Owner facilities or work with the Stakeholders to develop a standard for the Owner that can be used on future projects.
    - Review and update the Standard after each major project. New materials or technology were likely used or some equipment made obsolete.
- Upgrades
    - Recognize that significant renovations may trigger requirements within the International Existing Building Code (Alteration Levels) that may require building-wide life-safety upgrades such as fire suppression and detection.
    - Include ADA/Accessibility upgrades within the building and the surrounding site access whenever possible.
    - Add storage space; both interior/conditioned and exterior/unconditioned.
        - Coordinate with Facilities Management on storage space needed for spare parts.

    - Install technology that allows remote metering and trending of fuel and electricity usage. Match with outputs meters (such as BTU meters) to evaluate energy efficiency of the facility.
        - Consider creating an "energy dashboard" for each school and have it viewable by staff and students so they can see the real-time energy use of the facility.
        - Institute power monitoring and include sub-monitoring. At a minimum monitor 120, 277 and 480 volt feeds and keep histories to find irregularities.
        - Alaska Housing Finance Corporation (AHFC) has a free open source building monitoring system, BMON, that may be an inexpensive option for some users.
- Preventive Maintenance
    - Do not defer Preventative Maintenance. It costs four times more to repair/replace than prevent.
        - Fix things when they are small issues before they become big issues.
    - Purchase a software package that tracks Work Orders and automatically generates work orders for regular maintenance work.
        - Integrate age and life expectancy of each system (i.e. roof) and piece of equipment (boiler, lights, etc). Proactively add expected replacement into CIP plan.
        - Integrate warranty expiration dates for all systems and equipment. Schedule an inspection 1-2 months prior to expiration.
        - Use software for inventory control of spare parts.
    - Invest in low-cost infrared cameras for each facility. This is an invaluable inspection and troubleshooting tool for building envelope, HVAC, and electrical systems as well as locating radiant floor tubes so that they are not punctured during renovation work.
- Maintenance Contracts
    - Review annually.
    - Check with Users and Facility Management Team prior to annual review to ensure that services are being adequately provided and identify what services need additional effort.
- Design Team Selection/Contracts
    - Ensure design team has cold-region experience.
    - Ensure design team has experience unique to your project/location including high seismic requirements, high winds, snow drifting, rural/remote construction, elevated construction, and limited construction seasons.
    - Require Record Drawings.
        - Require that they are provided electronically in PDF. The Owner can then print a set out for the site. Half size drawings (11x17) can be easily stored in three-ring binders that can be stored in the maintenance room or mechanical room.
    - Require in your design contract that the design team provide CAD drawings (AutoCAD or Revit format) of the record drawings at the end of the project. This will save future design costs as design teams will not need to redraw the floor plan and systems.

- Require in contract deliverables the expected levels of design completion for each milestone.
  - Requiring the design to be more complete in the earlier submittals provides a better and more thorough review for the Owner. Note however that Owner changes later in the process can result in significant impacts for the design team and potential requests for change of scope additional funding.
  - For specifications, it is recommended that all sections be edited specific to the project and at least 80% complete at the 65% design milestone and 98% complete at the 95% design milestone including a Sequence of Operation to allow the Owner to fully review the products and installation requirements.

- Construction Contracts
  - Require Record Drawings.
    - This also includes contractor shop drawings for sprinkler system, fire alarm, Building Automation System (BAS) and SCADA control diagrams, and other performance-based designs.
  - Provide a separate line item in the project Schedule of Values for "close-out" activities. This includes record drawings, O&M manuals, balancing, training, spare parts, and anything else needed to get the facility going in the right direction. Commissioning is often times a separate line item but can also be included in this section.
    - Withhold a significant amount of money aside for this line item. At least 10x the cost of the activity itself. If the amount is too little, the Contractor may skip it which will have grave impacts on the long term operational cost of the project.
  - Have all O&M and Record Drawings delivered in electronic format in order to make available remotely.
  - Utilize an online construction project management software to track submittals, change orders, and field questions.
    - Use the software to track all close-out documents to ensure they are submitted.
    - Archive the project at the end of construction and keep it with the electronic O&M files. These documents can be useful in future projects or troubleshooting operating issues.
  - Look into alternative project delivery mechanisms such as CMGC/CMAR (Contractor at Risk) in place of traditional design-bid model.
    - These delivery methods bring a Contractor on during the design stage to provide design recommendations and accurate pricing.
    - This leverages the knowledge and experience of your construction team during the design process to make for a cost-effective facility and easier construction.
    - The selection process typically includes qualification based criteria such as resumes, references, and experience with similar types of facilities. This traditionally provides a better quality end product.

        - This also opens the possibility of phasing the design and permitting allowing an earlier construction than traditional design-bid-build.
    - Require that seismic support systems and all other life/safety systems are installed prior to occupancy. This is sometimes at Conditional Certificate of Occupancy and may be long before official substantial completion, especially for HVAC upgrades.
- Construction
    - Be wary of Contractor "Value Engineering" suggestions. These often provide lesser quality materials or systems that require more long-term maintenance.
        - Be sure both the design team and Facility Manager has an opportunity to review and provide input on suggestions.
    - Require the Contractor take daily/weekly construction photos of the construction progress and post them to a cloud based, file sharing service.
        - Have the design team review the photos weekly.
        - This is especially important for remote projects.
        - Archive these photos with the O&M manual as it shows what and where things are concealed within construction.
    - Have Facility Staff complete inspections of the site throughout construction. It is critical to complete this inspection at the rough-in stage in case there is desire to move something and at substantial completion.
- Warranty and Post Construction
    - Notify the contractor of warranty issues immediately.
    - Keep track of what activities the Facility Team completes on the facility during the warranty period. Some warranty work will be claimed that it was due to the actions of the Facility Team.
    - Consider follow up commissioning 10 months after Owner acceptance.
        - This will ensure the system is still operating as designed and any failures will be identified within the warranty period.
        - Compare operating costs against anticipated energy usage. Research any significant variances with the Design Team.
- Emergency Preparedness:
    - Consider setting up open contracts for emergency inspection services with local engineering firms. For situations like a major earthquake, it is imperative to have the facility quickly assessed to ensure it is safe to occupy. This is critical for facilities used as disaster shelters. Having contracts in place makes the process immediate and also prioritizes your facilities with architectural and engineering firms.
    - Have emergency contact information readily available in facility Disaster Preparedness documentation (see above).

Design Best Practices to Support O&M

- Communication

- All communication is to be constructive with the intent to collaboratively create a better facility.
- All team members are to approach the project with a positive attitude, open to suggestions and recommendations from all parties. Great ideas come from all sources.
- Conduct community outreach and external affairs to ensure the project meets all needs and goals of the end users. Not doing this may result in late changes that may impact O&M.
  - Complete research on the community, region, culture, and the type of the facility.
  - Outreach is to be culturally sensitive and consider cultural activities (subsistence, whaling, fishing, etc.) when scheduling meetings and public comment periods.
- Keep all stakeholders apprised of the project throughout the design and construction process. For O&M, this especially includes the Facility Management Team.
  - Allow appropriate time in the schedule to complete outreach.
- Foster ownership of the design and construction with the occupants and all user groups. A facility is more likely to be treated better and maintained when there is ownership.

- Codes
  - Verify what, if any, energy codes or certifications are required for the project and notify all of the design team at the beginning, prior to fee preparation.
  - Note that some energy conservation requirements are not appropriate for cold climates and can result in significant additional maintenance complexity and long term costs. Do not hesitate to request exemptions where appropriate.
    - Building envelope standards should always be met, if not exceeded to reduce energy use and minimize the mechanical system sizes.
- Planning Stage / Early Design
  - Plan for future expansions/renovations. Ensure all stakeholders have been asked about their future plans.
    - This includes implementing renewable energy, captured heat, and other technology into the facility.
  - Identify design guidelines and review them with staff to verify they are up to date.
  - Include the Facility Management Team in the planning meetings and all charrettes.
  - Work with owner to identify the level of complexity that the User and Facility Staff can use and maintain.
  - Acquire local knowledge when orienting the building. Particularly in regards to wind directions and snow drifting.
  - Have a separate Mechanical, Electrical, Plumbing (MEP) planning charrette with the MEP engineers and Facility Staff.
    - Review different types of systems, energy usage expectations, and level of complexity that can be comfortably maintained.
    - Identify the level of redundancy for each type of system.
    - Facility Management team should have complete buy-in on the MEP systems being provided in the facility.

- Design
  - Design for durability and maintainability.
    - Balance first costs of appearance with long term costs of maintenance.
  - Use readily available materials.
    - Select equipment based on readily available parts and technicians.
    - There will be a higher chance of familiarity with how to maintain and repair the equipment/materials and replacement parts will be easier to obtain.
    - Some European materials and equipment can have very long lead times for new and replacement parts. The replacement parts typically cost more money.
  - Utilize the Owner's standardized manufacturers and materials to simplify replacement and reduce maintenance materials (spare parts).
  - In general, do not use new industry systems/materials/equipment unless the Owner has full buy-in on the pros and cons of the proposed solution.
    - Owner and Facility Staff needs to understand and acknowledge that new technology/approaches may require modifications (and potentially money) after construction to fully achieve the theoretical benefits. The design team needs to be engaged during this process. These are not design errors per se, but a tuning of the solution to fit the final installation conditions.
  - Have Facility Staff and Users involved in milestone design reviews and attend design review meetings.
  - Utilize cost analysis tools for system selection.
  - Don't use "boiler plate" specifications. Specs need to be written specific to the job and the equipment being used.
  - Request from Owner past project "Lessons Learned".
  - Learn design concepts from industry leaders in similar climates such as Canada and Northern European countries.
  - Provide adequate space for maintenance including equipment maintenance clearances as well as ways to easily remove and replace equipment.
- Construction
  - Keep the MEP engineers and the commissioning agent in contact with the contractors throughout construction. This will ensure that the intended systems are installed in a manner that facilitates long term maintenance and operation.
  - The Design Team should check with the Facility Management Team on any changes to the design during construction that may impact O&M including submittal substitutions.
  - Bring younger designers to the jobsite inspections so that they can learn about constructability (at no cost to the Owner).
- Commissioning
  - Commissioning is recommended for all projects to ensure the systems are operating correctly, control elements are calibrated, and at their most energy efficient at the time of Owner acceptance.

        - Various organizations have provided recommendations when commissioning is required. LEED requires commissioning for facilities/additions larger than 20,000 SF while the 2019 International Energy Conservation Code requires commissioning when the combined heating and domestic hot water systems exceed 600 MBH.
    - Integrate Commissioning into the design close-out for anything that has an automatic function. This goes beyond traditional mechanical building automation systems including lighting controls and building envelope testing.
- Training
    - Provide extensive training for Facility Staff.
        - Repeat training, at least on BAS/SCADA systems, 6 months after occupancy.
    - Provide training for Users.
    - Video tape training and digitally store training so it is easily accessible for future reference.
    - Consider having design team provide introductory training session to facility staff to explain the systems, the design intent, and how the systems are intended to operate.
- Close Out Documentation
    - Require contractor record drawings. Have design team review and update drawings based on contractor red lines as well as all field changes (RFIs, etc).
        - Require record drawings for all contractor developed shop drawings such as sprinkler, fire alarm, and audio/video.
    - Develop thorough Operation and Maintenance Manual for all materials and equipment that will require replacement and maintenance.
        - Require cover sheet for each piece of equipment with the manufacturer, specific model number, installing contractor contact information, contact information for local source of replacement parts, and warranty information including when the warranty expires.
        - Consider developing a pictorial reference document specific to the site and for each piece of equipment. Document includes
            - Wrtten step-by-step operating procedures on how to start and stop the equipment.
            - Photographs of the installation with arrows pointing to what needs to be manipulated to achieve the procedure.
            - Snips of user interfaces or BAS system graphics.
        - Digitize O&M manual and keep readily available to staff. Use a combination of cloud-based storage and local storage in case power/internet is not available.
- Post Construction
    - Owner should contact design team with issues that arise after construction.
        - Design teams want to have successful projects and happy clients. They will likely know what the issue is or be a useful resource in troubleshooting the cause.

- This will also help in improving the Design Team's designs on future projects.

- Communication to be solution-based. Litigious verbiage prolongs solving the issue and may actually result in the design team taking a "not our issue" stance from fear that making modifications to the installation would be viewed as confirmation of an error in the design.

- Complete a "Lessons Learned" exercise that includes the design team, project manager, contractor, User group, and Facility Staff.
  - Update design guidelines and contract verbiage accordingly.

SITE AND LANDSCAPING

Scheduled O&M Tasks

- General
  - Immediately address vandalism.
- Site
  - Walk the grounds daily
    - Pick up litter.
    - Verify handrail integrity.
  - Sweep the parking lot in the spring to remove excess gravel. Will increase life of floor finishes.
  - Identify and fill cracks in concrete and asphalt as soon as possible. Freezing during Winter can further expand crack.
  - Maintain fencing, particularly the fencing (typically chain link) around the perimeter of raised structures.
  - Prune trees that may impact electrical utilities.
- Winter Operations
  - Do not use salt on sidewalks if possible.
  - Manage gravel usage to minimize interior finish damage.
  - Provide identifying flags for snow removal equipment as follows:
    - Flag locations of fire hydrants so that they can be quickly found by first responders as well as not be hit during snow removal. Maintain access for quick response.
    - Flag locations of power transformers and other utility boxes that also may be hit by snow removal equipment.
    - Flag corners of parking lots and curbs to assist with blade operation.
  - Locate snow piles in locations that will be able to drain away safely from buildings and public walkways during thawing season.
    - Runoff can refreeze and not allow drainage paths for other parts of the site (i.e. parking lots)
  - Maintain access to fuel and water storage tanks and other items on site that will need access during the winter.
  - First Responder access
    - Maintain access for firetrucks around the facility
    - Maintain access to Fire Department Connection (FDC) to the sprinkler system.
    - Maintain access to fire hydrants, clearly identify with flags.
    - Maintain access to exterior building power disconnects.
  - Be able to locate the exterior water service key/curb box isolation valve (if provided) so it can be accessed for thawing of frozen pipes or, in an emergency, used to isolate the building's water service.

  - Be able to locate the yard cleanout outside of the facility so if a blockage occurs during the winter, the cleanout can be found under the snow.
  - If storm water has an outfall, verify that the heat trace system is working prior to the heating season.
- Site Lighting
  - Annually clean exterior light sensors.
  - Replace non-functioning lights immediately.
  - Verify that lights are turning on and off (if appropriate) at night.
- Fire Prevention
  - Reference State and other jurisdiction recommendations for wildfire prevention measures.
    - Use fire resistive trees and landscaping techniques.
    - Maintain recommended tree and grass distances from structures.
  - Keep brush, trees, and combustibles away from facility.
    - Remove dead spruce trees from site.
  - Maintain perimeter fences around raised structures so that individuals cannot gain access below the structure. Schools have been burnt down in Alaska from kids playing with fire below the building.
- Landscaping
  - Maintain landscaping. Remove dead plants.
  - Remove/Thin trees as required based on growth (i.e. if trees were planted close together at time of construction with intent they are thinned to 10 ft on center when mature).
- Security
  - Make sure trees next to buildings and exterior siding cannot be used to gain access onto the roof.
  - For seasonal facilities, such as schools, consider having RVs park on the site to watch over the site and facility during summer break.
    - Provide RV parking spots with water and electrical connections to facilitate this operation.
- Corrosion
  - Annually check corrosion control systems (sacrificial anodes, etc.) for any steel and buried tanks.
  - Address corrosion as soon as possible. Coat unprotected surfaces.
- Water Wells
- Septic Systems
  - Provide regular maintenance for septic system. Schedule pumping activities during the summer.
- Storm Water
  - After a rainfall, verify that water is sloping away from the building and drains towards designated catch basins.
  - Look for standing water.

- Verify that dry wells are functioning.
- Clear debris that may be keeping water from draining.

Capital Improvement Upgrades

- General
  - Upgrade materials with vandal proof coverings or systems.
- Site
  - Install chain link fences around the perimeter of raised structure buildings.
  - Utilize fencing to reduce foot traffic through site and limit access to lighted areas.
  - Provide ADA/Accessibility upgrades if required.
  - Upgrade signage (including braille where appropriate), particularly for parking lots and service entrance locations.
- Site Lighting
  - Upgrade to LED lights.
  - Upgrade lighting controls, integrate in with security system activation.
- Fire Prevention
  - Replace grasses and other high-burn hazard landscaping with fire-resistive solutions.
- Security
  - Install security cameras/CCTV systems.
- Utilities
  - Extend municipal utilities to the site if feasible.
  - Extend municipal waste heat to the facility if feasible. This will have a considerable reduction in heating costs.

Design Best Practices to Support O&M

- General
  - Consider wildlife in all aspects of the site design (landscaping, nonvisible bedding down locations, etc.)
    - Design garbage storage with bears in mind.
- Materials
  - Be mindful of corrosive environments such as coastal locations.
    - Use aluminum or fiberglass materials in corrosive environments
  - Be mindful of winter temperatures and do not use exterior materials that may catastrophically fail if impacted or torqued during cold temperatures (PVC).
  - Use vandal-resistant material coatings.
- Site
  - Identify or generate master plan with the owner. Consider the following:
    - Future expansions.

        - For schools, locate where portable classrooms will be located on the site if needed in the future.
        - Future utility extensions such as municipal waste-heat or natural gas.
    - Orient site with southern exposure in mind for parking lots and walkways. Reduces snow and ice buildup.
    - Slope the grade away from the building and sidewalks.
    - Eliminate hiding spots immediately around building as well as on the site.
        - Ensure vehicle site lines are clear.
    - Design access around facility for first responders (fire trucks) with winter operations in mind.
    - Gravel
        - Consider gravel availability; whether it must be brought in from an outside source.
        - If gravel is brought to the site, ensure there is adequate time in the project schedule to obtain and transport the material to the site.
        - Additional stockpiles of gravel may be desired by the owner for future use or for maintenance.
    - Identify prevailing wind direction during the winter. Verify with local knowledge/history. Layout should consider snow drifting.
        - Use NOAA winter precipitation and wind speed to predict snow drifts. Try and take climate change into account (More snow? More ice?)
    - Consider thermal system resiliency measures such as portable generators or boilers.
- Walkways
    - Provide covered walkways, stairwells, and entries. This will reduce icing which will reduce the amount of gravel and salt.
    - Provide heated sidewalks (also known as snowmelt) and stairs rather than salt and gravel.
        - Use waste heat if possible.
        - Where high efficiency, natural gas fired boilers are used, snowmelt systems provide an excellent secondary loop off of the return piping immediately before the boilers.
        - Snowmelt systems should be hot enough to evaporate the water rather than just melt the snow. Melted snow can generate ice sheets and cause higher hazards.
        - If the system will melt into a storm drain, the storm drain may need to be heat traced to ensure the water does not freeze in the storm drain.
        - Complete energy study to understand the expected annual costs associated with a snowmelt system.
    - Design steps and railings to facilitate snow removal.
    - Watch snow drifting and stairs. Avoid toe kicks/risers on built stairs as they will trap snow.
    - Design for ADA/Accessibility to/from facility as well as playground and other areas.
    - Segregate foot traffic from vehicle traffic.
- Parking Lots
    - Design parking lots to facilitate snow removal and storage.

        - Ensure adequate, and code required, parking places are maintained with snow storage locations.
        - Design for snow removal on access roads leading to parking lots.
    - Locate hydrants and utilities with snow removal in mind (reference Schedule O&M Task section).
    - Consider minimum slopes; 3% for gravel surfaces and 2% for hard surfaces.
- Site Lighting
    - Avoid light pollution. Keep lit area limited to facility property line.
    - Light the site from the building if possible. Reduces light poles that may present issues with snow removal.
- Playgrounds
    - Design equipment that is age-appropriate.
    - Use non-flammable materials (particularly surfacing materials).
    - Use surfacing materials that are appropriate for cold temperatures.
        - Materials must be impact resistant at design temperatures.
        - Avoid exposed metal surfaces that can damage children's hands at sub-zero temperatures.
- Landscaping
    - Do not put landscaping (trees, bushes, etc) next to the building.
    - Select vegetation that does not require regular maintenance or irrigation.
    - Plan for what the landscaping will look like in 5, 10, 15 years.
        - Do not locate trees below or around electrical overhead utilities.
    - For schools, consider outdoor education opportunities.
- Security
    - Provide chain link security fencing around the building perimeter of raised structures.
    - Utilize fencing to reduce foot traffic through site and limit access to lighted areas.
    - Do not put trees next to buildings that will grow and become access paths onto roofs.
    - If using RVs for off-season security, provide utility connections (electricity, water, sewer) for likely parking locations.
    - Provide CCTV cameras around the facility.
        - Beware of camera blind-spots. Cover areas that may be prone to transient camping.
        - Provide coverage of the parking lot.
- Storm Water
    - Research past history of dry well dependability on projects in area.
    - Do not expect storm drain systems to work in the winter and during spring break-up as they will likely freeze.
    - Consider site drainage from sloped roofs.
- Water Wells
    - Clearly locate well heads.

- Variable frequency drives should be specified with some level of graphical user interface. Integrate the drive information into the BAS/SCADA system including failure alarms.

- Sanitary Sewer
  - Avoid lift stations if at all possible. Use gravity waste wherever possible.
-
  - Do not locate septic systems under playgrounds. Anticipate what will be impacted if/when the system backs up.

BUILDING ENVELOPE

Scheduled O&M Tasks

- General
  - Immediately address vandalism.
- Envelope
  - Walk the grounds daily
    - Ensure windows are closed.
    - Identify peeling siding
    - Ensure exterior and interior lights are off.
    - Look for wall panel warping.
    - All wall and roof penetrations are sealed.
  - Semi-annually inspect windows to ensure proper operation and that they have good seals.
  - Annually inspect door, window, and roof hatch seals.
  - Annually inspect building flashings and building sealants, with particular focus on foundation system flashings and sealants.
  - Use an infrared camera to inspect the building envelope annually.
    - Will identify leaking gaskets/seals as well as settling that may have created gaps in the envelope.
    - Roofs and wall panel systems are best evaluated early in the morning during swing seasons so that snow and solar heat gain do not mask water saturated materials and thermal bridging.
      - Wet insulation will appear warmer than dry insulation.
    - Capture the images and compare with previous inspections. This will highlight issues such as slow deterioration of insulation/envelope systems and water migration.
      - This is best accomplished if the surveys are conducted during the same time of year and day.
  - Seal rodent/wildlife entrances with heavy gauge metal. Squirrels can chew through bird-screen, expanded metal is better though be mindful of frosting with smaller dimensions.
- Roof
  - Walk flat roofs at least once a month.
    - Ensure membrane is still secure.
    - Remove debris including dirt that may start growing vegetation.
    - Remove any sharp objects immediately.
    - Inspect flashing to make sure it is secure and sealed.
    - Walk the roof after rain cycles and look for standing water.
  - Have roof warranties, including project number and manufacturer contact info, laminated and prominently affixed at all roof access points.

- For sloped roofs, look for ice damming and warm spots. May be a sign of damage to the roof/insulation system that may expand to rot and mold if not fixed.
  - Manually activate snow slide-off rather than waiting for large amounts of snow and ice to release on their own. Large snow and ice falls can harm pedestrians below as well as create building damage (sheared roof vents, broken windows, etc.).
- Annually check cold attics for mold, insulation integrity, and condition of structural trusses.
  - Check cold attic venting system to ensure baffles are clear and system is operable.
- Annually clear the roof, roof gutters, downspouts of debris at the end of fall.
- Ensure heat trace systems are working prior to the heating season.

Capital Improvement Upgrades

- General
  - Upgrade materials with vandal proof coverings or systems.
- Envelope
  - Consider envelope insulation upgrades. It is better to add insulation to the outside of a building than to the interior. Interior insulation may create dew points on the warm side of the vapor barrier (unless the vapor barrier is also relocated during the renovation).
    - Window and door upgrades traditionally have a quicker payback than wall insulation upgrades.
- Windows
  - Replace windows after 20 years.
  - Replace seals with high quality materials.
- Roof
  - Increase roof insulation and sloping during replacement. Verify with structural engineer that the roof structure can handle the additional insulation and snow load.
    - Verify if existing roof drain locations are adequate (based on standing water).
    - Verify that overflow drains and/or scuppers are existing. Add if needed.
    - Replace all roof drains and overflow drains.
  - Consider replacing mechanical equipment and other systems that are on the roof near the end of their useful life as part of a roof replacement project.
    - Coordinate having mechanical system upgrades prior to roof replacement projects. Mechanical modifications may result in unneeded roof penetrations.
  - Add/Upgrade interior roof access during roof projects.
  - Add snow guards/ladders on metal roofs where snow sliding can impact building entries and exits or be dangerous to pedestrians/equipment below.
- Doors
  - Replace exterior doors after 20 years.
  - Replace corroded doors.
  - Replace seals with high quality materials.
- Replace windows that are single pane, leaky, or non-functioning.

- Repair exterior gaps in walls to protect building envelope.
    - Ensure gaps are not due to building settlement.
- Include ADA/Accessibility upgrades.

Design Best Practices to Support O&M

- General
    - Design around master plan including future expansions, site developments, etc. Note what future work has been taken into consideration on the construction documents for future designers and owner's knowledge.
    - Consider requiring mock-ups of building envelope and penetrations, particularly for remote sites. Define the requirement clearly in the specifications.
- Building Massing
    - Orient building, entries with predominant wind direction in mind.
    - Simplify wall angles for snow removal and maintenance. This also reduces heat loss and typically provides for a higher quality vapor barrier installation.
    - Identify snow drifting locations. Verify with local knowledge and history.
    - Set building floor-to-floor heights to provide adequate above-ceiling space for maintenance of lights and future renovations.
        - Congested ceilings add to maintenance costs due to difficulty of reaching/maintaining systems. This may include the need to remove and reinstall piping, ductwork, lights, conduits, and/or ceilings to gain access to the item needing repair.
        - Do not design building height around specific mechanical systems such as VRF or DOAS. Future renovations may require routing piping or ductwork through limited space.
    - For elevated structures, ensure there is enough room below the building for wind scouring.
        - Consider having a crawlspace below the main floor for piping (waste primarily though this is an excellent path for hydronic heating piping) rather than having the piping in the subfloor. Below building panels will always leak once they are accessed. Leaking water piping will compromise below building soffits.
    - If using thermosyphons or heat pipe pilings, verify there will be proper airflow across condenser fins. Verify at schematic level of design.
    - Locate mechanical fan rooms and air intake locations with good indoor air quality in mind. Watch for proximity of idling vehicles and boiler flues. Look at wind patterns that occur throughout the year.
        - Mechanical rooms located centrally in the building have lower electrical costs due to less pressure drop in piping and ductwork.
    - Watch cold roof/attic vents for rodent (squirrel) access. Squirrels can chew through bird-screen so heavy gauge expanded metal is preferred.
    - Provide vestibules at public entries.

        - Provide overhangs over all entry and exit doors (including boiler room access).
- Materials
    - Be mindful of corrosive environments such as coastal locations.
    - Be mindful of winter temperatures and do not use exterior materials that may catastrophically fail if impacted or torqued during cold temperatures (PVC).
    - Use vandal-resistant material coatings.
    - Use aluminum or fiberglass materials in corrosive environments.
    - Consider higher UV protection on southern and western facing materials.
    - In general, provide low-maintenance materials.
        - Avoid painted wood.
- Building Envelope
    - Design a robust building envelope with insulation values that exceed ASHRAE 90.1 requirements.
        - High insulation values and a well designed vapor barrier will make the mechanical systems smaller as well as reduce long term utility costs.
    - Select siding appropriate for the environment, i.e. be mindful of corrosive environments.
    - PVC/Vinyl siding is brittle in cold temperatures and can be easily broken by rocks, hands, or balls.
        - These materials are cost effective and maintenance free, use in areas not prone to impact.
    - Allow exterior cladding systems to drain (i.e. weep holes).
    - Design exterior walls that can't be climbed.
    - Assume all sealants will fail.
    - Clearly detail door and window sealant systems.
    - Detail and clearly specify vapor barrier and wind screen sealing.
        - Consider having building envelope testing/commissioning either via blower door or thermal imaging inspection. Include testing performance requirements in construction and commissioning documents.
        - Vapor barriers must be continuous around the perimeter and the roof prior to interior studs being installed.
            - Plumbing walls that are perpendicular to exterior walls sometimes have non-continuous vapor barriers and will freeze under high wind conditions. Same with non-continuous cold roof vapor barriers on internal plumbing walls.
    - Consider using furring on the inside of the building vapor barrier. This will keep reduce penetrations (wires, piping, etc.) in the vapor barrier and also make it easier to fish wiring down exterior walls in the future.
- Windows
    - Use high quality glazing and window systems.
    - Do not use "Tilt-Turn" windows.

- Design for passive solar opportunities.
- Use smaller size operable windows that can be more easily operated. Smaller windows, if broken, do not cost a lot of money to replace.
- Avoid skylights. They are prone to leaking.
- When designing clerestory windows, provide enough height above the adjacent roof to adjust for snow drifting.
- Consider interior shading for southern exposure windows. This can significantly reduce HVAC cooling loads.
  - Coordinate shading systems with maintenance staff. These can be high-maintenance items.

- Roof
  - Avoid "hot" roofs. Provide adequate ventilation for cold roof ventilation.
    - Be mindful of mechanical exhaust locations so that they do not exhaust heat and moisture into the cold roof vents.
  - Access
    - Provide interior access points to the roof. Exterior ladders are dangerous to use in the winter. Portable ladders are even more dangerous.
      - Avoid using ladders to go from one section of the roof to another section.
    - Provide horizontal access to the roof (i.e. through a door) if possible. Difficult to bring tools and spare parts up ladders.
  - Minimize stepped roofs and complex roof geometry.
  - Sloped Roofs
    - Do not slope roofs onto building entries and exits.
      - Be mindful of walkways and parking spots in falling snow/ice zone.
    - Weigh steeper pitch roofs to remove snow verses lower pitch roofs.
    - Metal is a durable material for roofs but the design team must control snow and ice shedding for safety and property damage.
    - Mechanical penetrations to be located as close to the peak as possible, detail in the drawings diverters/"crickets" upstream of penetrations to protect them from damage from shedding ice.
      - Ensure crickets are designed for anticipated depth and weight of sliding snow. Larger is better.
    - Do not slope big roofs onto small roofs or flat roofs without design for handling snow/ice shedding. This may damage the roof membrane.
    - Provide careful detailing of ridge vents to prevent water intrusion.
  - Flat Roofs
    - Provide anchor points where applicable to support maintenance access/activities.
    - Avoid roof payer systems. It is difficult to locate leaks.
    - PVC roofs should be avoided – slippery. Surface not as durable.
    - Specify heavy 80-90 mil membrane EPDM.

- Be mindful of snow drifting locations. Do not locate equipment in areas that may be covered in snow or that drifts may make maintenance access difficult.

FINISHES, FURNISHINGS, AND FLOOR PLAN

Scheduled O&M Tasks

- Have in place infection control protocols if applicable.
- Custodial
  - Clean spills and stains in a timely manner.
  - Utilize all-in-one cleaning carts.
  - Maintain custodial equipment.
  - Regularly reevaluate cleaning products.
  - Use manufacturer recommended cleaners/chemicals.
  - Address vandalism as soon as possible.
- Entries
  - Clean walk-off mats daily.
- Flooring
  - Post signs on exterior doors to remove snow cleats at entrance.
  - Keep all flooring systems sealed watertight, particularly near entries.
  - Replace chipped flooring as soon as possible. Water damage will erode subfloor.
- Keep ample spare parts on hand for FF&E and casework.
- Use a thermal imaging camera to identify frost or damp interior surfaces as that may be an indication of failing vapor barrier or building envelope system. Without a camera, dirt will slowly accumulate over these surfaces.
- Training
  - Consider the capability of staff to complete maintenance tasks.
  - Have training programs for custodial staff.
  - Ensure that staff knows what chemicals to use and how to clean/maintain surfaces.
  - Reference Operation and Maintenance manual for recommended cleaning methodology.

Capital Improvement Upgrades

- Evaluate finishes regularly to identify if they need to be replaced or just renewed.
- Purchase custodial equipment specifically appropriate for the surfaces/materials in that facility.
- Entries
  - Repair/Replace walk-off mats regularly.
  - Add benches to facilitate removal of ice cleats.
- Flooring
  - Upgrade gym floors. Rubber/urethane floors can be restored by just adding a thin-layer of new material rather than having to replace the whole floor system.
  - Replace classroom carpeting with vinyl flooring. It is healthier, better for indoor air quality, and easier to clean.
  - Replace carpet and walk-off matts with modular/carpet squares.

- Finishes
    - Complete small upgrades to finishes such as patch/paint surfaces.
    - Upgrade wall surfaces to durable or water proof (FRP) materials based on use.
- Provide new signage (including braille).
- Replace chalk boards with whiteboards.
- Recapture facility square footage by reworking storage.
- Furniture, Fixtures and Equipment (FFE):
    - Replace broken furniture. A lot of maintenance time can be wasted fixing FF&E and many systems can only be repaired so many times.
- In seismic active locations, inspect ceiling systems for proper support. Verify lights, diffusers, and other hanging items within the ceiling are independently supported.

Design Best Practices to Support O&M

- General
    - Use appropriate materials for the environment and usage.
    - Design around longevity, durability, and cleanability.
        - Select materials that will age gracefully, "aging" in place.
    - Consider doing mock-ups of rooms to facilitate discussion with users and to define spatial needs.
    - Ensure that a robust Operations and Maintenance manual is provided that includes make and model for all finish materials (paint, carpet, ceiling tiles, etc.) for future patching as well as robust repair information (FF&E, casework, door hardware, etc.). Include all warranties.
    - Use actual exterior wall and interior wall thicknesses to assess square footage and space planning.
    - Select materials that have low/no off-gassing.
    - Specify ample additional/spare materials.
- Custodial
    - Involve custodial staff in design process.
    - Consider the capability of staff to maintain the finishes.
    - Avoid surfaces that require special cleaners/chemicals to clean. Consider transportation of chemicals to site and storage (heated/unheated).
- Entries
    - Provide arctic entries/vestibules at all entrances.
        - Design effective length/offset of entry so that outside door is closed before indoor door is opened.
    - Incorporate extensive walk-off mats.
    - Consider ways to minimize gravel/dirt coming into the facility to eliminate walk-off mats such as snowmelt or grating outside and/or inside the facility.
    - Incorporate benches to facilitate removal of ice cleats.

  - Do not build arctic entries with really high ceilings. It is difficult to keep heat at the floor level to melt snow and evaporate water.
  - Provide space for wall mounted, inverted flow cabinet unit heaters so that they can melt any tracked in snow and ice.
    - Provide double stud wall to fully recess the cabinet unit heater to minimize enclosure damage. Coordinate depth with mechanical engineer.
- Floors
  - Provide durable flooring to handle freezing temperature and moisture (melting snow, mud, etc.)
  - Utilize subfloor moisture mitigation techniques/coverings.
  - Use carpet squares.
- Finishes
  - Design around durability.
  - Design around standard paint colors already in use in the facility.
  - Use vandal and impact resistant surfaces.
  - Use color/patterns that are timelessness
  - Design bathroom wall and floor finishes to facilitate hose spray-down cleaning techniques.
- Materials
  - Design around durability.
  - Select materials that look the same throughout such as wood and terrazzo so that sanding/refinishing can be done with minimal notice.
  - Do not specify systems with wax finishes. They require regular maintenance.
  - Use quality solid surfaces for counters and flat surfaces that the public can reach.
  - Avoid using soft surfaces. They increase allergies, the spread of disease, and other pathogens.
- Ceiling:
  - Use 2x4 ceiling tiles rather than 2x2 tiles to improve above ceiling reach and maneuverability.
    - Do not use oversized tile sizes that are difficult to raise, can easily become damaged when accessing, or will be difficult to find replacements in the future.
  - Use standardized ceiling tile pattern and color that is readily available for future replacement. Require several boxes of spare tiles at end of project.
  - Specify fiberglass ceiling tiles. They are lighter, have the same durability, same Noise Reduction Coefficient (NRC) and have the ability to dry out if there is a leak.
  - Coordinate ceiling plan to provide access to MEP systems.
    - Designate access tiles on the Reflected Ceiling Plan sheets so that sprinkler heads, smoke detectors, and other performance specified items are not located in key access locations (i.e. VAV box access).
  - Locate lights so they are accessible for maintenance and can be replaced.
- Furniture, Fixtures and Equipment (FF&E):

  - Design with future flexibility of room layout and use in mind.
  - Design with actual dimensions of specified equipment.
  - Provide ample storage space for FF&E in multi-use spaces like gymnasiums and conference areas. Provide additional space for future furniture styles.
  - Coordinate FFE with all design disciplines, specifically electrical for power and data connections.
  - For schools, standardize classroom technologies (smart boards, computers, etc)
  - Select furniture that is easily reconfigurable without having to call maintenance.
    - Require training in specifications for how to operate furniture. Require diagrams that users can be provided.
  - For schools, design versatile classrooms that can be used for different activities and teaching styles.
  - Seismically strap tall furniture to the wall.
- Casework
  - Use plywood with veneer surface rather than particle or press board.
  - Use institutional grade casework for high-use areas.
  - Design lots of storage space into classrooms.
  - For schools, provide ample space for student snow gear, boots, regular shoes, backpacks, etc. Provide space for future larger class sizes.
- Doors
  - Utilize owner standardized hardware
  - Use Five Knuckle – Ball Bearing type hinges
  - Coordinate power, security, and communications requirements with electrical engineer.
- Floor Plan
  - Storage
    - Provide lots of storage, both inside the building and on the site for unheated storage.
    - Provide storage for snow removal and landscaping equipment. If exterior, provide power for battery chargers and lights.
    - Coordinate with Facilities on storage requirements for spare parts. Designate on the plans what storage is for spare parts so that other users do not assume it is for office supplies.
    - Provide more storage for school and maintenance functions.
    - Provide adequate storage for janitorial supplies inside janitor closets.
  - Ensure building has space for a workshop for onsite repairs and maintenance support.
  - Minimize the use of moveable walls/partitions.
  - Do not put plumbing fixtures on exterior walls.
    - Exception is if a furred plumbing chase is provided interior of the warm side of the vapor barrier and an accessible heat source is provided within the chase.

    - Identify temperature conditions for each room/zone. Some spaces, such as storage rooms, may be able to be kept at lower temperatures or even non-heated.
        - Provide insulation and potentially a vapor barrier in the walls between interior rooms of considerable temperature difference.
- Sound
    - Identify sound/privacy sensitive areas.
    - Provide sound batt in all mechanical room walls.
    - Provide sound batt on restroom walls as appropriate.
    - Utilize acoustical treatments to offset hard surfaces.

STRUCTURAL SYSTEMS

Scheduled O&M Tasks

- Identify new wall, floor, or window cracks.
    - Small cracks are generally not an issue.
- Look for doors and windows that don't close properly.
- Don't let staff cut, modify, or drill holes in wood, steel and concrete structural members.
- Develop guidelines for concrete floor cracking
- Identify and fix building envelope (roof, exterior wall, windows) leaks.
    - They lead to dry rot and if not addressed can lead to extensive (costly) repairs or even structural failure.
- Where rust is found, remove rust, prime surface with rust inhibiting product, and paint/seal.
    - Note that there is some steel, often referred to as weathering steel or "corten", which is designed to rust with the resulting oxide providing the protective cover.
- Use infrared camera to identify water penetration or condensation locations. These can identify rot and damage structural members.
- Foundations
    - Identify and remove vegetation that may be growing around foundations.
    - Keep up on yearly shoring/leveling of foundations/piling.
    - Annually verify thermosiphons and active freeze-back systems are charged and operational.
- Examine welds and bolted connections. Particularly where exposed to the weather.
- Verify integrity of lateral and shear bracing.
- Annually look at fire proofing above the ceiling and at assemblies.
- Annually washdown exposed structural members (raised construction) to reduce corrosion.
- Seismic
    - During routine maintenance activities, verify that seismic restraint systems are in place including equipment, ceiling systems, and lights.
    - Ensure that storage (water, fuel, etc) tanks are secure.
- Document additional permanent structural loads a it happens.

Capital Improvement Upgrades

- Complete Tier 1 Seismic Evaluation of the facility.
    - If deficiencies are identified in the Tier 1 report, there may be grant money available from FEMA to complete a more in-depth evaluation.
- Complete condition survey of existing seismic bracing in the building (ceilings, equipment, lights, etc.)
    - Fund upgrades with CIP as seismic upgrades.
- Have structural engineer review all seismic deferred submittals.
- Fund/perform structural maintenance to correct known failures before they cause major issues.

    - This is particularly important for thermosiphon and active-freeze back systems.
- If buildings are settling, schedule annual shoring/leveling of the system.
- Install system to monitor building movement.
- Install thermostat strings to monitor ground temp.
- Evaluate and plan for climate-change related impacts to structural foundations.
- Evaluate storage areas for allowable weight capacity and post signs with maximum loading.
- Always hire a Geotechnical Engineer for new construction and additions.

Design Best Practices to Support O&M

- Design for the specific location including seismic, wind, snow, flooding, soils and potential future changes in soil conditions.
- Design:
    - Design for future expansions/renovations.
        - Avoid using load bearing walls as it makes renovations difficult and more costly.
        - Consider future usage changes that may affect live and static loads.
    - Show all design loads (wind, snow, storage, etc.) on drawings so they are included in Record Drawing archives.
    - Design to avoid thermal bridging between exterior structure and interior structure
    - Coordinate supports for large diameter piping and heavy equipment. Coordinate anchor load points for piping system expansion and thrust loads.
    - Coordinate routing of duct mains, piping mains, and cable tray to maximize above-ceiling maintenance access.
    - Specify signage to be posted in storage areas noting maximum PSF loading.
    - Coordinate columns, shear walls, and brace framing to ensure equipment removal access is maintained.
    - Consider exposed structural members to reduce covering material as well as make inspections easier.
- Foundations:
    - Have Geotech survey completed to verify permafrost, ice lenses, and other soil abnormalities.
    - Consider the potential of foundation settlement in the future.
        - Same with heaving. Provide adequate depth of NSF fill.
    - Install temperature sensor strings to monitor foundations, integrate into BAS for trending.
    - Provide an adjustable foundation where settling may occur (climate change)
    - Avoid concrete slab on grades in areas of permafrost
    - Triodetic foundations are fantastic for skirting ground and flood zones for smaller buildings, (< 10,000 SF).
- Consider galvanizing or epoxy coating rebar.
- Thermosyphons and active freeze-back

    - Coordinate with mechanical on locations of exhaust and relief air.
    - Design for future warmer temperatures (additional fins, conversion to active system, etc)
    - Protect perimeter syphons from damage from vehicles and falling snow/ice.
    - For active freeze-back, see if there is a way to utilize the heat from the system to heat interiors of the building. But have back-up systems in case heat is not required (during the summer).
- Avoid timber and beam construction. Use structural steel for long term durability
    - However timber framing provides a warmer and softer feel for the building occupants
- Framing
    - Light frame construction is less expensive and may be a better option for smaller facilities, however it does have a higher long-term maintenance cost compared to heavier construction.
    - Larger facilities should be constructed with more durable materials such as steel or concrete.
- Roof
    - Coordinate structural design for anticipated snow drifting areas. Strengthen structure as opposed to building roof wedges
    - Add and show joist connectors/hold-downs.
- Exterior Construction
    - Provide cold temperature rated materials.
    - Specify exterior fasteners to be hot-dipped galvanized (HDG or galvanized) or stainless steel.
    - Evaluate corrosion potential, particularly on coastal areas.
    - Galvanize exterior steel.
        - For extreme/coastal areas, consider both galvanizing with additional painting or epoxy coatings.
    - Avoid exposed exterior beams, particularly structural steel members, that penetrate the thermal envelope
- For treatment plants, or other types of facilities with interior corrosion hazards, design all interior structural systems with corrosion in mind (galvanized coatings, stainless steel fasteners and members, etc).
- Seismic
    - Show seismic design criteria are provided in structural documents for current and future reference.
    - Ensure mechanical engineer has seismic restraint covered in their specifications including the requirement for deferred submittals on seismic bracing and calculations.
    - Coordinate seismic joints with all design trades early in the design.
        - Coordinate and document offset distances at each floor at each joint (it does change with elevation).
- Cover/Conceal wooden structures that would otherwise be exposed to the weather.

- Exposed structural steel is easier to inspect.

MECHANICAL SYSTEMS

Scheduled O&M Tasks

- Walk through mechanical rooms daily
    - Record/Document mechanical system performance (system pressures, operating temperatures, etc.) on a daily/weekly basis.
        - This helps identify slow changing conditions (such as decrease in system pressure) but also provides the Facilities Manager that walks are being completed.
        - Heating system pressures to be read at expansion tank if possible. If not, use pressure gauge at boiler. Maintaining a system minimum pressure reduces air entrainment which can reduce heat transfer as well as increase interior corrosion.
            - Minimum system pressure can be calculated by taking the height of the building in feet divided by 2.31 (to convert to psi) plus 5 psi. If boilers are in a basement, include height of basement.
    - Be sure staff who complete the walk through know to look for and notify Facility Management about any leaks and abnormal sounds.
- Walk through occupied spaces once a week to identify warm/cold spots. Ask staff about comfort in the rooms.
    - Make sure that finned tube radiators do not have obstructions placed along the top (if flat) and also under the units that will block natural convection. This is a common reason for cold calls.
- Verify doors between heated and temperate/non-heated spaces (such as vestibules and garages) remain closed.
- Look for open windows. This may indicate an unreported HVAC space temperature issue.
    - It is also a security risk.
- Plumbing
    - Know where water isolation valves are located throughout the facility.
        - Install ceiling identification tags to be able to quickly locate in the future.
    - Clearly document where each water entrance into the building can be found so that it can be quickly turned off if a major leak occurs.
        - If there are multiple locations, but maps of the building showing the locations in each water entrance room (so you know where the others are) and at a central location available to non-maintenance people such as the Admin desks.
    - Ensure there are seals between plumbing fixtures and floor/wall surfaces and that they are in good condition.
    - Annually take domestic water samples and send them in for testing. Get samples at water entrance and end of line fixtures. High minerals and/or copper can be signs of corrosion issues.
    - Immediately isolate and fix any leaking pipes, faucets, and fixtures prior to additional damage.

        - Water overfilling inside tank-type water closets can result in significant water usage costs.
    - Ensure that plumbing Vents-Through-Roofs (VTR) do not frost over.
    - Do not use 'Y' fittings on janitor sink or hose-bibb hose thread connections. These counteract the backflow prevention device and can cause cross contamination as well as hot/cold migration.
        - For exterior hose bibbs, this will keep it from draining and freeze/burst the hose bibb.
    - Water Heaters
        - Flush out bottom of tank annually to remove sediment.
        - Check sacrificial anode annually and replace as needed.
        - Check operation of Pressure Relief Valve (PRV) annually.
        - Annually verify the discharge temperature of tempering valves.
        - The manufacturer recommends that pressure relief valves be replaced every five years.
    - Traps
        - Every couple of years, power wash through floor drains to clear debris and built up dirt.
        - Inspect to ensure trap primers are working. Shine a flashlight through the floor drain to facilitate seeing water.
        - If trap primers have failed, regularly top off traps with mineral oil as it will not evaporate like water and will not go rancid like vegetable oil.
            - There are some mechanical trap seals on the market, such as the Trap Guard, that reportedly allow water to go through.
            - If a trap primer is not near a restroom, it may not be activating and may need to be replaced with an electric type unit that is not dependent on pressure fluctuations.
- Heating System
    - Provide isolation valves on automatic air vents and keep them isolated in most locations. These will "spit" from time to time, damaging ceiling tiles.
    - Have heating system fluid annually tested for pH and inhibitors. For glycol, check glycol concentration. Take sample and mail it in for testing and recommended treatment. pH strips may not provide the whole story on water/glycol quality and aggressiveness.
        - Never have a glycol system get make-up from water. This will lead to a slow dilution of the glycol and ultimately freezing coils. Isolate the system and have it connected to glycol make-up tanks or manual pumping.
        - Always use the same type and preferably brand of glycol. Mixing inhibitor packages can be very detrimental to the heating system.
    - Verify fuel fired condensate neutralization systems and any lab acid neutralization systems have adequate neutralization media.

        - Mix up neutralization media within the vessel to ensure liquid has good contact with the media before being discharged into the waste system. Condensate can create a straight tunnel through the media that is not visible from the exterior.
        - Condensate will disintegrate cast iron pipe if not neutralized.
    - Replace inoperable gauges. Ensure that replacement gauges are of the right temperature/pressure range to accurately show performance.
    - Consider rebalancing the hydronic system every 10 years back to design levels. If occupants are comfortable, this may not need to be completed.
    - Fuel Fired Appliances
        - Annually inspect fuel fired equipment and fuel distribution piping/equipment.
        - Annually inspect fuel fired equipment flues for cracks.
        - Annually inspect indirect fired heat exchangers for furnaces, air handlers, and other devices that distribute air to occupied spaces.
        - Plug carbon monoxide detectors inside rooms with fuel fired devices.
    - Make sure that all boilers and pressure vessels are registered with the State of Alaska.
        - Expansion tanks that are over 120 gallons and connected to pressure relief valves above 30 psi also need to be registered as unfired pressure vessels.
    - Boilers
        - Complete annual boiler inspection.
            - Some insurance agencies, such as the Alaska Municipal League Joint Insurance Association, provides their members free boiler inspections.
        - Annually test all safeties manually. Verify alarms come through on the BAS/SCADA system.
        - The manufacturer recommends that pressure relief valves be replaced every five years.
        - Verify that the PRVs are replaced with the correct pressure and BTU output for the appliance and system.
    - Heat Exchangers
        - Annually or every two years, isolate and back-flush both sides of heat exchangers to remove debris that may clog the equipment or reduce heat transfer.
        - Add strainers with blow-down isolation valves on both inlets to heat exchangers. Annually blow-down the strainer.
        - Verify if there are pressure relief valves on the heat exchanger side of isolation valves. If not, expansion from heat transfer when isolated may damage the system.
    - Terminal Heating Devices
        - Every couple of years, vacuum out finned elements. Depending on size of facility, this may be best accomplished with a rotating schedule.
        - Cycle manual air vents to remove any trapped air. This will need to be completed after any major leak or maintenance activity but also just as a standard item when convenient.

- Ensure that system is at its appropriate positive pressure at the expansion tank. Otherwise, opening manual air vents can introduce air into a system.
- Test water heat-add systems prior to the heating season.

  - Expansion Tanks
    - Annually check expansion tank for bladder failure. Pressure relief activation is likely a symptom of a failed expansion tank.

- Ventilation
  - Document locations of all filters and replace air filters on set schedule.
    - For air handlers and other items that operate year-round, it is recommended to change the filters quarterly. Can be changed based on pressure drop.
    - For equipment that has summer/winter filter configuration, typically where there are preheat coils, ensure that only one set of filters are installed. Having both filters installed only increases pressure drop and therefore energy usage and likely decrease system performance.
  - Complete bearing lubrication at recommended intervals.
  - Annually check motors for vibration and belt tension.
  - After motor replacement, ensure that fans are rotating in the correct direction.
    - Especially in three phase power, it is possible to wire them to operate backwards resulting in diminished performance.
  - During the winter, regularly check for frosting of intakes and filters.
    - Check for snow in outside air intakes.
  - Annually check coils for debris.
  - Verify damper actuators are operating and connected to shafts.
  - It is recommended that duct systems be cleaned every 10 years. Coils should be vacuumed/cleaned at that same time.
    - It is recommended to rebalance the ventilation system at this time. Cleaning often times changes the location of manual volume dampers.
    - Duct cleaning often times requires the inclusion of additional access doors. If the facility requires regular cleaning (i.e. hospital or school), consider adding access doors at time of construction.
- Fuel
  - Check fuel storage tanks for water prior to the heating season.
  - Do not let standby fuel (stored for generators or dual fuel applications) get old. Operate standby generators and dual fuel boilers regularly to both use the fuel and ensure system will be operable when needed.
    - Annually test standby-storage fuel. These fuels do need to be replaced over time.
  - Annually inspect storage tanks for signs of corrosion.
    - For buried tanks, check cathodic protection/sacrificial anodes annually.
  - Regularly check flue caps to ensure they are not freezing.
- Fire Suppression

  - Ensure that the sprinkler riser room door is clearly identified.
  - Recommend creating fire/safety plans showing the location of all fire extinguishers, Automated External Defibrillators (AEC), pull stations, sprinkler risers, and all building water entrances.
    - Locate framed/laminated signs at fire alarm panel as well as in conspicuous locations so the public can know where the devices are located in case of an emergency.
  - Make sure that all facility staff know where the sprinkler riser room is, how to unlock/access it, and how to shut off the water. Accidental sprinkler head damage can result in significant water damage if not immediately turned off.
    - Have plan in place to remediate water discharge from sprinklers. Activate it ASAP after an event to prevent extensive and costly water damage.
    - Not only will there be a lot of water, but it will also be black, oily, and foul-smelling.
  - Complete inspections and fire pump tests at recommended intervals.
  - Do not let staff hang anything below skylights that have sprinklers in them. Covering will pool the heat and set off the sprinkler.
- Corrosion
  - Identify and fix leaking valves and piping immediately.
  - Do not let copper or steel piping touch ceiling grids or other structure. Stray currents from lights and appliances will create electrolysis.
  - Complete ultrasonic testing (UT) on water and heating pipes every couple of years to check for interior corrosion/scaling or thin walls from aggressive water.
  - When pinhole leaks occur in piping, remove the section of pipe and send it to the Facility Manager for inspection. Cut pipe in half and identity why there was a leak. One leak may be a symptom of a greater issue and give you time to schedule a major CIP replacement before eminent system-wide leaks/failures occur.
- Building Automation System (BAS) or SCADA
  - Look at alarms and automation reports daily.
  - Look at room temperatures at least once a week.
  - Have extensive trends setup for all troubleshooting/diagnostic points.
  - Check trends of system operating/discharge temperatures twice a month.
  - Check occupied/unoccupied trends twice a month to ensure systems are off.
  - Do not override alarms unless item is fixed.
  - Do not put normally automatic functions in manual override.
    - Monthly run a report to identify what systems are currently in manual override.
  - Ensure night time/unoccupied mode setbacks are in place.
  - Closely monitor building humidification levels and have alarms. Too high of humidity (such as in pools) can quickly ruin a building envelope in cold climates.
  - Closely monitor building pressure.
    - Too low of building pressure will increase infiltration which will increase utility costs.

        - Too high of building pressure may push water vapor into the building envelope and ruin the envelope.
    - Calibrate demand ventilation control sensors (CO2) at recommended intervals. Even if equipment says it does not require calibration, check calibration every two years. This can be a significant energy waste.
- Training
    - Train facility staff on how the systems are intended to operate. No two facilities operate the same.
    - Train Users on how to use and properly set thermostats.
        - Minimize setpoint range through BAS system from 68-72 degrees F.
    - Train Users on how to maximize energy efficiency (lights, thermostat setpoints, etc).
    - Ensure that staff understands not to put books or other obstructions on top of baseboard, floor vents, or unit ventilators that will block heat or ventilation from getting into their space.

Capital Improvement Upgrades

- Replace equipment, particularly boilers, on a predictive-maintenance schedule.
- Install Variable Frequency Drives
    - Ensure that shaft grounding gets installed on fans at the same time.
    - Protects motors from brownout conditions.
    - Replace all fan inlet vanes with VFDs.
- Upgrade motors with higher efficiency motors.
    - Consider replacement of motors with ECM technology.
- Consider replacement of equipment with higher efficient equipment.
    - Oil fired boilers should all now be 3-pass designs rated for 87% efficiency.
    - Gas fired equipment can be “high efficiency” but consider the existing operating conditions/temperatures and how often the equipment will be condensing. Weigh if the additional maintenance costs associated with condensing operation is worth the utility savings when operating in condensing temperatures.
- Identify waste heat opportunities from within facility as well as within community.
    - Look for air-to-air heat recovery opportunities.
        - Enthalpy wheels have higher maintenance than static systems.
    - Consider Combined/Heat Power (CHP) solutions.
- Replace underground fuel tanks with above ground fuel tanks.
- Provide under/over voltage protection for equipment with circuit boards or prone to failure.
- Anticipate that building alterations may trigger International Existing Building Code requirement to upgrade building-wide life-safety measures including suppression and detection..

- Ensure that Record Drawings include field measurements for exact locations and depth of interior and exterior below grade piping, particularly waste piping systems that may be connected to in the future.
- Construction
    - Ensure that all thermometers/gauges can be easily viewable from the floor/platform.
    - Ensure that all seismic devices are installed before Owner Occupancy.
    - Require pipe and equipment identification. Duct identification where appropriate.
- Building Automation System (BAS) and/or SCADA
    - Upgrade pneumatic controls to electronic or full Direct Digital Controls.
    - Integrate night/unoccupied mode setbacks.
    - Replace or recalibrate sensors on recommended intervals. Particularly CO2 sensors.
    - Simplify systems.
    - Add automation and remote monitoring.
    - Select contractors based on performance during construction and most importantly on support after construction. Complete research on BAS firms from similar Owners/School Districts.
    - Specify "open" communication protocols such as BACnet or LonTalk. Specify system architecture to reduce proprietary networks that keep you locked into a specific vendor.
    - Consider installing analytics-driven monitoring software, sometimes referred to Monitoring-Based Commissioning, Ongoing Commissioning (OCx), and Fault Detection and Diagnostics (FDD) software. These systems can be from a separate party than the BAS provider. The system constantly monitors the BAS communication network looking for abnormalities that may be symptoms of failure or excessive energy use. This is a new service in the industry.

Design Best Practices to Support O&M

- Keep it simple.
- Planning Stage
    - Engage facility staff at the beginning of a project. Consider having a mechanical-specific design charrette.
    - Identify zoning for off-hours use, plan equipment accordingly to minimize energy use for unoccupied areas.
    - Identify temperature setpoints/conditions for each zone. Some spaces, such as storage rooms, may be able to be kept at lower temperatures or even non-heated.
        - Be sure to provide insulation and potentially a vapor barrier in the walls between rooms of considerable temperature difference.
- Design
    - Meet with Facility Staff and review the design at major milestones. In addition to Facilities Director, include staff who will be maintaining the facility.
        - Design for ability to maintain.
    - Design simple, easy to maintain systems.

- Design around passive systems first, if possible.

- Design for the end user.
  - Bigger, more pieces and parts are not always better.
  - Not all maintenance personnel can operate all equipment. Design complexity around the capabilities of the staff on site.
- Utilize 3D/BIM software to identify tight installations.
  - Show valve tree locations for air handler coils in mechanical rooms. These are often times not shown and extend into walk-ways and other maintenance access points.
  - Design with the structural and electrical lighting models incorporated into the model so spatial issues that will impact maintenance can be identified.
- Drawings
  - Locate/Notate all isolation valves on the drawings, do not rely on specifications for installation.
  - Consider putting Sequence of Operations on the drawings rather than in the specifications. All equipment and performance information should be on the drawings. Specifications get lost.
  - Coordinate wall/ceiling access panels with architect. Specify sizes and ensure they are large enough to complete desired maintenance through.
  - Coordinate designated access ceiling tiles with architect for RCP. Otherwise, sprinkler heads and smoke detectors may be placed at VAV box access points.
  - Show manufacturer's recommended maintenance clearances around equipment.
  - Show NEC clearances in front of/around electrical equipment. Coordinate panel locations.
  - Provide schematics/diagrams for boilers, water heaters, air handlers, and other mechanical systems. Show BAS sensors, gauges, thermometers, drains, vents, and other maintenance related items.
  - Consider having a separate return and relief air path drawing that identifies above-ceiling transfer openings. This sheet is easy to share with the carpenters and sheet rock installers. It is a common occurrence that above-ceiling return air openings are covered over.
  - Keep all piping and ductwork within the thermal envelope.
    - Ductwork that goes into cold attic spaces, even if insulated, will condense warm/moist air from the space when not in use.
- Specifications
  - Clearly identify training and commissioning requirements. Reference General Building Section.
  - Clearly identify robust O&M manual requirements. Reference General Building Section.
  - Specify low point drains and high point vents.

        - Specify spare parts and tools to be provided with the project. Coordinate needs with Facility Management team.
            - This may include a laptop or tablet for remote BAS/SCADA system monitoring.
    - Consider making a mock up of mechanical spaces for Users and Facility Staff to review and have buy-in.
        - This can be accomplished with 3D BIM development either through extensive sections or even Virtual Reality "walk-throughs" or even goggles.
- Acoustics
    - Be mindful of location of equipment and nearby occupancies.
    - In general, it is best to provide acoustical insulation in all mechanical room walls. Coordinate with architect.
- Equipment
    - Select equipment and systems based on durability and maintainability.
        - Additional accessories that complicate the system may be more hurtful than helpful.
    - Centralize equipment.
        - Locate as much equipment as possible in mechanical rooms or accessible mechanical walkways.
        - Ensure mechanical rooms have both interior and exterior access.
        - Minimum 30" wide x 60" high access corridor to all parts of the mechanical rooms.
    - Locate all equipment on the floor or walls within 6 feet of the floor so that they can be reached and maintained without ladders.
        - Do not put anything heavier than 60 pounds more than 8 feet in the air.
        - Strive to keep all MEP maintenance items out of the ceiling if at all possible.
    - Avoid putting equipment on the roof in extreme cold or high snow accumulation regions.
    - Consolidate equipment into centralized locations.
        - Better to provide two pumps in a primary/back-up configuration than 15 terminal pumps that need to be maintained.
        - Same with exhaust fans.
    - Make sure all equipment can be removed and replaced through doors. Provide other openings, such as removable wall panels, for larger equipment.
        - If using large louvers to remove equipment, ensure louvers are of appropriate size and provisions have been made on how to get equipment elevated through opening. Be mindful of water entrainment from snow drifting against louvers that are extended to the floor.
    - Redundancy
        - Provide redundancy for critical systems (i.e. multiple boilers, primary/back-up pumps, etc.).
        - Discuss if manual bypasses should be provided on VFDs. Evaluate potential negative conditions if equipment is operated at 60 hertz.

        - Design redundancy and turn-down into the system to maximize efficiency during non-design conditions.
        - Verify lead time on parts. Provide redundant systems or complete spares.
    - Put structural rails/pull points above motors 15 hp and higher to facilitate motor replacement. Coordinate with structural.
    - Avoid 1,200 RPM motors. They are a very long-lead item. 1750 RPM motors are most readily available for replacement.
- Fuel Fired Appliances
    - Minimize the number of fuel oil fired pieces of equipment. Typically use central boilers, quantity based on providing appropriate redundancy.
        - Diesel spills are very expensive to fix and cause significant indoor air quality issues.
        - Utilize indirect fired water heaters and hydronic unit heaters for fuel oil locations.
            - Indirect fired water heaters require that the boilers and heating system operate throughout the summer.
        - Fuel oil fired furnaces are heavy maintenance and traditionally blow fuel vapors into occupied spaces.
    - Tanks
        - Use aboveground tanks.
            - Exception being propane tanks in temperatures below -40 which are better to have be buried.
        - Always use double wall construction.
        - Provide bollard protection and/or fencing.
        - Ensure easy access by refueling trucks.
    - Flues
        - Do not route flues up the outside of the building. The cold flue will create hard starts and condensate will corrode the stack.
            - Route flues within the warm envelope until the roof termination.
        - Locate flues so that they are never upwind of the outside air intake.
            - Temperature inversions can keep products of combustion low along the roof during the winter so do not rely on convection for separation.
        - For condensing gas appliances, consider using high velocity exit cones for flue roof terminations instead of caps. Caps tend to collect condensate which freezes and creates a maintenance/safety issue.
            - This is the preferred installation for liquid fuel fired appliances in Antarctica as well.
            - Be sure that the flue has a tee at the bottom with a drain so that any precipitation (rain/snow) that comes down the flue does not go into the appliance. Route drain to a condensate neutralizer.
        - Do not locate condensing sidewall flue terminations above public ways as condensate will drip and create ice on walking surfaces.

        - Be mindful of sidewall vents in high-wind locations as well as cold attic intakes.
- Pipe and Pipe Accessories
    - Consider using a plastic pipe like PP-R (Aquatherm) or PP-RCT (Niron) piping in place of steel or copper on new or major replacement projects. It is lighter and easier to install, is fused like HDPE and therefore reduces fire risk from torches during construction, and has a 10 year warranty against leaks.
        - Consult with an engineer and other School Districts (such as Mat-Su School District) familiar with this product.
        - Do not use PP-R with systems that have a lot of copper pipes still in the system as the copper can lead to catastrophic failure of the PP-R pipe.
        - Ensure that first project includes providing the School District the installation tools used at the jobsite. They are expensive tools to purchase through operating budgets and are needed for maintenance.
        - Plumbing rough-in terminations (angle stops and flush valves) need to be supported to structure. Otherwise flush valves will move and be prone to leaking.
    - Specify tracing/locating wire for all buried piping outside the building.
    - Valves
        - Provide a significant amount of isolation valves on all mechanical and plumbing distribution piping.
        - Provide valves upstream and downstream of all replaceable parts.
        - Valves, valves, valves. More isolation valves!
        - Use ball valves whenever possible. Gate valves have maintenance requirements and do not always fully isolate after a period of time.
    - Provide more unions/flanges at equipment and in the mechanical piping to facilitate maintenance.
        - Do not allow dielectric unions. Use dielectric nipples with bronze unions or flanges with isolation gasket kits.
    - Specify and show on the drawing details more high point vents and low point drains.
    - Specify and show on the drawing ample uses of thermometers and pressure gauges.
- Plumbing
    - Provide isolation valves on pipe mains outside of all restrooms and major fixture groups.
    - Provide isolation valves on all major branches of the building so that sections can be isolated without shutting down the whole building.
    - Plumbing Fixtures
        - Do not put plumbing fixtures on exterior walls.
            - Exception is if a furred plumbing chase is provided interior of the warm side of the vapor barrier. Consider adding heat in the chase that is accessible for maintenance.
        - Select age-appropriate fixtures.

        - Note that accessibility heights are different in schools and day care centers for youth.
    - Use hardwire infrared faucets and flush valves rather than battery powered.
    - For public restrooms, provide heavy-duty water closet carriers.
        - Use wall carriers for urinals and wall mounted lavatories.
    - Drinking fountains
        - Utilize hydration stations instead of drinking fountains. Or provide combination units.
        - Avoid using chillers unless absolutely necessary.
    - Provide cold water hose bibb (in locked cabinets) in restrooms to allow cleaning through hosing down the surfaces.
    - Specify floor-mount janitor closets. Pedestal units are difficult to get a mop bucket into.
    - Provide ABS/PVC waste piping on waterless urinals until point of dilution.
    - Garbage disposals and insta-hot water dispensers have maintenance impacts.
- Floor Drains
    - Ensure design team shows floor slopes to floor drains.
    - Provide floor drains in all restrooms accessible to the public or youth regardless of code requirement.
    - Include in specifications that floor drains and floor sinks be installed flush with the floor.
    - Provide drains directly below emergency eye wash stations and showers. Hard-pipe discharges if possible.
    - Locate drains immediately outside of shower stalls and ADA roll-in showers.
- Trap Primers
    - Consider using the type that come off of flush valves and flush tanks. They will last longer than traditional diaphragm type units and do not require pressure fluctuations for activation.
        - Careful using sink drop tube units as debris from the sink may clog the trap line.
    - Use electric type units when not near flush valves. Diaphragm type may not operate away from flush valves.
    - Provide detail with branch off top of supply main and access doors.
    - Coordinate concealed trap primer locations. Detail access doors and verify access is maintained (not behind casework or tables).
    - Consider mechanical trap seals if the local AHJ will allow its use.
- Water Service
    - Verify the condition of the water service for treatment, particularly from wells.
        - Provide a space inside the facility for water treatment equipment if needed once the well is being drilled during construction.

        - Verify the aggressiveness of the water. Municipal water services that use nano-filtration can be so clean that they eat the copper/metal pipes.
            - They make sacrificial copper coils that can be put at a water entrance to save the building water piping.
    - Sanitary Sewer
        - Locate waste pipe cleanouts in accessible locations.
            - Wall cleanouts are preferred over floor cleanouts. Floor cleanouts can be below the level of backed-up fluid and create significant mess when opened.
            - Consider extending cleanouts to the outside of the building (yard cleanouts) if feasible/appropriate. Less mess.
        - Minimize the use of lift stations. Use gravity waste wherever possible.
        - Use cast iron pipe underground if the facility will have a high possibility of regular obstructions that will be cleaned out (penitentiary, school, public facility, etc.)
    - Storm Water
        - Specify flexible boot connections. These held up better under earthquakes.
        - Roof drains and overflow drains that are not above heated spaces (i.e. overhangs) should be heat traced in cold weather locations. Avoid this condition if possible.
        - Coordinate storm water outfalls with civil engineer. If heat trace is required, provide easily accessible location at building perimeter for installing and inspecting heat trace.
    - Heat Trace
        - Design solutions that do not require heat trace if possible.
            - Consider glycol heat trace systems.
            - Slope roof so that roof drains are located over warm portions of the building.
        - Provide installation detail for heat trace on overflow spouts. Securely fasten heat trace to inside of pipe to minimize vandalism.
        - See electrical section for additional heat trace recommendations.
- Heating
    - Provide isolation valves on all major branches of the building so that sections can be isolated without shutting down the whole building.
    - Avoid central air heated systems for occupant comfort. More expensive to operate during unoccupied hours.
    - Boilers
    - Heat Exchangers
        - Provide pressure gauges and thermometers on all four sides of the unit to verify performance and troubleshoot fouling conditions.
        - Provide drains on all four pipe connections of a heat exchanger to allow for back-flushing.

        - Provide strainers with ball valve blow-downs on inlets to both sides of the heat exchanger.
        - Ensure that pressure relief valves are located on both side of the heat exchangers, between isolation valves and the heat exchanger. Once isolated, heat expansion can damage equipment.
    - Expansion Tanks
        - Consider specifying units with bladder integrity alarms/indicators. Note that some of these require electrical connections.
    - Pumps
        - Provide redundant pumps on system critical legs (main distribution system) and elsewhere when feasibly possible.
        - All pumps above 1 hp to meet new Hydraulic Institute energy usage Standards (new 2019 requirement).
    - Terminal Heating Units
        - Use inverted flow cabinet unit heaters in vestibules to melt snow/ice.
            - Fully recess units or provide sloped tops to reduce damage from sitting or drinks.
        - For baseboard in high impact areas, specify brackets and additional wall fasteners be installed every 32 inches (or two studs). Use minimum 18-gauge enclosures.
        - Locate unit heaters so they are easily accessible with ladders.
    - Locate perimeter hydronic heat valves in the ceiling space.
        - If not possible, coordinate access points for casework with interior designer and casework design.
    - Air vents
        - Provide isolation valves on manual and automatic air vents. They are typically isolated.
        - Specify high quality air vents such as the Spirovent system.
        - Consider detailing manual air vents as 1/4” isolation valve and 180 degree bend with a hose connection so that discharge can be directed to a bucket.
    - Design snowmelt systems with insulation underneath and on the edges.
        - Provide enough heat that evaporates water rather than just melts it and becomes ice in an adjacent location.
        - Be mindful that interfaces between heated and non-heated surfaces will have sudden changes in elevation due to compacted snow/ice which may create access issues.
        - Provide conduit out to the snow sensor so that the thermocouple and wiring can be replaced in the future.
- Ventilation
    - Design fan rooms such that you can gain access everywhere without having to climb over ducts.

        - Provide easy access to air handling units (i.e. not requiring ladders or lifts).
    - Outside Air Intakes
        - Design outside air intake systems appropriately for wind and snow conditions to keep snow from entering the building.
        - Locate air intakes with good indoor air quality in mind. Watch for proximity of idling vehicles and boiler flues. Look at wind patterns that occur throughout the year.
        - Keep in mind cold temperature inversions will keep vapors low.
    - Return Air System
        - Calculate return and relief air path pressure drop. Too high of a pressure drop for gravity systems will over-pressurize parts of the building driving vapors into the building envelope.
        - Verify during construction that all transfer air openings were installed.
    - Exhaust/Relief Air System
        - Locate discharges away from walkways where it may create icing.
        - Do not discharge exhaust or relief air near thermosyphon fins. Heat will keep the refrigeration system from fully working.
        - Recognize that variable speed kitchen hood/exhaust fan systems are hard to maintain and may not be suitable for all applications.
    - Distribution
        - Evaluate sizing ductwork systems at low pressure verses medium pressure. This will have higher first cost from larger ducts but can result in significant reductions in static pressure, fan horsepower and long-term energy usage.
    - Filters
        - Provide appropriate filters in the appropriate (and maintainable) locations
        - Provide permanent sliding ladders for filter banks higher than 7 feet within air handlers.
    - For VAV boxes, provide minimum, heating, and maximum flow rates. Minimum rates should be significantly lower than 50% max rates.
    - Detail access doors on upstream side of duct coils for inspection and cleaning. It is preferred to have access on both sides of coils if feasible.
    - Consider heat recovery and DOAS systems for energy efficiency.
    - Most ECM fan motors are integral to the fan assembly, requiring replacement of the entire assembly. This is more expensive than traditional motor replacement. Note this is not typical for pumps with ECM motors.
    - For above-ceiling fan powered units, maintain access for fan, motor, and bearing replacement.
        - Show access on drawings so that piping and conduits do not impinge on access.
    - Consider displacement ventilation systems or other vent location solutions that allow the designer to reduce heat loads associated with lights and people as well use a Zone Air

Distribution Effectiveness factor of 1.2 which reduces minimum ASHRAE 62.1 outside air volumes.
    - This can have significant first cost savings in smaller systems and long term savings in lower ventilation heating and cooling loads.

- Cooling
    - Use destratification/ceiling fans.
        - High Volume, Low Speed (HVLS) units are typically more energy efficient than multiple smaller fans but do not provide redundancy and have a higher first cost.
    - Locate and address all sources of heat including pumps, refrigerators and freezer condensing units, and transformers.
    - Consider locating condensers in areas that can utilize the heat during the winter (i.e. garages and warehouse space). Consider summer conditions and ability to remove heat from that space.
    - Use refrigeration based occupant cooling only where skilled technicians will be available for service. Verify with Owner.
        - Note that the use of DX cooling can significantly reduce peak room design airflow values as well as the associated infrastructure and distribution first costs.
        - Resulting smaller fans will be more efficient during the lower air volumes needed for winter operations and are easier to maintain and replace.
- Humidification
    - Avoid humidification if at all possible. It is high maintenance and can have significant impacts on the building envelope.
    - If humidifying, complete hygrothermal study of all building envelope components in the immediate area of humidification and surrounding areas where humidity will migrate. This is especially true for windows.
    - Coordinate building envelope requirements with the architect.
        - Utilize vestibules to isolate humidified spaces to reduce migration.
    - Treat water to a quality defined by the humidifying equipment manufacturer's recommendations. Traditionally RO filtration.
        - Be mindful of backwash conditions.
    - Closely monitor building pressure in areas of humidification and have high pressure alarms.
    - For pools, measure and control chloramines. Chloramines can significantly degrade electrical wiring.
- Fuel Oil Systems
    - Locate fuel tanks so they do not get damaged by falling snow/ice. Note that snow can curl around the edge of a roof and fall on tanks located right up against a building.
    - Protect fuel lines between ASTs and the building, particularly those located 5 feet and beyond the building so that fuel lines are not accidentally damaged while being covered with snow.
    - Specify oil safety valves and anti-syphon valves for fuel lines to mitigate spills.

    - Design normally closed solenoid valves for day tank fill lines as secondary precaution against overfilling.
    - See ADEC website for recommended fuel tank design for long term spill prevention.
    - Single pipe Tigerloops are preferred for heating appliances. Less piping to get air leaks in, cup provides dearation and preheats fuel which improves efficiency.
        - Generators should have two pipe systems that go back to a tank since generators reject some heat into the return fuel system.
- Natural Gas Systems
    - Provide flexible pipe connections at equipment that has firing rate of 200 MBH or less. Can be provided on larger units. In November 2018 Southcentral Alaska earthquake, gas leaks were identified at hard-pipe installations at unions at equipment.
- Fire Suppression
    - Avoid dry pipe systems if possible.
        - Utilize non-combustible construction for exterior canopies.
        - Separate canopies from the building.
        - Utilize side-wall dry heads off of the wet sprinkler system.
        - If a dry pipe system is required, use upright sprinkler heads. Pendent (down) type heads collect condensation then freeze and burst in the winter.
        - All dry piping should be galvanized. Consider painting exterior piping for additional protection.
        - Outside components should be galvanized, stainless steel. There are corrosion-resistant finishes for sprinkler heads.
    - If feasible, specify flex connections at sprinkler heads rather than oversized escutcheons. They will work better in an earthquake.
    - Design around interior corrosion such as pools.
- Specialty Systems
    - For locations prone to brown-outs, install VFDs, high/low voltage protectors, or other protective items on all equipment that is susceptible to damage from power fluctuations.
- Corrosion Control
    - Ensure that pipe hangers and accessories clearly note to isolate/insulate copper pipes from steel Unistrut and hangers and in general against dissimilar materials.
    - For exterior buried piping or tanks, test soils for corrosive conditions.
    - Provide electrical grounds on water, heating, and sprinkler piping systems to reduce electrolysis.
- Energy Efficiency
    - Use demand ventilation control strategies.
    - Use variable frequency drives and ECM motors.
- Building Automation Systems
    - Keep the control systems simple.
        - Where appropriate, consider stand-alone control systems.

  - For remote SCADA systems, focus on alarms rather than control
  - Use sequences that the owner has standardized or used on other facilities.
  - Monitor relative humidity and provide alarms for high levels.
  - Setup trending points for all room temperatures, motor operation, and major system analytics such as temperature and flow.
  - Provide lots of remote and local monitoring points as well as overrides.
    - Limit overrides through user access level.
    - Require override activities to note who, when, and why the override condition was made.
    - Consider having an alarm on manual overrides that are in place for a week.
    - Make override conditions obvious in the graphics.
    - Have overrides be able to be trended. Provide a report button for regular viewing.
  - Provide simple user interfaces outside of the BAS/SCADA graphics such as spring-wound timers for temporary occupancy and green/red colored LED status/condition panels. Clearly label their use.
  - Provide visual gauges/thermometers near sensor points for visual verification of the system and BAS calibration.
  - Require that a copy of the BAS/SCADA programming be included with the physical and electronic copies of the O&M manual so that the system can be "reset" back to owner occupancy levels if need be.
- Inspections
  - Ensure access to all equipment.
  - Ensure seismic bracing is installed on all equipment, piping, and ductwork. Make sure diffusers and other ceiling mounted units are independently braced from the ceiling grid.
- Commissioning
  - Ensure commissioning is covered in the specifications for all disciplines.
  - Re-verify commissioning at the 10 month point. This will identify warranty items prior to contract close-out as well as incorrect control changes completed by staff that were done before they were familiar with the system.
- Spare Parts
  - Provide redundancy on all critical systems.
  - For remote sites, or sites that can be separated from the road system by avalanches/rock slides, identify critical spare parts for heating and plumbing systems.
    - Often equipment installation manuals will have recommended spare parts list.

ELECTRICAL SYSTEMS

Scheduled O&M Tasks

- Walk electrical rooms daily.
    - Maintain NEC clearances in front of electrical panels (6'-6" vertical, 30" wide and 36" in front for 120/208 volt panels and 42" in front of 480 volt panels)
- Walk the rooms weekly to identify burned out/flickering lamps.
- Occasionally vacuum out the inside of panels.
- Training
    - Train Users on how lighting control system works so they do not think it is a faulty electrical system.
    - Provide Users training on any "Watt Stopper" type systems that turn off the power in an area based on a time schedule.
    - Provide training on how to reset the Fire Alarm Panel, procedure on who to call if it goes into trouble or alarm.
- Power
    - Have back-up plan for extended power outages from emergency underground electrical repairs or broken transmission lines.
    - Annually trip all interior and exterior GFCI receptacles and verify wiring integrity with GFI wall plug tester.
    - Annually cycle all circuit breakers.
    - Inspect exterior electrical outlets and equipment for corrosion from salt water or other corrosive environments.
    - Ensure that grounding at water main, gas line, and rest of building is secure.
        - Ensure that water meters have grounding straps attached to both sides of the connecting piping.
    - Complete inverter and UPS unit battery system maintenance & repair at recommended intervals.
    - Verify heat trace is operational prior to the winter.
    - Annually inspect panels and electrical connections with infrared camera to identify overloaded circuits and failing equipment.
    - Consider "megger" testing wiring and equipment as appropriate.
- Generator
    - Complete Generator and Automatic Transfer Switch (ATS) testing on recommended schedules.
        - Verify that room cooling (dampers) is being completed. Generator will turn off if the room is too hot.
    - Annually inspect and test batteries. Ensure they are kept fully charged.
    - Keep generator space warm to extend battery life.
    - If block heaters are provided, verify operation annually.

- Lighting
    - Turn off the lights.
    - When replacing lights, verify and match color/temperature of surrounding lamps. Keep extra lamps on hand and purchase new based on the spare units or save a photo of the previous purchased boxes.
- Security
    - Regularly check security system and camera system to ensure it is operational and recording in both day and night modes.
- Communication/Data
    - Manage the WiFi system including after-hours use.
- Fire Detection
    - Check emergency/egress lighting batteries annually.

Capital Improvement Upgrades

- Keep up with technology and efficiencies when replacing equipment.
- Power
    - Phase monitoring and protection from loss of phases.
    - Consider UPS systems for critical infrastructure. These also provide power conditioning/protection.
        - Onsite servers
        - Control panels
    - For locations prone to brown-outs, install VFDs, high/low voltage protectors, or other protective items on all equipment that is susceptible to damage from power fluctuations.
    - Upgrade transformers to higher quality models.
    - Add power monitoring through BAS/SCADA upgrades.
    - Investigate replacing electric heat trace with hydronic heat trace.
    - Investigate upgrading power service and motors to more energy efficient three-phase power if available.
    - When extending power to a site for future facilities (such as a potential school site), extend three-phase.
        - Utilize underground services if possible unless there is potential ground movement (permafrost). Underground systems are less prone to damage from trees.
- Generator
    - Upgrade to automatic transfer switches and switchgear.
    - Add universal generator connections on exterior of the building so that portable/mobile generators can be used. Provides redundancy for standby generators.
- Lighting
    - Upgrade lighting to LEDs.
    - Upgrade site lighting to protect against vandalism.

    - Install motion sensors.
    - Upgrade internal lighting controls including natural light harvesting, multi-level switching, higher quality front end equipment, and wireless retrofit options.
    - Upgrade to a centralized emergency/egress light power system rather than distributed batteries.
- Security
    - Upgrade security.
    - Add motion sensors at secure locations.
    - Add interior and exterior cameras (and signage) to ward off vandalism.
- Communication/IT
    - Increase WiFi capability and bandwidth within the facility. Current trends in facility maintenance is to use live-streaming video from smart phones to coordinate repairs with remote technicians.
        - Also facilitates distance learning and video conferencing for users.
    - Consider adding WiFi extenders to get coverage throughout the building including mechanical rooms.
    - Be mindful that having non-secure WiFi extending out to a parking lot may result in the public parking there at night and using the internet.
- Fire Detection
    - Upgrade outdated/non-supported fire panels and nonaddressable fire alarm systems.
    - Anticipate that building alterations may trigger International Existing Building Code requirement to upgrade building-wide life-safety measures including suppression and detection..
- Renewable Energy
    - When considering renewable energy (solar, wind, etc.), be sure that maintenance costs are included in payback analysis.

Design Best Practices to Support O&M

- Planning Stage
    - Identify surplus power opportunities from within facility as well as within community.
    - Work with owner to identify the level of complexity that the User and Facility Staff can use and maintain.
    - Identify power quality from local utility and if standby power generation and power quality protection needs to be added to the facility.
- Design
    - Meet with Facility Staff and review the design at schematic level and at major milestones.
        - Consider MEP system charrette at the beginning of a project.
    - Specify commissioning for automated systems like lighting control.
    - Specify underground power and data lines be provided with tracing wire for field locates.
- Equipment

- Simplify and minimize pieces of equipment.
- Design around simple and durable systems.
- Select equipment based on lifecycle and availability of manufacturers support.
- Locate in easily accessible locations. Minimize locating access points above ceilings or in concealed locations.
- Use stainless steel fasteners/hardware for external equipment.
- Be mindful of corrosive environments both outside the building (salt water) and inside the building (chlorinated pools).
- Provide unique equipment identification and clearly label equipment.

- Power
  - Confirm available service power and phase capabilities early in design.
  - Provide three-phase service if feasible.
    - Design motors ¾ HP and higher to have three-phase power.
  - Verify quality of utility power.
    - Provide loss of phase protection.
    - Consider if building-wide power conditioning is appropriate.
  - Use high efficient transformers
  - Future proof the design
    - Provide plenty of spare capacity in panels.
    - Provide spare breaker locations in MDP and switchgear for future renovations/expansions.
    - Provide provisions for Combined Heat/Power (CHP) and renewable energy tie-ins to power system.
  - Consider Combined Heat/Power or battery storage systems to minimize demand charges.
  - Metering
    - Institute power monitoring and include sub-monitoring. At a minimum monitor 120, 277 and 480 volt feeds and keep histories to find irregularities.
    - Monitor and trend power usage through the Building Automation System (BAS) or SCADA system. Allow remote monitoring.
  - Motors and Disconnects
    - Avoid 1,200 RPM motors. They are a very long-lead item. 1750 RPM motors are most readily available.
    - Use VFDs or soft starts on motors.
  - Variable Frequency Drives
    - Coordinate manual bypass requirements with mechanical. Reference additional requirements under that section.
    - Locate VFDs as close to motors as possible.
    - If VFD is remote, wire power to disconnect first, then to VFD, then to equipment.

        - If power first goes to VFD, add permanent placard at equipment disconnect that power needs to be first disconnected at VFD or circuit breaker prior to shutting down equipment.
      - For fans, ensure that shaft-grounding is provided.
    - Receptacles
      - Provide ample number of receptacles in mechanical spaces for maintenance usage.
      - Provide lots of connections for power for charging of electronics.
      - For public spaces, consider using receptacles with integral USB power ports.
      - Consider having different colored receptacles for circuits that are powered off of the standby generator.
    - For heat trace, use "Tattle-Tale" or other LED light indicator noting if the heat trace is active.
      - Consider central monitoring of heat trace.
      - See mechanical section for additional heat trace recommendations.
    - Consider if lightning protection is required.
- Generator
    - Verify if generator is standby or emergency.
    - Locate generator in area that will not be a noise issue when regularly tested.
    - Generator spaces should be heated to maintain battery life.
    - In addition to all heating equipment, ensure that BAS/SCADA, Fire Alarm, and Security systems are on standby power.
      - Show dedicated standby power circuits for BAS/SCADA terminal controller transformers.
- UPS
    - Provide UPS units on critical equipment for both power conditioning/protection and bridge between power loss and standby generator operation.
      - Servers
      - Fire Alarm Panel
      - BAS system main panel
      - Communication panel
      - Security panel
- Lighting
    - Coordinate with mechanical and architectural on above-ceiling heights to ensure there is proper maintenance space above recessed lights.
    - Minimize the number of unique lamps and transformers (unique lighting fixtures in general).
      - Use lamps that can be bought at local hardware store.
    - Use LEDs. Consider lighting controls/lighting levels in selection.
    - Select lights based on quality.
    - Coordinate light color/temperature with Owner and rest of facility.
    - Locate lights where they can be easily accessed. Avoid locations such as over stairs or multi-story openings where access is difficult

  - Avoid site light pollution.
  - Be mindful of glare on monitors and laptops.
  - Be careful of complex lighting control systems. These get turned into on/off switches.
  - Higher reflectance finishes to use natural light more efficiently.
  - Use multi-level light switching.
  - Use centralized emergency/egress light power system rather than distributed batteries.
- Security
  - Use motion sensing
  - Do not purchase server type security systems. Use a dedicated system.
- Communication/Data
  - Coordinate with users on benefit of ample network connections verses WiFi solutions.
  - Identify a designated IT rack location.
    - Coordinate ventilation/cooling with mechanical design.
    - Consider putting network rack on standby generator. WiFi may be used by facility staff to troubleshoot with remote technicians.
  - Ensure that BAS system network connection and phones (if using comm) are on UPS and standby power.
- Fire Detection
  - Select contractors based on performance during construction and most importantly on support after construction. Complete research on firms from other owners in the area.
  - Fire alarm panels should have intuitive interfaces so that operators and first responders can quickly assess the threat and location of the issue.
  - All devices should be addressable and provided unique identifiers to facilitate troubleshooting and emergency conditions.
- Renewable Energy
  - Coordinate with utility at the schematic level on ability to utilize renewables or Combined-Heat-Power (CHP) in that location. Some utilities have a limit on the amount of renewables and inverter based power generation that are allowed to be on the grid.
  - Talk with owner regarding potential for future renewable energy or Combined-Heat-Power (CHP) system and make provisions to the power design as appropriate. Note the future considerations in the design documents for future reference and that 'VE' changes are not made during construction.

ADDITIONAL RESOURCES AND LITERATURE

- Inspection and Maintenance
  - ANSI/ASHRAE/ACCA Standard 180-2018, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems
    - This has a thorough list of regularly scheduled maintenance procedures/checklists for numerous mechanical pieces of equipment.
  - Good School Maintenance, Fourth Edition, 300 page manual. Available at www.IASB.com
- Hands on Maintenance Training
  - Illinois Association of School Business Officials (IASBO) Facilities Operations Program. Onsite training for Facilities, Maintenance, Grounds, and Custodial. https://www.iasbo.org/iasbo/facilities/facprograms/fop Based on the Good School Maintenance book.
- Energy Efficiency Guidelines/Codes
  - ASHRAE
    - ASHRAE 90.1
    - ASHRAE 189.1
  - International Code Council, International Energy Conservation Code
  - National Energy Code of Canada for Buildings (NECB)
- Published Manuals for Cold Climate Design
  - ASHRAE Cold Climate Building Design Guide
  - Northern Building Design, Kenneth Maynard 2004
- Resources for Cold Region Building and Energy Efficiency
  - Alaska Center for Energy and Power
  - Alaska Energy Authority
  - Cold Climate Housing Research Center
  - University of Alaska Fairbanks Cooperative Extension
- Equipment Service Life Expectancy (Predictive Maintenance)
  - ASHRAE Applications Handbook, 2015, Chapter 37.
  - CIBSE Guide M, Maintenance Engineering and Management.
- Project Management
  - Construction Specifications Institute (CSI) Manual of Practice.
  - Project Management Institute's Project Management Body of Knowledge (PMBOK).