Fire Station Efficiency Solutions Package

The Fire Station Efficiency Solutions Package aims to assist municipalities nationwide reduce carbon footprints, lower utility bills, and increase resiliency by selecting improvements that will reduce energy and water use in existing buildings by at least 20%. This toolkit is a product of a collaboration of the City of Atlanta (CoA) and Southface Energy Institute through the Advanced Commercial Buildings Initiative in partnership with the U.S. Department of Energy. All CoA fire stations were benchmarked in ENERGY STAR® Portfolio Manager, and select stations were assessed through ASHRAE Level 2 audits, energy monitoring, performance testing and energy modeling to develop a deep understanding of their energy consumption profiles. Southface also supported the CoA during upgrade selection and implementation. Through this solutions package, municipalities and fire departments will be equipped to plan and implement individual and portfolio-level upgrades.

Background

Across the nation there are at least 21,198 fire departments who operate approximately 50,700 fire stations. These fire stations house a total of 1,066,300 career and volunteer fire fighters each year.[1] The Atlanta Fire and Rescue Department manages 37 fire stations, which are home to 948 fire fighters. Fire stations' heavy operating hours, long-term building occupation and technically savvy staff create the potential for large energy savings, especially where upgrades can be standardized across a portfolio.

Because fire departments are a common municipal building type and play a prominent role in civic life, the CoA research efforts focused on characterizing energy and water consumption across the portfolio and providing upgrade solutions which are applicable to the vast majority of fire stations nationwide.

Problem Statement and Barriers

Aging building shells and inefficient equipment across fire station portfolios waste taxpayer dollars and create uncomfortable and unhealthy living environments for fire fighters who dedicate themselves to public service.

Barriers to implementing energy efficiency projects at municipal fire stations include:

- Limited access to financing
- Higher prioritization of upgrades such as life safety and ADA (Americans with Disabilities Act)
- Lack of defined and measurable goals related to energy efficiency
- Gaps in utility data collection and lack of data verification protocol
- Lack of training around best practices regarding energy efficiency

This solutions package aims to address the last three barriers listed above.

Goals

Over 169 U.S. cities have committed to the Compact of Mayors, an international initiative supporting cities with addressing climate change by providing a framework to track emissions, set targets, and create plans. In addition to committing to the Compact of Mayors, the CoA has committed to reducing greenhouse gas emissions by 20% by 2020 and 40% by 2030, relative to a 2009 baseline.[2] This toolkit provides the resources to support meeting local and national emission reduction targets.

[1] https://apps.usfa.fema.gov/census/summary
[2] http://p2catl.com/climate-action/ghg-emissions-and-reduction-targets/

BENCHMARKING

OVERVIEW

Fire Station energy usage cannot be managed until it is measured. Benchmarking fire stations involves tracking and evaluating fire station energy usage and comparing performance to other fire stations.

Why benchmark a portfolio of fire stations?

- Compare energy performance and prioritize upgrade efforts
- Set energy reduction goals and measure progress
- Identify and cease payment for unused meters in building portfolio
- Meet city benchmarking requirements

What tools can help benchmark utility data?

ENERGY STAR Portfolio Manager is a free online tool used nationally to benchmark buildings.

What data is needed to benchmark a building?

A common metric used in benchmarking is Energy Use Intensity (EUI). To calculate EUI, the following data is needed:

- Building square footage
- 12 months of consecutive building energy use data

BARRIERS

While benchmarking utility data in ENERGY STAR Portfolio Manager, three main barriers emerged:

Education

- Limited staff training budgets and technical experience and high turnover

Documentation

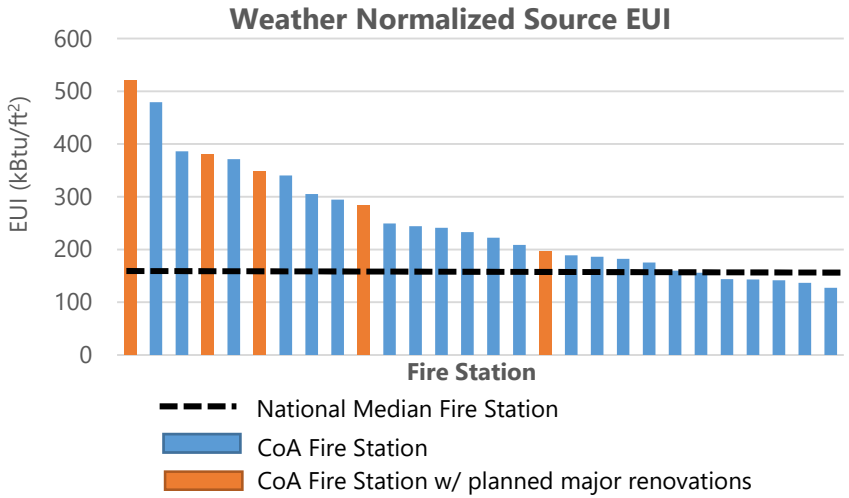
- Erroneous, missing and failing utility meters
- Conflicting or missing records

Processes

- Regulatory process between city departments, prolonging access to city drawings and building data
- Lack of process for data verification

DATA & SOLUTIONS

How are CoA fire stations performing compared to each other and the national median station? The median CoA fire station source Energy Use Intensity (EUI) is 59% above the national median value (244 kBtu/ft^2 and 154 kBtu/ft^2, respectively). There is a very large range in performance within the CoA portfolio, ranging from 127 kBtu/ft^2 to 519 kBtu/ft^2. No relationship was found between building performance and age. All five stations with planned major renovations (orange bars) are currently consuming more than the national median and will likely benefit greatly from energy efficiency upgrades.



From benchmarking data, estimated cost savings were calculated. Meeting the Atlanta Better Buildings Challenge goal of reducing fire station energy use by 20% would save the city approximately $95,000 annually.

To address the barriers related to energy benchmarking, Southface developed a data verification protocol. The protocol aims to standardize the process for verifying data already inputted into ENERGY STAR Portfolio Manager, as well as provide a reference to those with limited technical experience. The Protocol for Verifying Utility Data may be found on page 7.

[1] https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/difference

FIRE STATION CHARACTERISTICS

OVERVIEW

Fire stations are heavily used, as they are occupied every day of the year, at all times. They are used simultaneously as a workplace, community space and a home, most typically comprised of a bunk room, kitchen, day room, workout area, office, and a vehicle bay. In the CoA fire station portfolio, the average building area is 8,000 ft^2. Typical system characteristics of a CoA fire station are:

- ***HVAC*:** Constant volume split systems or packaged units with gas-fired furnaces. Bay area only heated with gas unit heaters.
- ***Interior Lighting*:** Mixture of T12 and T8 linear fluorescents, and incandescent and CFL screw-in bulbs controlled by manual switches.
- ***Exterior Lighting*:** Metal halide wall packs controlled by manual switches or photocells.
- ***Appliances*:** Residential-grade refrigerators and kitchen exhaust fans; commercial-grade clothes washer, clothes dryer and ice machine. Kitchen range is gas with continuous pilot lights.
- ***Water Heating*:** Storage tank, gas, residential-grade.
- ***Envelope*:** Slab on grade; single story; built-up metal deck roof.

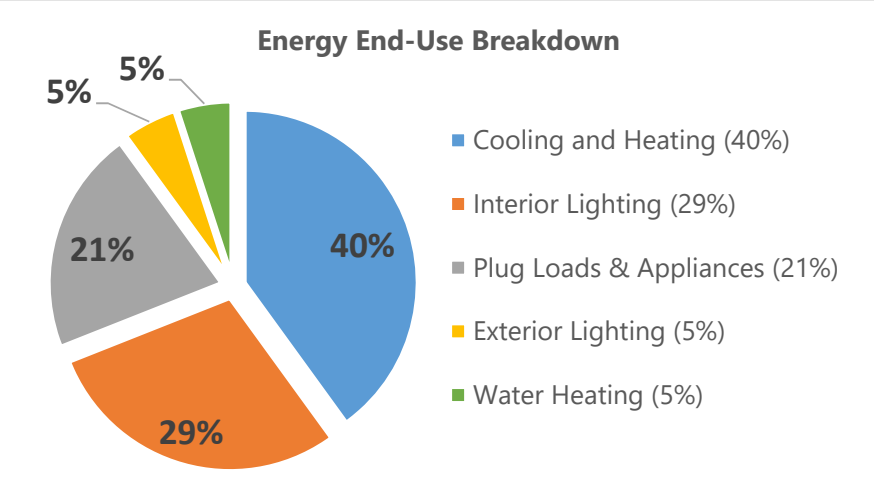
SOLUTIONS

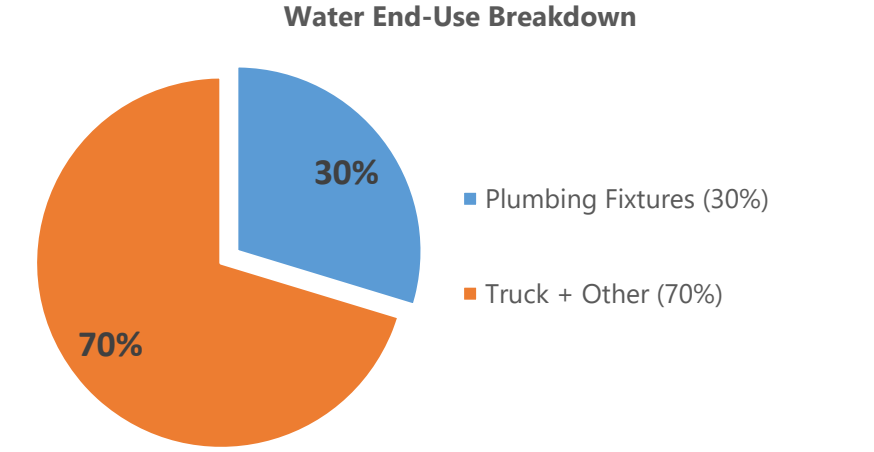
Keep the following in mind to successfully implement energy efficiency projects at fire stations:

- Investing in high quality, durable equipment will reduce replacement frequencies and complaints, resulting in a lower total cost of ownership.
- Engage fire station personnel early in the design process to understand and address the particular needs of the station.
- Always remember to take a systems approach when assessing and upgrading fire stations. For example, air sealing and insulating duct systems will reduce energy use and also improve indoor air quality. It is important to see these connections to comprehensively upgrade stations and optimize upgrades. The *Buildings are Complex Systems*[1] factsheet provides an overview of this concept.

DATA

Where are energy and water being used at a fire station? Charts below show the average source energy and water end-use breakdown of a CoA fire station. Heating and cooling combined account for the largest energy consumption (40%). Interior lighting is next (29%). Station fire trucks account for the majority of water use (70%). This includes washing trucks and refilling truck water tanks that leak water. To gain higher energy/water savings, the largest end-users should be targeted for efficiency measures.





[1] www.southface.org/programs/acbi

PATHWAY TO 20% ENERGY SAVINGS

OVERVIEW

Mechanical, lighting, plumbing and building envelope systems of 14 City of Atlanta fire stations were assessed through ASHRAE Level 2 energy audits. The most commonly recommended projects with the highest savings are included in the 20% energy savings package.

Energy conservation measures are recommended across all end uses, including lighting, heating, cooling, water heating and plug loads and appliances. As noted in the previous section, HVAC and lighting accounted for the highest energy users; as seen in the graph to the right, they also have the highest energy savings potential.

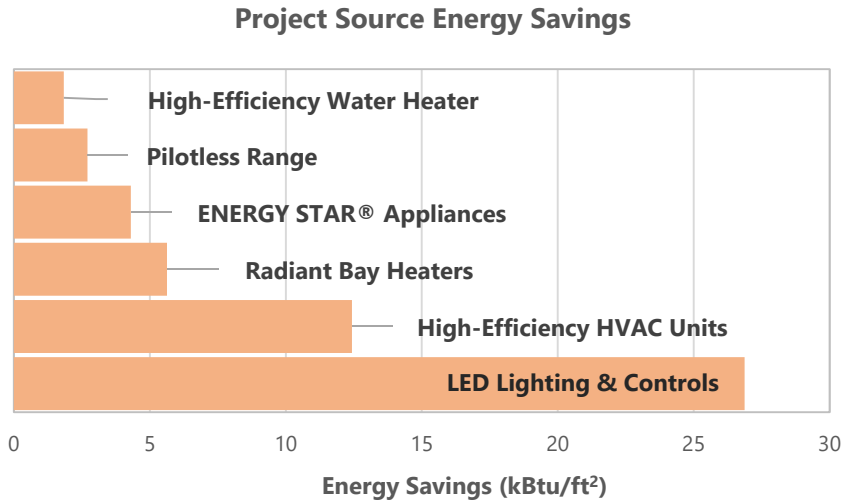
BARRIERS

During the project selection and implementation phases, three main barriers emerged:

- Proposed efficiency projects lacked clear and standardized specifications. Adding these details to the project scope of work holds contractors responsible for implementing the project correctly, and ensures equipment is installed as intended.
- Limited budgets and value engineering can eliminate efficiency measures from project scopes. Ranking projects in terms of energy savings potential help inform where efficiency efforts should be prioritized.
- Equipment rated efficiency and remaining useful life metrics are extremely valuable when evaluating equipment upgrades. Establishing a standardized system for tracking building equipment characteristics provides useful information to support planned or future upgrade decisions.

DATA & SOLUTIONS

Which upgrade projects will help meet the 20% energy savings goal? Below, the most frequently recommended energy conservation measures and their associated energy savings are shown. LED lighting and controls have the highest savings potential, at 27 kBtu/ft^2. This means a 10,000 ft^2 station with typical equipment has the potential to reduce electricity costs by more than $2,500 per year by upgrading all lights to LEDs with controls[1].



Rankings efficiency projects by energy savings potential supports project managers with determining where efforts should be focused.

In addition, for the successful implementation of the projects above, detailed specifications are needed. Implementation guidance for the projects above is outlined in the Pathway to 20% Energy Savings Specifications section, on page 9.

LOW-COST AND QUICK-PAYBACK SOLUTIONS

OVERVIEW

Some energy conservation measures should be implemented as soon as possible, either due to the low or no cost, or very quick payback (< 1 year). These measures are listed below:

Equipment

- Turn off unused or unnecessary equipment (e.g., electric space heaters in the summer)
- Convert all electric dryers to gas dryers (if gas available at facility)
- Stock only ENERGY STAR qualified screw-in replacement bulbs
- Unplug & remove vending machines
  - If not possible, de-lamp machine and/or install VendingMiser™

Water

- Install low-flow showerheads and faucet aerators (more details on page 10)
- Fix leaks promptly

Behavioral

- Hold energy and water savings competition between fire stations, as the town of Cary, NC did a few years ago[1]
- Educational signage
- Benchmark energy use, as described on page 2

BARRIERS

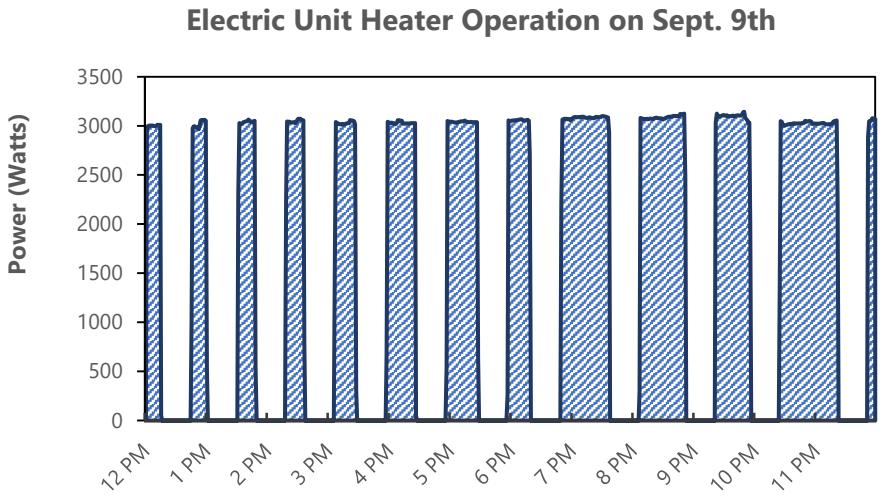
The main barrier to implementing low-cost or quick-payback measures is making an intentional effort to do so. Integrating these recommendations into policies and procedures will increase the likelihood of them being implemented. In addition, by engaging the fire station men and women who are most familiar with the building about efficiency goals, additional opportunities for savings may be realized.

DATA & SOLUTIONS

Do low cost measures have a noticeable impact on energy use?

In one instance, circuit level monitoring at an Atlanta fire station revealed an electric resistance wall heater located in the lobby continuously turning on during the summer. On a September day, when outdoor temperatures peaked at 84°F, the inefficient heater cycled on and off (below), using 3000 watts each time it was on. For comparison, 3000 watts is equivalent to turning on 50 typical incandescent light bulbs.

From April through September, when supplemental electric resistance heating should not be necessary, this heater consumed 2,774 kWh. If each fire station in the CoA had 1 electric heater accidentally turned on during the summer, this would cost an estimated $9,695 each year.



Simple awareness and an intentional effort to turn off unused or unnecessary equipment can go a long way to reducing energy use and energy bills. Conducting an "energy walk-through" periodically, or during an already planned site visit, can help minimize wasted energy consumption.

[1] http://www.firehouse.com/news/10754820/nc-fire-officials-present-fire-chiefs-energy-challenge

OTHER CONSIDERATIONS

HEALTH AND SAFETY

Fire fighters know that health and safety are top priorities. Fire station assessments also documented building elements impacting the health and safety of fire fighters living and working there. Best practices to encourage better indoor air quality in the stations include:

1. **Building Envelope:** It is necessary to air seal all exterior walls, roof, and floor of a building to minimize the loss of heated and cooled air to the outside. At a fire station, in addition to air sealing at exterior surfaces, it is important to air seal bay walls that are adjacent to living spaces. A typical station layout includes a bunk room area and kitchen/dayroom area, with the bay area in the middle. Fire trucks are stored in the bay area, and as a result this area is susceptible to truck exhaust fumes. All living spaces should be air sealed from the bay area to minimize exposure to these harmful fumes. Detailed specifications for air sealing at fire stations can be found in the *20% Pathway section*.

2. **Kitchen exhaust fan:** Station kitchens are typically used throughout the day for breakfast, lunch and dinner. A functional kitchen exhaust fan is vital to maintaining adequate indoor air quality while cooking. However, it's important to not oversize the kitchen exhaust hood to optimize energy efficiency. Guidance for kitchen hoods with air quality and energy conservation in mind can be found in the *20% Pathway section*.

3. **Combustion Safety:** Many stations use gas for space and water heating, with heating equipment located inside the building envelope. It is important to make sure that adequate air is supplied to heating equipment for combustion, and that combustion gases are completely exhausted from the building. Carbon monoxide (CO) detectors should be installed on each floor, and combustion testing should be performed by a trained contractor in order to minimize the risk of carbon monoxide and other combustion gases entering the living/working space. Guidance for combustion best practices in small commercial building can be found in the *Small Commercial Combustion Appliance Guidelines*[1].

POLICIES

Energy and water efficiency strategies must be explicitly tied to a department's mission, captured by procedures, and supported by leadership to be effective in the long term. Department goals should align with municipality sustainability and resiliency goals.

A procurement policy implemented at a municipal level can help standardize efficiency and upgrade specifications across departments. For instance, a suggested performance criteria is to require the purchase of LED lighting certified by ENERGY STAR or DesignLights Consortium in order to lock in energy savings.

On the other hand, operations and maintenance procedures are typically defined at the department level. Operations and maintenance should incorporate energy and water efficiency standards into their procurement policy, and be regularly reviewed and updated to reflect best practices. It is best to plan for equipment replacements and have specifications in place. For instance, above code heating and cooling equipment and WaterSense plumbing fixtures.

Greater consistency in equipment across a building portfolio can reduce overall operations and maintenance expenses by reducing requirements for stocking parts (e.g., lamp types), as well as increase technician expertise with servicing specified equipment. Further, the incremental cost of installing above-code equipment typically pays back within the life of the equipment.

[1] www.southface.org/programs/acbi

Protocol for Verifying Utility Data

Goal: to provide a protocol to verify and/or correct utility data already entered into ENERGY STAR Portfolio Manager (ESPM) accounts. Three key pieces of information must be validated:

1. Year built
2. Gross Floor Area
3. Utility consumption (electricity, gas, and water)

Navigation: Return to Benchmarking Section

1. Year Built:

- **Definition**: This is the year in which your property was constructed. If your property has undergone a complete renovation that included gutting and rebuilding the interior, then you can indicate the date of this renovation as the year built.
- **Verification:** There are three ways to verify the year the property was built, and all three options should be employed for increased accuracy:
  1. Compare with the bottom-right corner of as-built drawings
  2. Site visit observations (including plaques and/or corner stones found in the property)
  3. Site visit interviews with fire station occupants

2. Gross Floor Area

- **Definition:** Gross Floor Area should include all space within the building(s), including office areas, vehicle storage areas, residential areas (if applicable), storage areas, break rooms, kitchens, elevator shafts, stairwells, and hose towers.
- **Verification:** There are three ways to verify the property's gross floor area, and all three options should be employed for accuracy:
  1. Check property record data, if accessible online
  2. Calculate using architectural plans
  3. Physically measure the exterior dimensions of the building

3. Utilities

- **Definition:** Utilities should include at least one electricity meter and one water meter (there may be a separate irrigation water meter, but it is unlikely). If gas is consumed onsite, there will also be a gas meter. The utilities should only pertain to the property's energy and water consumption, and not alternative uses (communications tower, usage of previous property, etc.)
- **Verification:** The following steps should be completed to compare utility data in ESPM to utility bills:
  1. Compile a list of all utility accounts attributed to the property, including:
     - Address
     - Account Number
     - Meter Numbers
       - It is recommended to conduct a site visit and obtain meter numbers from the physical meters onsite.
  2. Calculate annual consumption and cost for each utility in ESPM
     - Login to ESPM and click on your property in the Properties list
     - Click on the Energy tab
     - For each meter, click on the Meter ID
     - Add the Usage and Cost values from the most recent 12 months to determine annual metrics
     - Note the Start and End Dates for the 12 month period
  3. Calculate annual consumption and cost for each utility through their online account (either directly through the utility or through a utility management system)
     - Login to the utility account
     - Search for the property by its Account Number (from Step 1 above). Once identified:
       - Verify the listed property address matches the actual address (from Step 1 above)
       - Verify the listed Meter Number(s) match the actual Meter Number (from Step 1 above)
     - For the same (or similar) 12 month period in Step 2 above, add the total utility use and cost.
  4. Compare annual utility consumption and cost from Step 2 and 3.
     - Annual metrics are compared, rather than month to month, because utility management systems may normalize bills to be evenly distributed across each month, which adjusts the monthly billed consumption slightly. Therefore, annual totals should be compared for accuracy. Be sure

to check the Start Date and End State between both sets of data to ensure both annual totals are over a similar date range.
- Look for red flags, including zero consumption or cost.

5. Correct any errors in ENERGY STAR Portfolio Manager as appropriate

- Error correction methodology will vary, but general guidance for correcting errors is as follows:
- If you find an annual total in ESPM that doesn't match the data in the online utility account, overwrite the existing data in ESPM with the monthly bills from the online utility account.
- After replacing ESPM entries with the correct data, ensure the annual total match.

Pathway to 20% Energy Savings Detailed Specifications

Goal: This document outlines detailed specifications for energy conservation measures to be implemented in fire stations. Project numbers 1 – 4 are recommended to reach 20% energy savings. Project numbers 5 – 7 provide guidance on measures related to health and indoor air quality, or low-cost measures.

Navigation: Return to Pathway to 20% Savings Section

---

1. **Lighting Efficiency Measures**
   a. Interior Lighting & Controls
      - All lights should be ENERGY STAR® or DesignLights Consortium® certified.
      - Replace all existing T12 and T8 fluorescent fixtures with LED fixtures.
      - Replace all existing incandescent and CFL bulbs with LED screw-in bulbs.
      - Replace all existing can lights with air tight and IC rated LED can lights.
      - Replace all interior light switches with vacancy and occupancy sensors in all areas except the bunk room. Install *vacancy* sensors (manual-on, auto-off) in all day-lit spaces and *occupancy* sensors (auto-on, auto-off) in all spaces without daylighting where artificial lighting is required for sight. Provide dimming controls in bunkroom, day room, and offices. *Sensor timeouts should be 5 minutes.*
   b. Exterior Lighting & Controls
      - Replace exterior metal halide fixtures with LED fixtures. New fixtures should have photocell and bi-level occupancy controls. Bi-level occupancy controls will operate the fixture at a lower power/light level unless occupancy is detected.
   c. *Additional resources*: https://www.energystar.gov/products/lighting_fans

2. **HVAC Efficiency Measures**
   a. Replace all air conditioners with ENERGY STAR rated units that meet the following criteria:
      - Air conditioner system efficiency meets SEER ≥ 16 (EER ≥ 12.8)
      - Air handler fan with an ECM (Electronically Commutated Motor) and variable speed capabilities
   b. Replace all furnaces with ENERGY STAR rated units that meet the following criteria:
      - Heating system efficiency meets AFUE ≥ 90%
      - Condensing furnace with a two-pipe or concentric pipe PVC flue system
   c. Visually inspect ductwork. Seal with mastic and re-insulate where needed.
   d. Replace all bathroom exhaust fans with an ENERGY STAR fan.
   e. Replace gas unit heaters in bay with radiant gas heaters. Ensure radiant heaters are strategically positioned only in areas where people frequent in the bay.
   f. *Additional Resources*: https://www.energystar.gov/products/heating_cooling

3. **Appliance Efficiency Measures**
   a. Replace existing refrigerators/freezers with ENERGY STAR rated refrigerators/freezers.
   b. Replace existing ice machine with an air-cooled ENERGY STAR rated ice machine.
   c. Replace existing kitchen range with a pilotless range.
   d. *Additional resources*: https://www.energystar.gov/products/appliances

4. **Water Heating**
   a. Replace existing water heater with an ENERGY STAR tankless or storage water heater.
      - Condensing water heater should have a two-pipe or concentric pipe PVC flue system.
   b. Additional resources: https://www.energystar.gov/products/water_heaters

5. **Building Envelope Measures**
   a. *Roof air sealing*: Remove all unused roof penetrations, such as defunct exhaust fans. Seal and insulate resulting opening.
   b. *Wall air sealing*: Air seal and insulate with a **foam based** sealant the intersection of the CMU block wall and metal roof decking along all exterior walls and walls **separating the bay and living space**. Also, seal with a foam based sealant all exterior and bay wall penetrations, such as holes from refrigerants lines, wires, piping, ducts, and wall louvers.
   c. *Door air sealing*: Weatherstrip all exterior doors and doors between the bay area and living space. Ensure all doors fully close; add a door closer if not present. Insulated core doors required between apparatus bay and living spaces.
   d. *Additional resources*: https://www.energystar.gov/products/building_products

6. **Kitchen Exhaust Hood**
   a. Energy efficiency criteria per ASHRAE 90.1 – 2010 is as follows
      a. Exhaust hood flow rate (cubic feet per minute) should not exceed 210 x length of range (feet), per Table 6.5.7.1.3 (assuming kitchen range is medium-duty)
      b. Make-up air flow rate should be equivalent to 75% of exhaust hood flow rate
         - A make-up air unit with a gas furnace should heat the make-up air (if gas is available at the facility).
      c. Exhaust hood should be a wall mounted canopy configuration
      d. Exhaust hood and make-up air fan switch should be interlocked to ensure they operate as the same time.

7. **Water Efficiency Measures**
   a. Replace existing showerheads with WaterSense labeled 1.5 gallon per minute (GPM) showerheads *(lower cost).*
   b. Replace existing faucet aerators with WaterSense labeled 0.5 gallons per minute (GPM) faucet aerators (*lower cost*).
   c. Retrofit the existing kitchen spray nozzle and faucet with a WaterSense labeled 1.28 GPM spray nozzle and 1.5 GPM faucet.
   d. Replace existing water closets with WaterSense labeled 1.28 gallon per flush units and manual flush (no automatic sensor).
   e. Replace existing urinals with WaterSense labeled 0.125 gallon per flush units and manual flush (no automatic sensor).
   f. Install a 2,500 gallon rain water storage tank with necessary filters and pumps for use in truck washing.
   g. *Additional resources*: https://www3.epa.gov/watersense/products/index.html