GENERAL BUILDING OPERATION

Daily/Weekly O&M Tasks

- Speak to Users (Teachers, 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 Staff.
- For distributed campuses like School Districts, provide remote site BPOs with iPads/tablets and use video Facetime to troubleshoot issues.
    - Also good to scope maintenance/repair work in advance of traveling to the site including verification of what parts and tools need to be brought to complete the repair.
- Documentation
    - Use District web page to share information, 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.
- Training
    - Train Users on how to utilize the systems in the building (i.e. thermostats).
    - Provide training for all new facility staff as well as Users.
    - Provide regular refresher training for all staff. For schools, complete it annually as part of the before-school in-service days as there are always new teachers.
        - Develop a teachers training packet/handout on how to operate the thermostat or other controls. Have Facility's contact number prominently displayed.
- Require DDC and other service agencies to operate and maintain the systems based on maximizing energy efficiency and not just keeping the facilities operating. Include in your service agreements.

Capital Improvement Upgrades

- 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.
    - Make and keep good communication with the Districts and schools for ongoing issues they need to know about and as changes in status occur.
- 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 provider.
- Upgrades
    - Include ADA/Accessibility upgrades within the building and the surrounding site access at every opportunity.
    - Add more storage space.

    - 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.
- Preventive Maintenance
    - Do not defer Preventative Maintenance. It costs four times more to repair/replace than prevent.
    - 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.
        - ASHRAE Standard 180-2018 is an excellent resource for regularly scheduled maintenance checklists for various pieces of mechanical equipment
    - Fix things when they are small issues before they become big issues.
    - Have a central tracking form or maintenance software package that tracks age and life expectancy of each system (i.e. roof) and piece of equipment (boiler, lights, etc). Proactively add expected replacement into CIP plan.
    - Purchase a software package that tracks Work Orders and automatically generates work orders for regular maintenance work.
- Design Contracts
    - 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 so that you don't pay future design teams to redraw the floor plan and systems. Saves the Owner money!
- Construction Contracts
    - Require Record Drawings in both the construction and design contracts.
        - This also includes contractor shop drawings for sprinkler system, fire alarm, BAS control diagrams, and other performance based designs.
    - Withhold a significant amount of money in the contract Schedule of Values for Contractor Record/Redline Drawings to ensure it gets completed and submitted. Contractor will skip small amounts of money at end of project.
        - Consider naming the line item as "Contract Close-Out" and also including Owner Training and O&M manuals.
    - Receive and archive close out documents electronically.
    - Look into alternative project delivery mechanisms such as CMGC/CMAR (Contractor at Risk) in place of traditional design-bid model. Leverage knowledge and experience of your construction team during the design process to make for a cost-effective facility and easier construction.
- Construction
    - Be wary of Contractor "Value Engineering" suggestions. These often times provide lesser quality materials or systems that require more long term maintenance.
    - Have Facility Staff complete inspections of the site. Critically at the rough-in and substantial completion stages.

- Purchasing
    - For School Districts, create state-wide purchasing agreements with suppliers to improve buying power and reduce costs.
    - Leverage

Design Best Practices to Support O&M

- Design Team
    - 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, and limited construction seasons.
    - Ensure design team
- Planning Stage / Early Design
    - Consult Facility Management Team at the very beginning of a project.
    - Identify design guidelines and review them with staff to verify they are up to date.
    - Work with owner to identify the level of complexity that the User and Facility Staff can use and maintain.
    - Acquire local knowledge and help when orienting the building. Particularly in regards to wind directions and snow drifting.
- Design
    - Design for durability and maintainability.
    - Have Facility Staff 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.
    - Use standardized manufacturers and products to simplify replacement and reduce maintenance materials (spare parts). Typical for all building systems.
- Commissioning
    - 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 systems, at 6 months.
    - 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 update drawings based on contractor red lines as well as all field changes (RFIs, etc).

Please send additional comments to Craig Fredeen at Cold Climate Engineering, LLC: cfredeen@coldeng.com

    - Develop thorough Operation and Maintenance Manual for all materials and equipment that will require replacement and maintenance.
    - Digitize O&M manual and keep readily available to staff.
- Post Construction
    - Owner should contact design team with issues that arise after construction.
    - Design team may know solutions and will learn how to improve future projects.

BUILDING ENVELOPE AND EXTERIOR

Daily/Weekly O&M Tasks

- Walk the grounds daily
    - Ensure windows are closed.
    - Identify peeling siding
    - Ensure lights are off.
- Walk roof at least once a month.
    - Remove debris including dirt that may start growing vegetation.
    - Remove any sharp objects immediately.
- Do not use salt on sidewalks.
- Manage gravel usage to minimize interior finish damage.
- Immediately address vandalism.
- Semi-annually inspect windows to ensure proper operation and that they have good seals.
- Annually inspect door seals.
- Maintain fencing.
- Use an infrared camera to inspect the building envelope annually.
    - Will identify leaking gaskets/seals.

Capital Improvement Upgrades

- Replace corroded doors.
- 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 at every opportunity.
- Upgrade materials with vandal proof coverings or systems.

Design Best Practices to Support O&M

- Massing
    - Orient building, entries with predominant wind direction in mind.
    - Identify snow drifting locations.
    - Set building 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.
    - 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.
- 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
- Building Envelope
  - 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.
    - The material is cost effective and maintenance free, use in areas not prone to impact.
  - Design walls that can't be climbed.
  - Assume all sealants will fail.
  - Clearly detail door and window sealant systems
  - Detail and clearly specify vapor barrier sealing.
    - Consider having building envelope testing either via blower door or thermal camera inspection. Include testing performance requirements in construction documents.
- 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 and replaced.
  - Use smaller size window modules that, if broken, do not cost a lot of money to replace.
- Roof
  - Provide steeper pitch roofs – be mindful of snow/ice shedding zone.
    - Metal is a durable material for roofs but the design team must control snow and ice shedding for safety and property damage.
    - Mechanical penetrations need to be as close to the peak as possible, detail in the drawings diverters/"crickets" upstream of penetrations to protect them from damage from shedding ice.
  - 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
- Site
  - Eliminate hiding spots around building.
  - Provide heated sidewalks rather than salt and gravel. Use waste heat if possible.
  - Ensure that drainage is away from the building.
  - Design steps and railings to facilitate snow removal.
  - Design parking lots to facilitate snow removal and storage.
    - Ensure enough parking places still existing with snow piles.
  - Design for ADA/Accessibility including access to school, playground and other areas.

    - Provide security fencing around the building perimeter of raised structures.
- Playgrounds
    - Design equipment that is age-appropriate.
    - Use non-flammable materials (particularly surfacing materials).
    - Use surfacing materials that stay resilient year-round.
- Landscaping
    - Do not put landscaping (trees, bushes, etc) next to the building.
- Provide covered walkways, stairwells, and entries.

INTERIOR FINISHES AND FLOOR PLAN

Daily/Weekly O&M Tasks

- Have in place infection control protocols.
- Utilize all-in-one cleaning carts.
- Clean walk-off mats daily.
- Maintain custodial equipment.
- Regularly reevaluate cleaning products.
- Consider the capability of staff to complete maintenance tasks.
- Training
    - Have training programs for custodial staff
    - Ensure that staff knows what chemicals to use and how to clean/maintain surfaces.

Capital Improvement Upgrades

- Evaluate finishes regularly to identify if they need to be replaced or just renewed.
- Replace seals with high quality materials.
- Flooring
    - Repair/Replace walk-off mats regularly.
    - 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. More healthier.
    - Replace carpet and walk-off matts with modular/carpet squares.
- Purchase custodial equipment specifically appropriate for the surfaces/materials in that facility.
- Complete small upgrades to finishes such as patch/paint surfaces.
- Provide new signage.
- Replace chalk boards with whiteboards
- Recapture facility square footage by reworking storage

Design Best Practices to Support O&M

- Involve custodial staff in design conversations.
- Consider the capability of staff to maintain the finishes.
- Floors
    - Utilize subfloor moisture mitigation techniques/coverings.
    - Incorporate extensive walk-off mats.
    - 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

    - Do not use soft surfaces. They increase allergies, the spread of disease, and other pathogens.
    - 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.
- 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.
    - 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 (FFE):
    - 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.
    - Design versatile classrooms that can be used for different activities and teaching styles.
- Casework
    - Design lots of storage space into classrooms.
- Doors
    - Utilize owner standardized hardware
    - Coordinate power, security, and communications requirements with electrical engineer.
- Floor Plan
    - Provide more storage for school and maintenance functions.
    - Provide adequate storage for janitorial supplies.
    - Do not build arctic entries with really high ceilings.
    - Ensure building has space for a workshop for onsite repairs and maintenance support.
    - Minimize the use of moveable walls/partitions.

MECHANICAL SYSTEMS

Daily/Weekly O&M Tasks

- Walk through mechanical rooms daily
    - Record/Document mechanical system performance (system pressures, operating temperatures, etc) on a daily/weekly basis.
    - Be sure staff who complete the walk through know what to look for.
- Walk through occupied spaces once a week to identify warm/cold spots.
- Look for open windows. This may indicate an unreported HVAC space temperature issue.
- Complete regular maintenance such as seasonal filter replacement
- Plumbing
    - Ensure seals between plumbing fixtures and floor/wall surfaces 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.
- Heating System
    - Provide isolation valves on automatic air vents and keep them isolated in most locations.
    - Have heating system fluid annually tested for pH and inhibitors. Take sample and mail it in for testing and recommended treatment.
- Fuel
    - Check fuel storage tanks for water regularly.
    - Do not let standby fuel get old. Operate standby generators and dual fuel boilers regularly to both use the fuel and ensure system will be operable when needed.
    - Annually inspect storage tanks for signs of corrosion.
- Fire Suppression
    - 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 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)
    - 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.
    - Ensure night time/unoccupied mode setbacks are in place.
- Training
    - 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).
    - Train facility staff on how the systems are intended to operate. No two facilities operate the same.

Capital Improvement Upgrades

- Replace equipment, particularly boilers, on a preventative-maintenance schedule.
- Install Variable Frequency Drives
    - Ensure that shaft grounding gets installed at the same time.
    - Consider replacement of motors with ECM technology.
    - Protects motors from brownout conditions.
- Provide under/over voltage protection for equipment with circuit boards or prone to failure.
- Identify waste heat opportunities from within facility as well as within community.
- Consider Combined/Heat Power (CHP) solutions.
- 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.
- Building Automation System
    - 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 firms from other 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.

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.
- 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 simple, easy to maintain systems.
    - 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 coils. 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
        - 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.
        - Show manufacturer's recommended maintenance clearances around equipment.
        - Show NEC clearances in front of 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.
        - Keep all piping and ductwork within the thermal envelope.
    - Specifications
        - Clearly identify training and commissioning requirements.
        - Clearly identify robust O&M and training requirements.
        - Specify low point drains and high point vents.
    - Consider making a mock up of complicated installations for Users and Facility Staff to be familiar with.
- Equipment
    - Locate all equipment on the floor or walls so that they can be reached and maintained without ladders.
        - Do not put anything heavier than 100 pounds more than 8 feet in the air.

  - Centralize equipment in mechanical rooms.
    - Ensure mechanical rooms have both interior and exterior access.
  - Consolidate equipment.
    - Better to provide two pumps in a primary/back-up configuration than 15 terminal pumps that need to be maintained.
    - Same with exhaust fans.
  - Redundancy
    - Provide redundancy for critical systems (i.e. multiple boilers, primary/back-up pumps, etc.).
    - Discuss if manual bypasses should be provided on VFDs.
  - Put structural rails/pull points above motors 15 hp and higher to facilitate motor replacement. Coordinate with structural.
  - Select equipment and systems based on durability and maintainability.
  - Make sure all equipment can be removed and replaced through doors. Provide other openings, such as removable door panels, for larger equipment.
- Pipe and Pipe Accessories
  - Consider using Aquatherm (manufacturer of PP-R 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
    - More valves on all mechanical system distribution piping.
    - Provide valves upstream and downstream of <u>all</u> replaceable parts.
    - Valves, valves, valves. More isolation valves!
    - Do not use gate valves.
  - 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 details 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.
  - Utilize hydration stations instead of drinking fountains.
  - Ensure design team shows floor slopes to floor drains.
  - Locate waste pipe cleanouts in accessible locations.
  - Provide cold water hose bibb (in locked cabinets) in restrooms to allow cleaning through hosing down the surfaces.
  - Specify floor-mount janitor closets.
  - Trap Primers
    - Consider using the type that come off of flush valves and flush tanks. They will last longer than traditional diaphragm type units.
    - 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 locations so that access is maintained.
- Heating
  - Provide isolation valves on all major branches of the building so that sections can be isolated without shutting down the whole building.
  - Provide drains on all four pipe connections of a heat exchanger to allow for back-flushing.
  - 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 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.
- Ventilation
  - Filters
    - Provide appropriate filters in the appropriate (and maintainable) locations
    - Provide permanent sliding ladders for filter banks higher than 7 feet.
  - Manage the return and relief air paths.
    - Verify during construction that all transfer air openings were installed.
  - For VAV boxes, provide minimum, heating, and maximum flow rates. Minimum rates should be significantly lower than 50% max rates.
  - Detail access doors on at least one side of duct coils for inspection and cleaning.
  - 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.
  - Consider heat recovery, DOAS systems for energy efficiency.

    - 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. Results in smaller systems and lower ventilation heat loads.
    - Design fan rooms such that you can gain access everywhere without having to climb over ducts.
        - Provide easy access to air handling units.
        - Minimum 30" wide x 60" high access corridor to all parts of the mechanical rooms.
- Fuels
    - 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.
- 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.
    - Ground your 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.
    - Use sequences that the owner has standardized or used on other facilities.
    - Provide simple systems.
    - Monitor relative humidity
    - 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.
        - Lock-down overrides or make override conditions obvious in the graphics.
- Inspections
    - Ensure access to all equipment.
- 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.

ELECTRICAL SYSTEMS

Daily/Weekly O&M Tasks

- Walk electrical rooms daily.
- Walk the rooms weekly to identify burned out lamps.
- Turn off the lights.
- Complete Generator and Automatic Transfer Switch (ATS) testing on recommended schedules.
- Check emergency/egress lighting batteries annually.
- Complete inverter and UPS unit battery system maintenance & repair at recommended intervals.
- Manage the WiFi system including after-hours use
- Use an infrared camera to inspect panels and electrical connections to identify overloaded circuits and failing equipment.
- Inspect exterior electrical outlets and equipment for corrosion from salt water on the coast.

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.
    - 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 upgrades.
    - Add universal generator connections on exterior of the building so that portable/mobile generators can be used. Provides redundancy for standby generators.
    - Upgrade automatic transfer switches/switchgear
- Lighting
    - Upgrade lighting to LEDs.
    - Install motion sensors.
    - Upgrade 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 exterior cameras to ward off vandalism.
- Upgrade access to electronic

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 major milestones.
    - 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).
- Power
    - Provide plenty of spare capacity in panels.
    - Monitor power usage through BAS system. Allow remote monitoring.
    - Use VFDs or soft starts on motors.
    - Consider Combined Heat/Power systems to minimize demand charges.
- Generator
        - Verify if generator is standby or emergency.
        - Locate generator in area that will not be a noise issue when regularly tested.
    - Use high efficient transformers
- Lighting
    - Use LEDs. Consider lighting controls/lighting levels in selection.
    - Select lights based on quality.
    - Locate lights where they can be easily accessed. Avoid locations over stairs or multi-story openings.
    - Avoid light pollution
    - Be careful of complex lighting control systems. These get turned into on/off switches.
    - Higher reflectance finishes to use natural light more efficiently
    - 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
- Fire Detection

- Select contractors based on performance during construction and most importantly on support after construction. Complete research on firms from other School Districts.

STRUCTURAL SYSTEMS

Daily/Weekly 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 drill holes in wood and steel or 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 cost a lot of money in the long run.
- Paint rusting steel.
- Use infrared camera to identify water penetration or condensation locations. These can rot/damage structural members over time.
- Foundations
    - Identify and remove vegetation that may be growing around foundations.
    - Keep up on yearly shoring of foundations/piling.
- Examine welds and bolted connections. Particularly where exposed to the weather.

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.
- Fund/perform structural maintenance to correct known failures before they cause major issues.
- Minor Upgrades Structural
- If buildings are settling, schedule annual shoring of the system
- Install system to monitor building movement
- Install thermostat strings to monitor ground temp

Design Best Practices to Support O&M

- Provide an adjustable foundation where settling may occur (climate change)
- Design:
    - Specify exterior fasteners to be galvanized or stainless steel.
    - Design to avoid thermal bridging between exterior structure and interior structure
    - Coordinate supports for piping and heavy equipment. Coordinate anchor load points for piping system expansion.
- Foundations:
    - Sensors to monitor foundations
    - Rural Alaska Small School Foundation will a shallow concrete foundation work: yes or no
    - Design adjustable pile foundation in permafrost areas.
    - Avoid concrete slab on grades in areas of permafrost

    - Triodetic foundations are fantastic for shirting ground and flood zones for smaller buildings, (< 10,000 SF).
- 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.
- Coordinate structural design for anticipated drifting areas. Strengthen structure as opposed to building roof wedges
- Exterior Construction
    - Galvanize exterior steel
    - Avoid exposed exterior beams, particularly structural steel members, that penetrate the thermal envelope
- Cover/Conceal wooden structures that would otherwise be exposed to the weather.
- Avoid load bearing walls
    - Load bearing walls make readapting spaced more difficult as the users' needs change.
- Leave structural steel exposed