# Topeka Housing Authority Phase I EPC

## Investment Grade Audit

This document is a draft investment grade energy audit of the resource efficiency opportunities at Deer Creek Village, Jackson Towers, Marshall Square, Pine Ridge Manor, Polk Plaza, Tennessee Town I, Tyler Towers, and Western Plaza, Echo Ridge, and Tennessee Town II.

Version 3.0

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# 1 Executive Summary

Group14 Engineering has conducted an investment grade energy audit, identifying several energy and water conservation measures (ECMs) for inclusion in Phase I of an Energy Performance Contract. The assessment included 744 public housing units managed by the Topeka Housing Authority (THA). Building types include 3 high rises, 5 large row home type project developments, and 4 sites with multiple duplex homes. Group14 worked closely with THA to ensure that pressing capital needs with an efficiency component were included in the recommended bundle of ECMs.

Opportunities for improved water and energy efficiency performance were found in all facilities. ECMs include:

- Central plant control installation and optimization
- Furnace upgrades
- Domestic hot water heater upgrades
- Bathroom heating element timers
- In-unit, common area, and exterior lighting upgrades, including new fixtures, lamp/ballast replacement, and controls
- Low flow aerators (kitchen and bathroom) and showerheads
- Building envelope improvements
- Solar Photovoltaics

The report is organized by ECM category: Mechanical, Appliance, Lighting, Envelope, Water and Renewable system upgrades. Savings are reported by HUD Project Number. Because all Phase 1 work is being implemented through a GC/CM model, some specific design elements have not yet been finalized. This narrative documents existing conditions, performance requirements for the proposed ECMs, equipment counts and preliminary savings and cost estimates. In the investment grade audit to follow this effort, savings calculations, refined cost estimate, and bid specifications will be provided for each measure.

*It should be noted that all existing condition descriptions are provided for audit purposes only. Contractors are required to verify all on-site conditions on which their bids are based.*

Group14 would like to thank Topeka Housing Authority staff and residents for sharing their time and deep knowledge of the building portfolio. Because of stakeholder input, the proposed ECMs should do more than reduce utility costs and address THA capital needs. Significant operations and maintenance savings should be realized. Procurement processes will now support efficiency goals. Most importantly, the Phase I project will result in real improvements in resident thermal comfort, dwelling unit light levels, and indoor air quality.

| Tag Name | Description | Spec/Narrative Location |
|---|---|---|
| **AHU1** | Install New Space Heating Boiler Plant with Setpoint Enable and OA Reset Controls | |
| **B1** | Install New Space Heating Boiler Plant with Setpoint Enable and OA Reset Controls | |
| **CH1** | Upgrade central plant controls to optimize heating plant and chiller plant operation. | |
| **CHWP** | New chilled water pumps with variable frequency drives | |
| **F1** | 94%+ AFUE condensing 2-stage furnaces | |
| **HWP1** | New space heating pumps with variable frequency drives | |
| **HP** | 9.5 HSPF heat pumps | |
| **I1** | Weather strip windows and exterior doors, and seal all penetrations | |
| **I2** | Seal all penetrations | |
| **In1** | Unit attic insulation level increased to R-38 and air seal attic penetrations | |
| **L1** | 11 W screw-in LEDs provided for hard-wired lamps | |
| **L2** | 14 W screw-in LEDs provided for spotlights | |
| **L3** | 18 W screw-in LEDs provided for bollards | |
| **P1a** | 70W LED pole light fixture heads with multi-level lighting control (single-headed) | |
| **P2a** | 102W LED pole light fixture heads with multi-level lighting control (single-headed) | |
| **PV1** | Install carport mounted photovoltaic systems | |
| **R1** | 2x4’ T12 magnetic ballast fixtures, retrofit with T8 electronic | |
| **R2** | 4x4’ T12 magnetic ballast fixtures, retrofit with T8 electronic | |
| **R3** | 3x4’ T12 magnetic ballast fixtures, retrofit with T8 electronic | |
| **R4** | 4x2’ T12 magnetic ballast fixtures, retrofit with T8 electronic | |
| **R5** | 2x8’ T12 magnetic ballast fixtures, retrofit with T8 electronic | |
| **R6** | 2-lamp U-bulb T12 magnetic ballast fixtures, retrofit with T8 electronic | |

| | |
|---|---|
| **ST1** | Safe-T Element temperature limiting control stovetops |
| **T1** | Dial Timers for Bath Heat Lamps |
| **Rf1** | Energy Star refrigerators |
| **X1** | LED exit signs |
| **W1** | 41W LED wallpacks with integrated photocells |
| **WF1** | Kitchen aerator replacements (1.5 gpm) |
| **WF2** | Bathroom aerator replacements (0.5 gpm) |
| **WF3** | Showerhead replacements (1.5 gpm) |
| **WF4** | Full shower install with showerhead (1.5 gpm) |

*Please refer to complete narrative and specification set for all construction requirements.*

# 2 General Assumptions

Many of the gas and water and sewer savings calculations in this audit use the weather regression of 2014/2015 utility data to quantify baseline energy consumption. This analysis develops an energy use equation that shows the relationship between the aggregate utility data associated with each HUD project number and average daily weather from the baseline period, calculated using a weighted ordinary least squares regression. The energy use equations are then “normalized” using geographically appropriate Typical Meteorological Year weather data to produce projected energy use during a typical weather year pre-Phase 1 retrofit. This typical energy use is separated in to weather dependent and independent components – gas heating, gas baseload, electric heating, electric baseload, electric cooling, domestic water use, and irrigation water use. These are the components that are used as inputs into some savings calculations. Each component value used as a calculation input is stated in the report.

Some of the energy savings calculations have been performed using energy modeling software – the eQuest 3.6 interface for DOE-2.2. It uses an hourly typical weather year and was calibrated to the weather-regressed utility data. This allows all of the different interactions between envelope and heating and cooling systems.

To ensure utility data validation, a thorough audit of Authority records was performed during the development of the utility baseline.

This type of analysis ensures that savings are based on actual consumption data, as opposed to stipulated savings calculations based on building use assumptions. It is more compatible with an Option C Measurement and Verification Protocol, the preferred approach for this project. In some few cases, baseline adjustments have been proposed to enable an Option C IPMVP approach. Supporting narratives and calculations have been provided in these cases.

When stipulated savings calculation and building use assumptions are employed in this report, such assumptions are clearly stated in the associated Savings Calculations report section.

The measure narratives and specifications that will guide implementation have been designed to support the efficiency performance projected in this audit. Additionally, they will meet or exceed the standards established by Topeka Housing Authority and applicable Authorities Having Jurisdiction. The following standards have specific relevance to one or more ECMs:

- ASHRAE 90.1
- ASHRAE 62.1 and 62.2
- Illuminating Engineers Society of North America (IESNA) Guidelines
- Environmental Protection Agency (EPA) and Energy Star regulations and standards
- The National Electrical Code (NEC)
- Codes and Standards of the local Authorities Having Jurisdiction

A note on energy savings calculations; in some cases, it is assumed that there will be degradation in energy or water savings over the term of the Phase 1 EPC. This can be due to decreases in equipment performance over time (before equipment failure), or because of detrimental interaction between ECMs and building users. In these cases, a variance factor has been applied to reduce the projected savings. This is clearly indicated in the relevant calculations presented in this report.

# 3 Site Descriptions

Below is a table summarizing the properties included in the investment grade energy audit.

| AMP | Site # | Site Name | Structure Type | Senior/ Family/ Mixed | Total | Unit Count | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 0 | 1 | 2 | 3 | 4 | 5 |
| KS002000001 | KS02-01.0 | Pine Ridge Manor | Semi-Detached (SD) (duplex) | Family | 211 | - | 71 | 80 | 48 | 12 | - |
| KS002000001 | KS02-09.0 | Marshall Square | Row/Townhouse (RW) | Family | 26 | - | 24 | 2 | - | - | - |
| KS002000002 | KS02-03.0 | Polk Plaza | Elevator Structure (ES) | Mixed | 109 | 65 | 35 | 9 | - | - | - |
| KS002000002 | KS02-08.0 | Tennessee Town I | Row/Townhouse (RW) | Mixed | 25 | - | 25 | - | - | - | - |
| KS002000003 | KS02-04.1 | Deer Creek Village | Row/Townhouse (RW) | Family | 92 | - | 10 | 44 | 34 | 2 | 2 |
| KS002000003 | KS02-04.2 | Western Plaza | Row/Townhouse (RW) | Family | 22 | - | - | 12 | 8 | 1 | 1 |
| KS002000004 | KS02-04.0 | Tyler Towers | Elevator Structure (ES) | Senior | 75 | - | 75 | - | - | - | - |
| KS002000005 | KS02-02.0 | Jackson Towers | Elevator Structure (ES) | Mixed | 102 | - | 94 | 8 | - | - | - |
| KS002000007 | KS02-07.0 | Tennessee Town II | Row/Townhouse (RW) | Mixed | 16 | - | 16 | - | - | - | - |
| KS002000008 | KS02-10.0 | Echo Ridge | Semi-Detached (SD) (duplex) | Family | 66 | - | 16 | 38 | 12 | - | - |
| | | | | **TOTAL** | 744 | 65 | 366 | 193 | 102 | 15 | 3 |

## 3.1 Pine Ridge Manor

Pine Ridge Manor is a 211 unit public housing family site built in 1962. This site consists of duplex and single family, detached homes, and has (71) one bedroom, (80) 2 bedroom, (48) 3 bedroom units and (12) 4 bedroom units.

### 3.1.1 Lighting Systems

The lighting in a typical unit at Pine Ridge Manor consists of primarily incandescent and compact fluorescent ceiling mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens.

Each unit has (2) wall mounted porch lights with either incandescent or compact fluorescent bulbs. Aside from porch lights, exterior lighting is primarily provided through utility owned street lights. There are also (10) metal halide wallpacks on the community and aquaponics building.

The only common area lighting is in the community and aquaponics building. Lighting is primarily linear fluorescent (mostly T8 and T5 electronically ballasted fixtures, with a few magnetically ballasted T12 fixtures) and ceiling mounted screw in incandescent.

### 3.1.2 Building Envelope

Pine Ridge Manor is a family site that is comprised of single story duplex and detached homes. Most homes have double pane windows with vinyl frames, and pitched, shingled roofs. The buildings are wood frame construction with minimal batt insulation.

### 3.1.3 Building HVAC

The units at Pine Ridge Manor are each heated and cooled by an atmospheric, natural gas furnace with a remote condensing unit. Most units were Carrier furnaces, with a heating output range of 46,000 – 69,000 BTUH and predominately 1.5 ton condensing units (R-22 refrigerant). Domestic hot water (DHW) is provided by an atmospheric natural gas 40 gallon packaged boiler and tank. Observed manufacturers included Reliance, American Water Heater, Premium Plus, and others.

### 3.1.4 Utility Service

Pine Ridge Manor purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The residents pay their own electricity and gas bills, and thus use the residential rates.

Pine Ridge Manor purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using multi-family rates.

## 3.2 Marshall Square

Marshall Square is a 26 unit public housing family site built in 1955, but remodeled in 2006. This site consists of row type and single family, detached homes with (24) one bedroom and (2) 2 bedroom units.

### 3.2.1 Lighting Systems

The lighting in a typical unit at Marshall Square consists of incandescent and compact fluorescent ceiling mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens.

Each unit has (2) wall mounted porch lights with either incandescent or compact fluorescent bulbs. Aside from porch lights, exterior lighting is primarily provided through flood lights.

The only common area lighting is in the garage and laundry rooms. Lighting is linear fluorescent (T8 electronically ballasted fixtures and magnetically ballasted T12 fixtures) in the laundry rooms and ceiling mounted screw in CFLs in the garage.

### 3.2.2 Building Envelope

Marshall Square is a family site that is comprised of row-type and detached homes. All units have double pane windows with vinyl frames, and pitched, shingled roofs. The buildings are wood frame construction with some batt insulation.

### 3.2.3 Building HVAC

The units at Marshall are each heated and cooled by a Carrier electric resistance furnace with a remote condensing unit (R-22 refrigerant). The 1 bedroom units are served by (2) 30 kW, 120 gallon electric Domestic hot water (DHW) heaters. The 2 bedroom units have 50 gallon, 4,500 watt individual in-unit electric DHW heaters.

### 3.2.4 Utility Service

Marshall Square is an all-electric site that purchases electricity from Westar Energy. The residents pay their own electricity bills, and thus use the residential rates.

Marshall Square purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using multi-family rates.

## 3.3 Polk Plaza

Polk Plaza is a 109 unit public housing family site built in 1969. This site consists of a 100 unit high rise and 9 row type cottages. The site has (65) studios, (35) 1 bedrooms, and (9) 2 bedroom units.

### 3.3.1 Lighting Systems

The lighting in a typical unit at Polk Plaza consists of incandescent and compact fluorescent ceiling and wall mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens. The first floor units also have linear fluorescent fixtures (primarily T8, electronically ballasted).

Exterior lighting is primarily provided (2) 400W MH pole lights, (19) 250W MH pole lights, and 3 bollards.

Common area lighting is primarily 4’ T8 electronically ballasted linear fluorescent fixtures (224) with a scattering of magnetic ballasted T12 and incandescent fixtures.

### 3.3.2 Building Envelope

The Polk Plaza high rise is comprised of double pane windows with aluminum framing. The building is CMU, concrete and steel construction with a flat EPDM roof. The cottages are comprise of brick/wood framed walls, double pane windows with aluminum frames and a sloped roof with asphalt shingles.

### 3.3.3 Building HVAC

The units and common areas at the Polk Plaza high rise are each heated by hydronic baseboard, with the exception of the 1st floor. The baseboard is controlled by 2 way thermostatic zone valves connected to analog non-programmable thermostats. The baseboard is served by 2 Weil-McLain power vent boilers, 2,843 MBH output each. The heating plant is manually enabled from October 15th through April 15th each year. Two (5) hp constant volume pumps circulate hot water for space heating.

Air conditioning is provided by authority owned window units in each apartment. Two window AC units per floor provide cooling to the corridors.

One power draft domestic hot water boiler provides hot water to one large storage tank. While the name plate was illegible, the authority reports that this boiler was installed in 2002.

One Carrier multi-zone hot deck cold deck air handling unit provides heating and cooling to the first floor, including (3) 1st floor units. This unit had significant water leaks. The AHU appears to be the only piece of equipment under DDC control. The building pressure is controlled by a large barometric release damper on the first floor.

The building exhaust is controlled by a series of large exhaust fans on the roof that feed a series of chases serving each apartment. These exhaust fans run continuously and are in various states of condition from good to pour.

The 9 cottages are heated and cooled with atmospheric natural gas furnaces and a remote condensing unit on a non-programmable thermostat. 40 gallon atmospheric natural gas packaged boilers provide DHW.

### 3.3.4 Utility Service

Polk Plaza purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The authority pays electricity and gas bills, using commercial rates.

Polk Plaza purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using multi-family rates.

## 3.4 Tennessee Town I

Tennessee Town I is a 25 unit public housing family site built in 1982. This site consists of duplex and single family, detached homes, and has (25) one bedroom units.

### 3.4.1 Lighting Systems

The lighting in a typical unit at Tennessee Town I consists of incandescent and compact fluorescent ceiling mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens. There were also circline fluorescent fixtures in the kitchens.

Each unit has (3) wall mounted porch lights with either incandescent or compact fluorescent bulbs. Aside from porch lights, exterior lighting is primarily provided through utility owned street lights and authority owned pole lamps. There are (12) 6' 100 W incandescent pole lights and 7 solar powered LED pole lights. There are also (4) CFL wallpacks on the community building.

The only common area lighting is in the community building. Lighting is primarily linear fluorescent (mostly T8 electronically ballasted fixtures, with a few magnetically ballasted T12 fixtures) and ceiling mounted screw in incandescent and CFL fixtures.

### 3.4.2 Building Envelope

Tennessee Town I is a family site that is comprised of single story duplex and detached homes. Most homes have double pane windows with metal frames, and pitched, shingled roofs. The buildings are wood frame construction with minimal batt insulation.

### 3.4.3 Building HVAC

The units at Tennessee Town I are each heated and cooled by an atmospheric, natural gas furnace with a remote condensing unit. Most units were Carrier furnaces, with a heating output of 44,000 BTUH and predominately 1.5 - 3 ton condensing units. Domestic hot water (DHW) is provided by an atmospheric natural gas 40 gallon packaged boiler and tank. Observed manufacturers included Reliance and American Water Heater. There are electric heaters in the bathrooms, controlled by a timer.

### 3.4.4 Utility Service

Tennessee Town I purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The residents pay their own electricity and gas bills, and thus use the residential rates.

Tennessee Town I purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using multi-family rates.

## 3.5 Deer Creek Village

Deer Creek Village is a 92 unit public housing family site built in 1969. This site consists of duplex and row-type family homes with (10) one bedroom, (44) 2 bedroom, (34) 3 bedroom units (2) 4 bedroom units, and (2) 5 bedroom units.

### 3.5.1 Lighting Systems

The lighting in a typical unit at Deer Creek Village consists of primarily incandescent and compact fluorescent ceiling mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens.

Each unit has (2) wall mounted or ceiling recessed porch lights with either incandescent or compact fluorescent bulbs. Aside from porch lights, exterior lighting is primarily provided through utility owned street lights. There is also (1) metal halide wallpack on the community building.

The only common area lighting is in the community building. Lighting is primarily linear fluorescent (a mix of T8 electronically ballasted and T12 magnetically ballasted fixtures), with a few ceiling mounted screw in incandescent fixtures and LED exit lighting.

### 3.5.2 Building Envelope

Deer Creek Village is a family site that is comprised of single and two story duplex and row-type homes. Most homes have double pane windows with metal frames, and pitched, shingled roofs. The buildings are wood frame construction with minimal batt insulation.

### 3.5.3 Building HVAC

The units at Deer Creek Village are each heated and cooled by an atmospheric, natural gas furnace with a remote condensing unit. Most units were Carrier furnaces, with a heating output range of 44,000 – 69,000 BTUH and predominately 1.5 - 2 ton condensing units (R-22 refrigerant). Domestic hot water (DHW) is provided by primarily Reliance atmospheric natural gas 40 gallon packaged boiler and tank. There is also an exhaust fan in each bathroom on switched control.

### 3.5.4 Utility Service

Deer Creek Village purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The residents pay their own electricity and gas bills, and thus use the residential rates.

Deer Creek Village purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using multi-family rates.

## 3.6 Western Plaza

Western Plaza is a 22 unit public housing family site built in 1970. This site consists of walk up multi-family buildings, and has (12) 2 bedrooms, (8) 3 bedroom units, (1) 4 bedroom unit, and (1) 5 bedroom unit.

### 3.6.1 Lighting Systems

The lighting in a typical unit at Western Plaza consists of primarily incandescent and compact fluorescent ceiling mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens.

Each unit has (2) wall mounted or ceiling recessed porch lights with either incandescent or compact fluorescent bulbs. Aside from porch lights, exterior lighting is provided through utility owned street lights. There is no other Authority owned exterior or common area lighting.

### 3.6.2 Building Envelope

Western Plaza is a family site that is comprised of three story walk up multi-family buildings. Units have double pane windows with metal frames and pitched roofs. The buildings are wood frame construction with minimal batt insulation.

### 3.6.3 Building HVAC

The units at Western Plaza are each heated and cooled by an atmospheric, natural gas furnace with a remote condensing unit. Most units were Carrier furnaces, with a heating output range of 44,000 – 66,000 BTUH and predominately 1.5 ton condensing units (R-22 refrigerant). Domestic hot water (DHW) is provided by an atmospheric natural gas 40 gallon packaged boiler and tank. Observed manufacturers included Reliance, Rheem, Premium Plus, and others.

### 3.6.4 Utility Service

Western Plaza purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The residents pay their own electricity and gas bills, and thus use the residential rates.

Western Plaza purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using multi-family rates.

## 3.7 Tyler Towers

Tyler Towers is a 75 unit public housing midrise built in 1972. This site consists of a single elderly elevated structure, and has (75) one bedroom units.

### 3.7.1 Lighting Systems

The lighting in a typical unit at Tyler Towers consists of primarily incandescent and compact fluorescent ceiling mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens. There is some T5 fluorescent under cabinet lighting.

Exterior lighting is primarily provided through lighting associated with Polk Plaza, some 100 W incandescent balcony lights, 150 W MH wall packs, and CFL jelly jar lights

Common area lighting is primarily 4' T8 linear fluorescent lighting with electronic ballasts. There are a few 4" T12 fluorescent fixtures with magnetic ballasts. These are located in hallways, laundries, community spaces, offices, and stairwells. There are both LED and incandescent exit signs present.

### 3.7.2 Building Envelope

Tyler Towers is an elderly site that is comprised of single midrise building. The building has double pane windows with aluminum frames, and a flat EPDM roof. The building is concrete and steel construction.

### 3.7.3 Building HVAC

The units at Tyler Towers are each heated and cooled by a 2 pipe fan coil unit. The fan coil unit is controlled by a manual "warmer/cooler" dial and 3 speed fan selector switch. The fan coil units are served by 2 power vent, natural gas Weil McLain boilers, one 1,904 MBH output and one 3,270 MBH output. There is (1) 5 hp constant volume space heating distribution pump. Chilled water is supplied by a new McQuay air cooled 160 ton chiller. There are 2 constant volume chilled water pumps (7.5 hp each). Domestic hot water is provided by 1 condensing Aerco DHW boiler, suppling a storage tank. Fan coil units in the corridors provide conditioning to the common areas.

### 3.7.4 Utility Service

Tyler Towers purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The residents pay their own electricity and gas bills, and thus use the residential rates.

Tyler Towers purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using multi-family rates.

## 3.8 Jackson Towers

Jackson Towers is a 102 unit public housing high rise built in 1969. The building has (94) one bedroom and (8) 2 bedroom units.

### 3.8.1 Lighting Systems

The lighting in a typical unit at Jackson Towers consists of primarily incandescent and compact fluorescent ceiling mounted fixtures throughout the bedrooms, hallways, living rooms and kitchens. Bathrooms may also have a linear fluorescent vanity fixture.

Common area lighting is primarily 4' T12 linear fluorescent lighting with magnetic ballasts, located in hallways, laundries, community spaces, offices, and stairwells. There are also some CFL fixtures serving the common areas.

There are 27 pole lights on site, each lamped with a 250 W mercury vapor bulb. Other exterior lighting includes 2 CFL jelly jar fixtures, (14) 100 W incandescent recessed can lights, and a 150 W MH wall pack.

### 3.8.2 Building Envelope

Jackson Towers is a 102 unit high rise with common areas, administrative offices, and laundry facilities (1 washer and dryer on floors 2-6). Windows are double pane with aluminum framing. The building is concrete and steel construction with a flat EPDM roof.

### 3.8.3 Building HVAC

The units at Jackson Towers are each heated and cooled by a 4 pipe fan coil unit. The fan coil unit is controlled by a digital thermostat that controls zone valves and fan speed. The fan coil units are served by 2 atmospheric, natural gas Ajax boilers (1,600 MBH output each). There are 2 constant volume space heating distribution pumps (10 hp each). Chilled water is supplied by a Carrier air cooled chiller, also original to the building. There are 2 constant volume chilled water pumps (25 hp each). Domestic hot water is provided by 2 condensing Lochinvar DHW boilers, suppling a storage tank. DHW boilers and circulation pumps appear to be ~10 years old. Two Carrier air handling units with chilled and hot water coils served by the central boiler and chiller plants provide fresh air to the common areas. The central HVAC system and fan coil units appear to be under direct digital control.

### 3.8.4 Utility Service

Jackson Towers purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The building is on the commercial rate structure, and utilities are authority paid.

Jackson Tower purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using the multi-family rate.

## 3.9 Tennessee Town II

Tennessee Town II is a 16 unit public housing family site built in 2010. This site consists of duplex and triplex homes, and has (16) one bedroom units.

### 3.9.1 Lighting Systems

The lighting in a typical unit at Tennessee Town II consists of primarily compact fluorescent ceiling mounted fans and fixtures throughout the bedrooms, hallways, living rooms and bathrooms. The vanities in the bathrooms occasionally have incandescents. Kitchens have T8 linear fluorescent ceiling fixtures.

### 3.9.2 Building Envelope

Tennessee Town II is a family site that is comprised of single story duplex and row-type homes. The homes have triple pane low-e windows with vinyl frames, and pitched shingled roofs with R-49 blown-in insulation. The buildings are wood frame construction with R-19 loosefill insulation.

### 3.9.3 Building HVAC

The units at Tennessee Town II are each heated and cooled by 1.5 ton Rheem heat pumps. The units are rated at 15 SEER and 9 HSPF. Domestic hot water (DHW) is provided by State electric 40 gallon DHW tanks. There is also an exhaust fan in each bathroom on switched control.

### 3.9.4 Utility Service

Tennessee Town II purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The building is on the commercial rate structure, and utilities are authority paid.

Tennessee Town II purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using the multi-family rate.

## 3.10 Echo Ridge

Echo Ridge is a 66 unit public housing family site built in 2010. This site consists of duplex and row-type family homes with (16) one bedroom, (38) 2 bedroom, and (12) 3 bedroom units.

### 3.10.1 Lighting Systems

The lighting in a typical unit at Echo Ridge consists of primarily compact fluorescent ceiling mounted fans and fixtures throughout the bedrooms, hallways, living rooms and bathrooms. Kitchens and garages have T8 linear fluorescent ceiling fixtures.

There are pole lights on site, each lamped with an 18 W CFL bulb. Other exterior lighting includes both ceiling and wall mounted CFL porch lights.

### 3.10.2 Building Envelope

Echo Ridge is a family site that is comprised of single story duplex and row-type homes. The homes have triple pane low-e windows with vinyl frames, and pitched shingled roofs with R-49 blown-in insulation. The buildings are wood frame construction with R-19 loosefill insulation.

### 3.10.3 Building HVAC

The units at Echo Ridge are each heated and cooled by FHP geothermal heat pumps. The units are rated at 15.2 EER and 3.2 COP. Domestic hot water (DHW) is provided by Bradford White electric 30 gallon DHW tanks. There is also an exhaust fan in each bathroom on switched control.

### 3.10.4 Utility Service

Echo Ridge purchases electricity from Westar Energy, and natural gas from Kansas Gas Service. The building is on the commercial rate structure, and utilities are authority paid.

Echo Ridge purchases water and sewer services from the City of Topeka. The authority pays for all of the water bills, using the multi-family rate.

# 4 Summary of Measures Evaluated

A broad range of measures was investigated during the investment grade energy audit. The measures deemed cost effective are summarized below.

| Resource Efficiency Measure List | Low Flow Aerators | | Low Flow Showerheads | | Common Area Lighting | | Exterior Lighting | | In-unit Lighting/ Heat Lamp Timers | | Photovoltaics | | Safe-T Range Controls | | Central Plant Upgrades | | Infiltration Reduction | | Attic Insulation/ Air Sealing | | Upgrade In-Unit Heating | | Refrigerators | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pine Ridge Manor | 211/211 | WF1/2 | 211 | WF3 | 6<br>1<br>9 | R3<br>R1<br>L1 | 10<br>1 | W1<br>L2 | 3049 | L1 | | | | | | | 211 | I1 | 211 | In1 | | | 19 | Rf1 |
| Marshall Square | 26/26 | WF1/2 | 26 | WF3 | 1 | R1 | 6 | L2 | 312 | L1 | | | 26 | ST1 | | | 26 | I2 | 26 | In1 | 26 | HP | | |
| Polk Plaza | 111/118 | WF1/2 | 109 | WF3 | 22<br>3<br>1<br>1<br>1 | R1<br>R4<br>R5<br>X1<br>L1 | 2<br>19<br>3 | P2a<br>P1a<br>L3 | 1125 | L1 | 1 | PV1 | | | 1 | AHU1 | | | | | | | | |
| Tennessee Town I | 25/25 | WF1/2 | 25 | WF3 | 5<br>4 | R1<br>L1 | 12 | L2 | | | | | 25 | ST1 | | | 25 | I1 | | | | | | |
| Deer Creek Village | 92/96 | WF1/2 | 58/<br>36 | WF3/<br>WF4 | 16<br>17<br>5<br>18 | R1<br>R6<br>R2<br>L1 | 6 | W1 | 1564 | L1 | | | | | | | 92 | I1 | 92 | In1 | 50 | A1 | | |
| Western Plaza | 22/24 | WF1/2 | 23 | WF3 | | | | | 363 | L1 | | | | | | | 22 | I1 | 22 | In1 | | | | |
| Tyler Towers | 78/79 | WF1/2 | 75 | WF3 | 6<br>1<br>8 | R1<br>R5<br>X1 | 2<br>3 | W2<br>L3 | 600<br>75 | L1<br>T1 | | | | | | | | | | | | | | |
| Jackson Towers | 104/106 | WF1/2 | 102 | WF3 | 231<br>8<br>14 | R1<br>R6<br>R4 | 27<br>1<br>14 | P2a<br>W2<br>L3 | 954 | L1 | | | | | 1<br>1 | CH1<br>B1 | | | | | | | | |
| Tennessee Town II | 16/16 | WF1/2 | 16 | WF3 | | | | | 272 | L1 | | | 16 | ST1 | | | | | | | | | | |
| Echo Ridge | 66/66 | WF1/2 | 66 | WF3 | | | | | | | | | 66 | ST1 | | | | | | | | | | |

# 5 Energy and Water Conservation Measures

## 5.1 Water

### 5.1.1 Low Flow Fixture Installation – ECM 1.1 and 1.2

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Pine Ridge Manor | KS002000001 | 211 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 211 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 211 | WF3 | showerhead replacements (1.5 gpm) |
| Marshall Square | KS002000001 | 26 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 26 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 26 | WF3 | showerhead replacements (1.5 gpm) |
| Polk Plaza | KS002000002 | 111 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 118 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 109 | WF3 | showerhead replacements (1.5 gpm) |
| Tennessee Town I | KS002000002 | 25 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 25 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 25 | WF3 | showerhead replacements (1.5 gpm) |
| Deer Creek Village | KS002000003 | 92 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 96 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 58 | WF3 | showerhead replacements (1.5 gpm) |
| | | 36 | WF4 | full shower install with showerheads (1.5 gpm) |
| Western Plaza | KS002000003 | 22 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 24 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 23 | WF3 | showerhead replacements (1.5 gpm) |
| Tyler Towers | KS002000004 | 78 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 79 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 75 | WF3 | showerhead replacements (1.5 gpm) |
| Jackson Towers | KS002000005 | 104 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 106 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 102 | WF3 | showerhead replacements (1.5 gpm) |
| Tennessee Town II | KS002000007 | 16 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 16 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 16 | WF3 | showerhead replacements (1.5 gpm) |
| Echo Ridge | KS002000008 | 66 | WF1 | kitchen aerator replacements (1.5 gpm) |
| | | 66 | WF2 | bathroom aerator replacements (0.5 gpm) |
| | | 66 | WF3 | showerhead replacements (1.5 gpm) |

During the course of the audit, it was observed that a large percentage of water fixtures had conventional aerators or showerheads installed. The efficiency measure is to replace all conventional bathroom aerators with 0.5 gpm aerators, all conventional kitchen aerators with 1.5 gpm aerators, and all conventional showerheads with 1.5 gpm showerheads.

At Deer Creek Village there are 33 units with bathrooms that currently have tubs only. There are an additional 3 units where the shower configuration was unable to be verified, however these units are assumed to also have tub-only configurations. Showers should be added to these bathrooms. For these bathrooms, this measure includes installing a tub-shower kit AND valve, a tub surround, all piping and fittings needed for the installation, and caulking. The showers should be equipped with 1.5 gpm showerheads.

The following specifications apply.

- 013300 – SUBMITTAL PROCEDURES
- 014000 – QUALITY REQUIREMENTS
- 017823 – OPERATION AND MAINTENANCE DATA
- 017839 – PROJECT RECORD DOCUMENTS
- 224200 – PLUMBING FIXTURES

**Improvements to Operations and Maintenance:**

The new low flow water fixtures should reduce the number of existing leaks, and associated work orders.

**Pricing and Site Specific Installation Notes to Contractor:**

Please price out at a 100% installation rate for these items, represented by the fixture count in the table at the beginning of this section. Basis of design products are available through HD Supply, the Authority's current procurement partner. Model numbers are listed in the spec. During installation, the contractor will be responsible for documenting the flow rate listed on the **existing** aerators and showerhead, using a table similar to the one provided below.

| Unit # | Existing Kitchen Flowrate | Replacement Kitchen Flowrate | Bathroom Count | Existing Bathroom Flowrate | Replacement Bathroom Flowrate | Shower Count | Existing Shower Flowrate | Replacement Shower Flowrate |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

The following addresses are units where a full shower install plus showerhead (WF4) is needed. If any of these addresses have two bathrooms, then a second shower install may be needed:

| Units that need shower install: |
|---|
| 2425 Colonial |
| 2429 Colonial |
| 2433 Colonial |
| 2437 Colonial |
| 2519 Burr |
| 2521 Burr |
| 2322 Burr |
| 2400 Colonial |
| 2402 Colonial |
| 2406 Colonial |
| 2410 Colonial |
| 2414 Colonial |

| |
|---|
| 2416 Colonial |
| 2418 Colonial |
| 2424 Colonial |
| 2430 Colonial |
| 2442 Colonial |
| 2403 Colonial |
| 2409 Colonial |
| 2411 Colonial |
| 2413 Colonial |
| 2431 Colonial |
| 2419 Colonial |
| 2423 Colonial |
| 2445 Colonial |
| 2463 Colonial |
| 2471 Colonial |
| 2473 Colonial |
| 2479 Colonial |
| 2453 Colonial |
| 2455 Colonial |
| 2461 Colonial |
| 2441 Colonial |

The shower configurations at the following addresses were unable to be verified, but are assumed to need a full shower install (WF4):

| Units that need shower install: |
|---|
| 2425 Colonial |
| 2420 Colonial |
| 2422 Colonial |

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Pine Ridge Manor | LF Kitchen Aerators | 1-101 | 292,102 | $ 0.0086 | $ 2,523 | - | $ - | $ - | 3,891 | $ 0.8668 | $ 3,372 | $ 5,895 |
| Pine Ridge Manor | LF Bathroom Aerators | 1-102 | 729,756 | 0.0086 | 6,303 | - | - | - | 3,891 | 0.8668 | 3,372 | 9,675 |
| Pine Ridge Manor | LF Showerheads | 1-103 | 573,771 | 0.0086 | 4,956 | - | - | - | 2,332 | 0.8668 | 2,021 | 6,977 |
| Marshall Square | LF Kitchen Aerators | 1-101 | 27,131 | $ 0.0086 | $ 234 | 1,052 | $ 0.1283 | $ 135 | - | $ - | $ - | $ 369 |
| Marshall Square | LF Bathroom Aerators | 1-102 | 57,600 | 0.0086 | 498 | 1,052 | 0.1283 | 135 | - | - | - | 633 |
| Marshall Square | LF Showerheads | 1-103 | 60,480 | 0.0086 | 522 | 791 | 0.1283 | 101 | - | - | - | 623 |
| Polk Plaza | LF Kitchen Aerators | 1-101 | 97,433 | $ 0.0092 | $ 892 | - | $ - | $ - | 148 | $ 0.6510 | $ 96 | $ 988 |
| Polk Plaza | LF Bathroom Aerators | 1-102 | 199,996 | 0.0092 | 1,830 | - | - | - | 162 | 0.6510 | 105 | 1,935 |
| Polk Plaza | LF Showerheads | 1-103 | 208,462 | 0.0092 | 1,908 | - | - | - | 422 | 0.6510 | 275 | 2,183 |
| Tennessee Town I | LF Kitchen Aerators | 1-101 | 15,702 | $ 0.0092 | $ 144 | - | $ - | $ - | 341 | $ 0.9373 | $ 320 | $ 464 |
| Tennessee Town I | LF Bathroom Aerators | 1-102 | 47,565 | 0.0092 | 435 | - | - | - | 341 | 0.9373 | 320 | 755 |
| Tennessee Town I | LF Showerheads | 1-103 | 41,437 | 0.0092 | 379 | - | - | - | 219 | 0.9373 | 205 | 584 |
| Deer Creek Village | LF Kitchen Aerators | 1-101 | 188,397 | $ 0.0092 | $ 1,732 | - | $ - | $ - | 2,012 | $ 0.8648 | $ 1,740 | $ 3,472 |
| Deer Creek Village | LF Bathroom Aerators | 1-102 | 373,429 | 0.0092 | 3,433 | - | - | - | 2,012 | 0.8648 | 1,740 | 5,173 |
| Deer Creek Village | LF Showerheads | 1-103 | 394,840 | 0.0092 | 3,630 | - | - | - | 1,694 | 0.8648 | 1,465 | 5,095 |
| Western Plaza | LF Kitchen Aerators | 1-101 | 42,775 | $ 0.0092 | $ 393 | - | $ - | $ - | 545 | $ 0.8527 | $ 464 | $ 857 |
| Western Plaza | LF Bathroom Aerators | 1-102 | 89,976 | 0.0092 | 827 | - | - | - | 545 | 0.8527 | 464 | 1,291 |
| Western Plaza | LF Showerheads | 1-103 | 86,470 | 0.0092 | 795 | - | - | - | 395 | 0.8527 | 337 | 1,132 |
| Tyler Towers | LF Kitchen Aerators | 1-101 | 78,998 | $ 0.0094 | $ 740 | - | $ - | $ - | 117 | $ 0.6415 | $ 75 | $ 815 |
| Tyler Towers | LF Bathroom Aerators | 1-102 | 156,231 | 0.0094 | 1,464 | - | - | - | 123 | 0.6415 | 79 | 1,543 |
| Tyler Towers | LF Showerheads | 1-103 | 165,520 | 0.0094 | 1,551 | - | - | - | 327 | 0.6415 | 210 | 1,761 |
| Tyler Towers | Common Area Lighting | 1-201 | - | - | - | 5,475 | 0.0770 | 422 | - | - | - | 422 |
| Jackson Towers | LF Kitchen Aerators | 1-101 | 71,311 | $ 0.0105 | $ 747 | - | $ - | $ - | 257 | $ 0.6240 | $ 160 | $ 907 |
| Jackson Towers | LF Bathroom Aerators | 1-102 | 146,430 | 0.0105 | 1,533 | - | - | - | 282 | 0.6240 | 176 | 1,709 |
| Jackson Towers | LF Showerheads | 1-103 | 107,873 | 0.0105 | 1,130 | - | - | - | 519 | 0.6240 | 324 | 1,454 |
| Tennessee Town II | LF Kitchen Aerators | 1-101 | 13,800 | $ 0.0094 | $ 129 | - | $ - | $ - | 243 | $ 0.9025 | $ 219 | $ 348 |
| Tennessee Town II | LF Bathroom Aerators | 1-102 | 29,028 | 0.0094 | 272 | - | - | - | 243 | 0.9025 | 219 | 491 |
| Tennessee Town II | LF Showerheads | 1-103 | 27,897 | 0.0094 | 261 | - | - | - | 187 | 0.9025 | 169 | 430 |
| Echo Ridge | LF Kitchen Aerators | 1-101 | 109,354 | $ 0.0089 | $ 969 | 33,713 | $ 0.1204 | $ 4,059 | - | $ - | $ - | $ 5,028 |
| Echo Ridge | LF Bathroom Aerators | 1-102 | 230,021 | 0.0089 | 2,037 | 33,713 | 0.1204 | 4,059 | - | - | - | 6,096 |
| Echo Ridge | LF Showerheads | 1-103 | 221,059 | 0.0089 | 1,958 | 26,739 | 0.1204 | 3,219 | - | - | - | 5,177 |

**Calculation Methodology:**

The total water use for each site was taken from historical utility data. The following breakdown in usage was assumed:

| | Percent of Total Water Usage |
|---|---|
| Kitchen Faucets | 12% |
| Lavatory Faucets | 10% |
| Showers | 20% |
| Toilets | 17% |
| Laundry | 10% |
| Misc. | 31% |

$$Wt\ Sav = Ann\ Wat \times \%\ Use \times \left(1 - \frac{Avg\ GPM_{new}}{Avg\ GPM_{old}}\right)$$

**Wt Sav – Total Water Savings, kgal/year**

**Ann Wat – Annual non-irrigation building water use, kgal/year**

**% Use – Percentage of total water load based on the above table = 0.12 (12%) for kitchen faucets, 0.1 (10%) for the bathroom lavatory faucets, 0.2 (20%) for showerheads**

**Avg $GPM_{new}$ – Flowrate of low-flow fixtures, gpm = 1.5 kitchen, 0.5 bathroom, 1.5 showerheads**

**Avg $GPM_{new}$ – Average flowrate of existing fixtures, gpm** *based on the energy audit*

| Site Name | Annual Water | Avg GPM kitchen | Avg GPM bath | Avg GPM shower |
|---|---|---|---|---|
| Pine Ridge Manor | 10,041 kgal/yr | 2.0 | 1.8 | 2.1 |
| Marshall Square | 756 kgal/yr | 2.1 | 2.1 | 2.5 |
| Polk Plaza | 2,710 kgal/yr | 2.1 | 1.9 | 2.4 |
| Tennessee Town I | 622 kgal/yr | 1.9 | 2.1 | 2.3 |
| Deer Creek Village | 5,193 kgal/yr | 2.2 | 1.8 | 2.4 |
| Western Plaza | 1,233 kgal/yr | 2.1 | 1.9 | 2.3 |
| Tyler Towers | 2,069 kgal/yr | 2.2 | 2.0 | 2.5 |
| Jackson Towers | 2,118 kgal/yr | 2.1 | 1.6 | 2.0 |
| Tennessee Town II | 398 kgal/yr | 2.1 | 1.9 | 2.3 |
| Echo Ridge | 3,152 kgal/yr | 2.1 | 1.9 | 2.3 |

For the authority paid gas sites, the gas savings is calculated in a similar manner. The total baseload natural gas use for each site was taken from historical utility data. The following breakdown in usage was assumed:

| | Percent of Total Hot Water Use |
|---|---|
| Kitchen Faucets | 16% |
| Lavatory Faucets | 7% |
| Showers | 34% |
| Toilets | 0% |
| Laundry | 17% |
| Misc. | 26% |

$$Gas\ Sav = Ann\ DHW \times \%\ Use \times \left(1 - \frac{Avg\ GPM_{new}}{Avg\ GPM_{old}}\right)$$

**Gas Sav – Total Natural Gas Saving, CCF/year**

**Ann DHW – Annual gas use for DHW, CCF/year**

**% Use – Percentage of total water load based on the above table = 0.16 (16%) for kitchen faucets, 0.7 (7%) for the bathroom lavatory faucets, 0.34 (34%) for showerheads**

**Avg $GPM_{new}$ – Flowrate of low-flow fixtures, gpm = 1.5 kitchen, 0.5 bathroom, 1.5 showerheads**

**Avg $GPM_{new}$ – Average flowrate of existing fixtures, gpm** *based on the energy audit*

| Site Name | Annual DHW | Avg GPM kitchen | Avg GPM bath | Avg GPM shower |
|---|---|---|---|---|
| Polk Plaza | 3,182 CCF/yr | 2.1 | 1.9 | 2.4 |
| Tyler Towers | 2,369 CCF/yr | 2.2 | 2.0 | 2.5 |
| Jackson Towers | 5,911 CCF/yr | 2.1 | 1.6 | 2.0 |

For the resident paid gas sites, the net DHW load and savings are calculated within the Utility Allowance Calculator. The savings are based on the following formulas.

The total water usage per person per year is calculated using the average GPMs of each fixture and the following table which is taken from Handbook of "Water Use and Conservation" by Amy Vickers:

| | Minutes Per Person Per Day |
|---|---|
| Kitchen Faucets | 8.1 |
| Lavatory Faucets | 8.1 |
| Showers | 5.3 |
| Toilets | 5.1 |

That annual consumption is multiplied by the number of residents per unit based on bedroom size, and then multiplied by 40.9% - the percent of total domestic water usage that is hot water (also from "Water Use and Conservation"). That value then feeds into the following formulas:

$$DHW\ Load = (DHW\ Temp - City\ Temp) \times 8.33 \frac{BTU}{gal^{\circ}\mathrm{F}} \times Ann\ Cons \times \%DHW$$

**DHW Temp – Temperature to heat the DHW = 120°F**

**City Temp – Temperature of mains water in Topeka = 55 °F**

**Ann Cons – Annual water consumption by residents at the site, *gal***

**% DHW = Percent of water consumption attributed to DHW**

$$DHW\ Tank = DHW\ Load \times 5\%$$

**DHW Tank – Tank losses**

$$DHW\ Flue = DHW\ Load \times 5\%$$

**DHW Flue – Tank losses**

$$DHW\ Burner = (DHW\ Load + DHW\ Tank) \times (100\% - Eff)$$

**DHW Burner – Burner losses**

**Eff – Average combustion efficiency**

$$DHW\ Gas = (DHW\ Load + DHW\ Tank + DHW\ Flue + DHW\ Burner)$$

$$Aerator\ Savings = (DHW\ Gas_{new} - DHW\ Gas_{ex} - Aquatherm\ Savings) \times \%Sav\ Aerators$$

**DHW $Gas_{new}$ – Annual energy use by the new water heaters (including new DHW Load from Low Flow and new Eff)**

**DHW $Gas_{ex}$ – Annual energy use by the existing water heaters**

**Aquatherms Savings – Savings attributed to Aquatherms**

**%Sav Areators – Percentage of annual gallons saved attributed to aerators**

$$Shower\ Savings = (DHW\ Gas_{new} - DHW\ Gas_{ex} - Aquatherm\ Savings) \times \%Sav\ Shower$$

**%Sav Showers – Percentage of annual gallons saved attributed to showerheads**

## 5.2 Lighting

The following performance-based specification sections are related to all scopes of work included in this section (note: some information in the specifications may relate to other scopes of work and may not be germane to this scope of work). The Lighting specification section includes detailed notes on fixture and control technology types, as well as basis of design products.

- 013300 – SUBMITTAL PROCEDURES
- 014000 – QUALITY REQUIREMENTS
- 017823 – OPERATION AND MAINTENANCE DATA
- 017839 – PROJECT RECORD DOCUMENTS
- 017900 – DEMONSTRATION AND TRAINING
- 019113 – GENERAL COMMISSIONING REQUIREMENTS
- 265100 – ELECTRICAL POWER AND LIGHTING SYSTEMS

### 5.2.1 In-unit Lighting Retrofit – ECM 2.1

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Pine Ridge Manor | KS002000001 | 3049 | L1 | LEDs provided for hard-wired lamps |
| Marshall Square | KS002000001 | 312 | L1 | LEDs provided for hard-wired lamps |
| Polk Plaza | KS002000002 | 1,125 | L1 | LEDs provided for hard-wired lamps |
| Deer Creek Village | KS002000003 | 1,564 | L1 | LEDs provided for hard-wired lamps |
| Western Plaza | KS002000003 | 363 | L1 | LEDs provided for hard-wired lamps |
| Tyler Towers | KS002000004 | 600 | L1 | LEDs provided for hard-wired lamps |
| Jackson Towers | KS002000005 | 954 | L1 | LEDs provided for hard-wired lamps |
| Tennessee Town II | KS002000007 | 272 | L1 | LEDs provided for hard-wired lamps |

Currently, most hardwired fixtures in the units have either screw in 60 watt incandescent bulbs or CFLs. It is recommended that all hardwire fixtures are re-lamped with screw-in replacement 11 watt LED bulbs which will provide equal or greater light output to the existing light bulbs, with comparable shape and distribution. All LED lamps for in-unit applications shall be 2700°K (warm white).

**Improvements to Operations and Maintenance:**

This measure will have no impact on operating or maintenance costs. No repairs are required for this measure to be effective and no new skills are required.

**Impacts to Residents:**

LED bulbs typically last longer than incandescent bulbs, reducing the frequency with which tenants have burned out lights.

**Pricing and Site Specific Installation Notes to Contractor:**

Please price out at a 100% installation rate for these items, represented by the fixture count in the table at the beginning of this section. Basis of design products are available through HD Supply, the Authority's current procurement partner and the model numbers are listed in the spec. Please provide an allowance as a separate

line item for the installation of an additional 10% of lamps. Also, please provide a $10,000 allowance for the replacement of broken fixtures. It is the contractor's responsibility to ensure that selected lamps will fit in the existing fixtures and are compatible with existing voltage and power requirements.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Pine Ridge Manor | In Unit Lighting | 1-202 | - | - | - | 121,277 | 0.1459 | 17,694 | - | - | - | 17,694 |
| Marshall Square | In Unit Lighting | 1-202 | - | - | - | 3,719 | 0.1283 | 477 | - | - | - | 477 |
| Polk Plaza | In Unit Lighting | 1-202 | - | - | - | 10,487 | 0.0793 | 832 | - | - | - | 832 |
| Deer Creek Village | In Unit Lighting | 1-202 | - | - | - | 79,074 | 0.1438 | 11,371 | - | - | - | 11,371 |
| Western Plaza | In Unit Lighting | 1-202 | - | - | - | 14,065 | 0.1420 | 1,997 | - | - | - | 1,997 |
| Tyler Towers | In Unit Lighting | 1-202 | - | - | - | 5,934 | 0.0770 | 457 | - | - | - | 457 |
| Jackson Towers | In Unit Lighting | 1-202 | - | - | - | 4,581 | 0.0634 | 290 | - | - | - | 290 |
| Tennessee Town II | In Unit Lighting | 1-202 | - | - | - | 4,503 | 0.1452 | 654 | - | - | - | 654 |

**Calculation Methodology:**

There are incandescents installed in the majority of hardwired fixtures in the units, primarily with 60 watt lamps. Both these and the CFLs are being replaced with 11 watt LEDs. The savings is evaluated by multiplying the change in lighting load by the typical runtime hours as shown.

$$kWh\ Savings = (Existing\ Load - New\ Load) \times Hrs \times Nbr\ Lamps \times \frac{kW}{1000W}$$

**Existing Load = Wattage of Existing Lamp/Fixture**

**New Load = Wattage of New Lamp/Fixture**

**Hrs – Annual hours of operation = 1,095**

**Nbr Lamps/Fixtures – Number of lamps to be replaced**

| Site Name | | Existing Load | | New Load | Nbr Lamps/Fixtures | |
|---|---|---|---|---|---|---|
| | | Incandescent | CFL | | Incandescent | CFL |
| Pine Ridge Manor | LEDs | 60 W | 13 W | 11 W | 2,238 | 811 |
| Marshall Square | LEDs | 60 W | 13 W | 11 W | 45 | 267 |
| Polk Plaza | LEDs | 60 W | 13 W | 11 W | 78 | 1,047 |
| Deer Creek Village | LEDs | 60 W | 13 W | 11 W | 1,492 | 72 |
| Western Plaza | LEDs | 60 W | 13 W | 11 W | 225 | 138 |
| Tyler Towers | LEDs | 60 W | 13 W | 11 W | 38 | 562 |
| Jackson Towers | LEDs | 60 W | 13 W | 11 W | 94 | 860 |
| Tennessee Town II | LEDs | 60 W | 13 W | 11 W | 267 | 5 |

### 5.2.2 Heat Lamp Timers – ECM 2.2

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Tyler Towers | KS002000004 | 75 | T1 | Dial Timers for Bath Heat Lamps |

The bathrooms at Tyler Towers each have a 250W heat lamp that is wall switched separately from the regular lights. These have the potential to be left on for long periods of time. It is recommended that a *Type T1* wall mounted push button timer be installed at these properties, which limits the run time to a maximum of 30 minutes.

**Improvements to Operations and Maintenance:**

This measure will have no impact on operating or maintenance costs. No repairs are required for this measure to be effective and no new skills are required. The equipment life of the timers is estimated to be 10 years.

**Impacts to Residents:**

This measure will not impact occupant health, comfort, or safety.

**Pricing and Site Specific Installation Notes to Contractor:**

*Note that there may be various switching and wiring configurations for the current heat lamp/electric space heater control. This could include two, three and four wires running to the switch plate, the heating element switch located on its own switch plate, and the heating element sharing a switch plate with the bathroom light switch. The Type T1 wall mounted timer should only control the heating element, not the lights. It is the contractor's responsibility to verify on-site conditions, submit, and install a compatible control solution that meets the intent of this narrative. It is also the contractor's responsibility to verify that the proposed timer is compatible with the existing heat lamp volt and power configurations.*

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Tyler Towers | Heat Lamp Timers | 1-204 | - | - | - | 13,756 | 0.0770 | 1,059 | - | - | - | 1,059 |

**Calculation Methodology:**

The bathrooms at Tyler Towers each have a 250W heat lamp in the restrooms. Adding 30-minute push button timers to these fixtures is expected to reduce the number of operating hours by from 3 hours daily to 1 hour daily.

$$kWh\ Savings = Heating\ Load \times Timer\ Savings \times Hrs \times Nbr\ Apts \times \frac{kW}{1000W}$$

**Heating Load = Wattage of Heating Element**

**Timer Savings = 0.67 (67%) for push button timers**

**Hrs – Annual hours of operation = 1,095**

**Nbr Apts – Number of units with bathroom heating elements**

| Site Name | Heating Load (W) | Nbr Apts |
|---|---|---|
| Candelaria | 250 | 75 |

### 5.2.3 Common Area and Exterior Lighting Retrofit – ECM 2.3

Common area and exterior lighting efficiency opportunities were found at the following sites. *On any sites where it is felt that there is not adequate lighting coverage, the GC should coordinate with the lighting sub to generate a photometric map as part of the bid, and indicate which fixtures are replacements as indicated in the measure below and which are new. New fixtures should be proposed to address exterior areas with insufficient light levels.*

*Table 1: Common Area Lighting*

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Pine Ridge Manor | KS002000001 | 6 | R3 | 3x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 1 | R1 | 2x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 9 | L1 | 11W LED bulbs |
| Marshall Square | KS002000001 | 1 | R1 | 2x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| Polk Plaza | KS002000002 | 22 | R1 | 2x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 3 | R4 | 4x2' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 1 | R5 | 2x8' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 1 | X1 | LED exit sign |
| | | 1 | L1 | 11W LED bulbs |
| Tennessee Town I | KS002000002 | 5 | R1 | 2x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 4 | L1 | 11W LED bulbs |
| Deer Creek Village | KS002000003 | 16 | R1 | 2x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 17 | R6 | 2-lamp U-bulb T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 5 | R2 | 4x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 18 | L1 | 11W LED bulbs |
| Tyler Towers | KS002000004 | 6 | R1 | 2x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 1 | R5 | 2x8' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 8 | X1 | LED exit signs |
| Jackson Towers | KS002000005 | 231 | R1 | 2x4' T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 8 | R6 | 2-lamp U-bulb T12 magnetic ballast fixtures, retrofit with T8 electronic |
| | | 14 | R4 | 4x2' T12 magnetic ballast fixtures, retrofit with T8 electronic |

**Pine Ridge Manor**

There are (6) 3-lamp 4' 40W T12 linear fluorescent fixtures and (1) 2-lamp 4' 40W T12 linear fluorescent fixture in the common areas. It is recommended that these fixtures be retrofitted with *Type R3* and *Type R1* (respectively) T8 retrofit kits with electronic ballasts and 28W lamps. There are also (9) incandescent bulbs. It is recommended that these be replaced with *Type L1* 11W LED bulbs.

**Marshall Square**

There is (1) 4' 2-lamp linear fluorescent fixture with 40W T12 bulbs and a magnetic ballast in the laundry room. It is recommended that this be retrofitted with a *Type R1* T8 retrofit kit with new electronic ballasts and 28W bulbs.

**Polk Plaza**

There are (22) 4' 2-lamp T12 linear fluorescent fixtures. It is recommended that these fixtures be retrofitted with *Type R1* T8 retrofit kits with electronic ballasts and 28W lamps. There are (3) 4-lamp 2' 20W T12 fixtures in the common areas. It is recommended that these fixtures be retrofitted with *Type R4* T8 retrofit kits with electronic ballasts and 17W lamps. There is (1) 2-lamp 8' 60W T12 fixture in the common area. It is recommended that this fixture be retrofitted with a *Type R5* T8 retrofit kit with electronic ballasts and 59W lamps.

Additionally, there is (1) incandescent exit sign and (1) screw-in incandescent. It is recommended that these be replaced with a *Type X1* LED exit sign and *Type L1* 11W LED bulbs respectively.

**Tennessee Town I**

There are (5) 2-lamp 4' 40W T12 fixtures in the common areas. It is recommended that these fixtures be retrofitted with *Type R1* T8 retrofit kits with electronic ballasts and 28W lamps. There are also (4) incandescent bulbs in the basement. It is recommended that these be replaced with *Type L1* 11W LED bulbs.

**Deer Creek Village**

There are (16) 4' 2-lamp 40W T12 linear fluorescent fixtures, (17) u-bend 2-lamp 40W T12 fluorescent fixtures, and (5) 4' 4-lamp 40W T12 linear fluorescent fixtures. It is recommended that these all be retrofitted with *Type R1, Type R6,* and *Type R2* (respectively) T8 retrofit kits with new electronic ballasts and 28W T8 lamps. There are also (18) incandescent bulbs throughout the common areas. It is recommended that these be replaced with screw-in *Type L1* 11W LED bulbs.

**Tyler Towers**

There are (6) 4' 2-lamp T12 linear fluorescent fixtures. It is recommended that these fixtures be retrofitted with *Type R1* T8 retrofit kits with electronic ballasts and 28W lamps. There is (1) 2-lamp 8' 60W T12 fixture in the common area. It is recommended that this fixture be retrofitted with a *Type R5* T8 retrofit kit with electronic ballasts and 59W lamps.

Additionally, there are (8) incandescent exit signs. It is recommended that these be replaced with *Type X1* LED exit signs.

**Jackson Towers**

There are (231) 4' 2-lamp T12 linear fluorescent fixtures. It is recommended that these fixtures be retrofitted with *Type R1* T8 retrofit kits with electronic ballasts and 28W lamps. There are (14) 4-lamp 2' 20W T12 fixtures in the common areas. It is recommended that these fixtures be retrofitted with *Type R4* T8 retrofit kits with electronic ballasts and 17W lamps. There are (8) 2-lamp 2' 40W u-shaped T12 fixtures in the common areas. It is recommended that these fixtures be retrofitted with *Type R6* T8 retrofit kits with electronic ballasts and 32W lamps.

*Table 2: Exterior Lighting*

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Pine Ridge Manor | KS002000001 | 10 | W1 | 41W LED wallpacks |
| | | 1 | L2 | 14W LED lamps |

| | | | | |
|---|---|---|---|---|
| Marshall Square | KS002000001 | 6 | L2 | 14W LED lamps |
| Polk Plaza | KS002000002 | 2 | P2a | Single headed pole light to be replaced |
| | | 19 | P1a | Single headed pole light to be replaced |
| | | 3 | L3 | 18W LED lamps |
| Tennessee Town I | KS002000002 | 12 | L2 | 14W LED lamps |
| Deer Creek Village | KS002000003 | 6 | W1 | 41W LED wallpacks |
| Tyler Towers | KS002000004 | 2 | W1 | 41W LED wallpacks |
| | | 3 | L3 | 18W LED lamps |
| Jackson Towers | KS002000005 | 27 | P2a | Single headed pole light to be replaced |
| | | 1 | W1 | 41W LED wallpacks |
| | | 14 | L3 | 18W LED lamps |

**Pine Ridge Manor**

Exterior lighting is provided by (7) 100W high pressure sodium wall packs and (3) 125W halogen wall packs. It is recommended that the wall packs be replaced with *Type W1* 41W LED wallpacks. There is also (1) incandescent bulb, which is recommended to be re-lamped with *Type L2* 14W LED bulbs. Install an astronomical timeclock to control exterior fixtures.

**Marshall Square**

There are (3) 2-bulb 90W halogen flood lights that provide exterior lighting. It is recommended that the flood lights be replaced with LED flood light fixtures with (2) *Type L2* 14W LED bulbs per fixture. This fixture should have integral photocells.

**Polk Plaza**

Exterior lighting is provided by (3) 100W incandescent bollards, (2) 400W metal halide 20' pole lights, and (19) 250W metal halide 10' pole lights. It is recommended that the bollards be relamped with *Type L3* 18W LED retrofit lamps and new pole light heads (*Type P2a* 102W LED for the 20' pole and *Type P1a* 70W LED for the 10' pole) be installed. Install an astronomical timeclock to control exterior fixtures.

**Tennessee Town I**

There are (12) 100W incandescent bulbs that provide exterior lighting. It is recommended that these be replaced with *Type L2* 14W LED bulbs. Install an astronomical timeclock to control exterior fixtures.

**Deer Creek Village**

Exterior lighting is provided by (6) 150W metal halide wall packs. It is recommended that the wall packs be replaced with *Type W1* 41W LED wallpacks. Install an astronomical timeclock to control exterior fixtures.

**Tyler Towers**

Exterior lighting is provided by (3) 100W incandescent cans and (2) 150W metal halide wallpacks. It is recommended that the cans be relamped with *Type L3* 18W LED retrofit lamps and the wallpacks be replaced with *Type W1* 41W LED wallpacks. Install an astronomical timeclock to control exterior fixtures.

**Jackson Towers**

Exterior lighting is provided by (14) 100W incandescent cans, (1) 150W metal halide wallpack, and (27) 250W mercury vapor pole lights. It is recommended that the cans be relamped with *Type L3* 18W LED retrofit lamps, the wallpacks be replaced with *Type W1* 41W LED wallpacks, and new *Type P2a* 102W LED pole light heads be installed. Install an astronomical timeclock to control exterior fixtures.

**Impacts to Operations and Maintenance:**

The equipment life of the new lighting fixtures is expected to be 18 years, which will reduce maintenance costs since they will not need to be replaced as often. No repairs are required for this measure to be effective. No new skills are required.

**Impacts to Residents:**

This measure will not impact occupant health. The lighting levels will not be lowered, but could be improved by the new lighting, which would improve occupant comfort and safety.

**Pricing and Site Specific Installation Notes to Contractor:**

Basis of design products are available through HD Supply, the Authority's current procurement partner and the model numbers are listed in the spec.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Pine Ridge Manor | Common Area Lighting | 1-201 | - | - | - | 2,258 | 0.1351 | 305 | - | - | - | 305 |
| Marshall Square | Common Area Lighting | 1-201 | - | - | - | 54 | 0.1351 | 7 | - | - | - | 7 |
| Polk Plaza | Common Area Lighting | 1-201 | - | - | - | 11,791 | 0.0793 | 935 | - | - | - | 935 |
| Tennessee Town I | Common Area Lighting | 1-201 | - | - | - | 917 | 0.0793 | 73 | - | - | - | 73 |
| Deer Creek Village | Common Area Lighting | 1-201 | - | - | - | 6,618 | 0.1450 | 960 | - | - | - | 960 |
| Tyler Towers | Common Area Lighting | 1-201 | - | - | - | 5,475 | 0.0770 | 422 | - | - | - | 422 |
| Jackson Towers | Common Area Lighting | 1-201 | - | - | - | 108,997 | 0.0634 | 6,907 | - | - | - | 6,907 |

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Pine Ridge Manor | Exterior Lighting | 1-203 | - | - | - | 3,967 | 0.1351 | 536 | - | - | - | 536 |
| Marshall Square | Exterior Lighting | 1-203 | - | - | - | 801 | 0.1351 | 108 | - | - | - | 108 |
| Polk Plaza | Exterior Lighting | 1-203 | - | - | - | 21,099 | 0.0793 | 1,673 | - | - | - | 1,673 |
| Tennessee Town I | Exterior Lighting | 1-203 | - | - | - | 3,928 | 0.0793 | 312 | - | - | - | 312 |
| Deer Creek Village | Exterior Lighting | 1-203 | - | - | - | 3,411 | 0.1450 | 495 | - | - | - | 495 |
| Tyler Towers | Exterior Lighting | 1-203 | - | - | - | 2,058 | 0.0770 | 158 | - | - | - | 158 |
| Jackson Towers | Exterior Lighting | 1-203 | - | - | - | 25,102 | 0.0634 | 1,591 | - | - | - | 1,591 |

**Calculation Methodology:**

The savings is evaluated by multiplying the change in lighting load by the typical runtime hours as shown.

$$kWh\ Savings = (Existing\ Lighting - New\ Lighting) \times Nbr\ Fixtures \times Hours\ of\ Operation \times \frac{kW}{1000W}$$

**Existing Lighting – Total lighting being replaced, W**

**New Lighting – Total lighting being installed, W**

**Nbr Fixtures – Number of similar fixtures undergoing replacement**

**Hours of Operation – Annual hours of operation**

*Table 3 – Common Area Lighting*

| Site Name | | Existing Lighting | New Lighting | Nbr Fixtures | Hours of Operation |
|---|---|---|---|---|---|
| Pine Ridge Manor | 2x4' T12s | 97 W | 48 W | 1 | 8,760 |
| | 3x4' T12s | 135 W | 72 W | 6 | 2,080 |
| | Incandescents | 75 W | 11 W | 1 | 365 |
| | Incandescents | 120 W | 22 W | 4 | 2,600 |
| | Wallpacks | 130 W | 41 W | 7 | 4,307 |
| | Wallpacks | 125 W | 41 W | 3 | 4,307 |
| | Incandescents | 60 W | 14 W | 1 | 4,307 |

| | | | | | |
|---|---|---|---|---|---|
| Marshall Square | 2x4' T12s | 97 W | 48 W | 1 | 1,095 |
| | Flood lights | 90 W | 28 W | 3 | 4,307 |
| Polk Plaza | 2x4' T12s | 97 W | 48 W | 22 | 8,760 |
| | 2x8' T12s | 113 W | 94 W | 1 | 2,600 |
| | 4x2' T12s | 91 W | 53 W | 3 | 8,760 |
| | Exit sign | 40 W | 4 W | 1 | 8,760 |
| | Incandescents | 100 W | 18 W | 1 | 2,600 |
| | Occ sensors | 44 W | - | 28 | 8,760 to 6,132 |
| | Occ sensors | 44 W | - | 16 | 8,760 to 4,380 |
| | Bollards | 100 W | 18 W | 3 | 4,035 |
| | Pole lights | 456 W | 102 W | 2 | 4,035 |
| | Pole lights | 295 W | 70 W | 19 | 4,035 |
| Tennessee Town I | 2x4' T12s | 97 W | 48 W | 5 | 2,080 |
| | Incandescents | 60 W | 11 W | 4 | 2,080 |
| | Incandescents | 100 W | 14 W | 12 | 4,307 |
| Deer Creek Village | 2x4' T12s | 97 W | 48 W | 16 | 2,080 |
| | U-bend T12s | 97 W | 47 W | 17 | 2,080 |
| | 4x4' T12s | 175 W | 97 W | 5 | 2,080 |
| | Incandescents | 100 W | 11 W | 9 | 2,080 |
| | Incandescents | 100 W | 11 W | 2 | 780 |
| | Incandescents | 200 W | 22 W | 1 | 2,080 |
| | Incandescents | 60 W | 11 W | 1 | 365 |
| | Incandescents | 120 W | 22 W | 2 | 1,095 |
| | Wallpacks | 173 W | 41 W | 6 | 4,307 |
| Tyler Towers | 2x4' T12s | 97 W | 44 W | 6 | 8,760 |
| | 2x8' T12s | 113 W | 94 W | 1 | 8,760 |
| | Exit signs | 40 W | 4 W | 8 | 8,760 |
| | Occ sensors | 44 W | - | 6 | 8,760 to 6,132 |
| | Incandescents | 100 W | 18 W | 3 | 4,035 |
| | Wallpacks | 173 W | 41 W | 2 | 4,035 |
| Jackson Towers | 2x4' T12s | 97 W | 44 W | 24 | 2,600 |
| | 2x4' T12s | 97 W | 44 W | 207 | 8,760 |
| | U-bend T12s | 97 W | 53 W | 8 | 8,760 |
| | 4x2' T12s | 97 W | 44 W | 14 | 8,760 |
| | Occ sensors | 44 W | - | 28 | 8,760 to 6,132 |
| | Occ sensors | 44 W | - | 16 | 8,760 to 4,380 |
| | Incandescents | 100 W | 18 W | 14 | 4,035 |
| | Wallpacks | 173 W | 41 W | 1 | 4,035 |
| | Pole lights | 285 W | 102 W | 27 | 4,035 |

### 5.2.4 Safe-T Range Controls – ECM 2.4

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Marshall Square | KS002000001 | 26 | ST1 | Safe-T Element temperature limiting control stovetops |
| Tennessee Town I | KS002000002 | 25 | ST1 | Safe-T Element temperature limiting control stovetops |
| Tennessee Town II | KS002000007 | 16 | ST1 | Safe-T Element temperature limiting control stovetops |
| Echo Ridge | KS002000008 | 66 | ST1 | Safe-T Element temperature limiting control stovetops |

The stoves at the above sites are electric. It is recommended that the stoves be retrofitted with Temperature Limiting Control burners, which help prevent stovetop fires and save energy by controlling the amount of energy supplied to the existing stovetop burners. The new Temperature Limiting Control burner system consists of solid cast iron cover plates that attach to the existing stovetop burners and a control board to electronically regulate the energy sent to the burners.

The following specifications apply.

- 013300 – SUBMITTAL PROCEDURES
- 014000 – QUALITY REQUIREMENTS
- 017823 – OPERATION AND MAINTENANCE DATA
- 017839 – PROJECT RECORD DOCUMENTS
- 017900 – DEMONSTRATION AND TRAINING
- 019113 – GENERAL COMMISSIONING REQUIREMENTS
- 113113 – STOVETOPS

**Improvements to Operations and Maintenance:**

This measure will have no impact on operating or maintenance costs. No repairs are required for this measure to be effective and no new skills are required.

**Impacts to Residents:**

This measure will not impact occupant comfort, but will reduce the chances of stovetop fires.

**Pricing and Site Specific Installation Notes to Contractor:**

It is the contractor's responsibility to document the existing stove models and range configurations.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Marshall Square | Safe-T Range Element | 1-206 | - | - | - | 4,992 | 0.1283 | 640 | - | - | - | 640 |
| Tennessee Town I | Safe-T Range Element | 1-206 | - | - | - | 4,800 | 0.1504 | 722 | - | - | - | 722 |
| Tennessee Town II | Safe-T Range Element | 1-206 | - | - | - | 3,072 | 0.1452 | 446 | - | - | - | 446 |
| Echo Ridge | Safe-T Range Element | 1-206 | - | - | - | 12,480 | 0.1204 | 1,503 | - | - | - | 1,503 |

**Calculation Methodology:**

There are electric stovetops at the above sites. These are being retrofitted with Temperature Limiting Control burners, which save energy by controlling the amount of energy supplied to the existing stovetop burners. The savings is evaluated by multiplying the change in annual stovetop energy usage by the number of units as shown.

$$kWh\ Savings = (Nbr\ Sites) \times (Existing - New\ Annual\ Energy\ Usage) \times \frac{kW}{1000W}$$

**Nbr Sites – Number of stovetops to be retrofitted**

**Existing Annual Energy Usage – Estimated annual energy usage (differs by bedroom count)**

- **0 BR – 733 kWh/yr**
- **1 BR – 1,027 kWh/yr**
- **2 BR – 1,320 kWh/yr**
- **3 BR – 1,613 kWh/yr**
- **4 BR – 2,053 kWh/yr**
- **5 BR – 2,347 kWh/yr**

**New Annual Energy Usage – Anticipated annual energy usage (differs by bedroom count)**

- **0 BR – 541 kWh/yr**
- **1 BR – 835 kWh/yr**
- **2 BR – 1,128 kWh/yr**
- **3 BR – 1,421 kWh/yr**
- **4 BR – 1,861 kWh/yr**
- **5 BR – 2,155 kWh/yr**

| Site Name | | Nbr Apts | Existing Annual Energy Use | New Annual Energy Use |
|---|---|---|---|---|
| Marshall Square | Temperature Limiting Control burners | 26 | see table | see table |
| Tennessee Town I | Temperature Limiting Control burners | 25 | see table | see table |
| Tennessee Town II | Temperature Limiting Control burners | 16 | see table | see table |
| Echo Ridge | Temperature Limiting Control burners | 66 | see table | see table |

### 5.2.5 Refrigerators – ECM 2.5

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Pine Ridge Manor | KS002000001 | 19 | Rf1 | Energy Star refrigerators |

Group14 evaluated all audited refrigerators and identified those with a rated annual energy consumption of more than 650 kWh/year. There are (18) refrigerators at Pine Ridge Manor. It is recommended that these inefficient refrigerators be replaced with Energy Star refrigerators.

Existing fridges should be replaced with 12 cubic feet refrigerators that are ENERGY STAR® rated appliances. The color shall be white, and the maximum height shall be 59.5”, maximum width shall be 24”, and maximum depth shall be 30”.

The following specifications apply.

- 013300 – SUBMITTAL PROCEDURES
- 014000 – QUALITY REQUIREMENTS
- 017823 – OPERATION AND MAINTENANCE DATA
- 017839 – PROJECT RECORD DOCUMENTS
- 017900 – DEMONSTRATION AND TRAINING
- 019113 – GENERAL COMMISSIONING REQUIREMENTS
- 114000 – REFRIGERATORS

**Improvements to Operations and Maintenance:**

Installing new, Energy Star refrigerators will reduce the amount of maintenance required by existing units, and ensure that replacement parts are available.

**Impacts to Residents:**

This measure will not impact occupant health or safety. In units where the refrigerators are broken or dirty, a replacement could improve occupant comfort.

**Pricing and Site Specific Installation Notes to Contractor:**

It is the contractor's responsibility to document the existing refrigerator models.

| Site | Unit Address | Refrigerator Model Number | Adjusted Energy Rating (kWh/yr) |
|---|---|---|---|
| Pine Ridge Manor | 1115 SE Highland | CTX14CABNRWW | 686 |
| Pine Ridge Manor | 2715 SE Gilmore | CTX14CABSRWW | 686 |
| Pine Ridge Manor | 2754 SE Gilmore | CTX14CABNRWW | 686 |
| Pine Ridge Manor | 2949 SE Highland | CTX14CABNRWW | 686 |
| Pine Ridge Manor | 2950 SE Highland | CTX14CABFRWW | 686 |
| Pine Ridge Manor | 2815 SE Highland | CTX16CYBJRWW | 718 |
| Pine Ridge Manor | 2621 SE 10th | CTX14CABDRWW | 686 |
| Pine Ridge Manor | 1111 SE Carnahan | CTX16CYSFLWW | 766 |
| Pine Ridge Manor | 3025 SE 10th | CTX14CABJRWW | 686 |
| Pine Ridge Manor | 3035 SE 10th | CTX14CABNRWW | 686 |
| Pine Ridge Manor | 3034 SE 11th | CTX16BYTGRWW | 706 |
| Pine Ridge Manor | 3030 SE 11th | CTX14CABNRWW | 686 |
| Pine Ridge Manor | 2864 SE Highland | CTX16CYBJRWW | 718 |
| Pine Ridge Manor | 2804 SE Highland | CTX16CABBRWW | 718 |
| Pine Ridge Manor | 2960 SE Highland | CTX16CYBSRWW | 718 |
| Pine Ridge Manor | 2831 SE Wear | CTX16CABBLWW | 718 |
| Pine Ridge Manor | 2855 SE Wear | CTX14CABNRWW | 686 |
| Pine Ridge Manor | 1010 SE Golden | CTX16CABNLWW | 718 |
| Pine Ridge Manor | 1004 SE Golden | CTX14CABARWW | 686 |

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Pine Ridge Manor | Energy Star Refrigerators | 1-205 | - | - | - | 4,179 | 0.1459 | 610 | - | - | - | 610 |

**Calculation Methodology:**

The new ENERGY STAR® refrigerators were assumed to use 330 kWh/year. The above chart shows that a number of refrigerators are high energy use and should be replaced with new ENERGY STAR® refrigerators. The following equation uses the existing energy use for the refrigerators to be replaced minus their replacement energy use times the number of refrigerators.

$$kWh\ Savings = \sum (Ex\ Ref\ Energy_1 \times \#Ref_1 + Ex\ Ref\ Energy_2 \times \#Ref_2 \ldots) - New\ Ref\ Energy\ Use \times \#Ref_{TOTAL}$$

**Ex Ref Energy = Adjusted annual energy rating for a model of refrigerator**

**#Ref = Count of that refrigerator model**

**New Ref Energy Use – Adjusted annual energy rating for new refrigerator = 330**

**#Ref$_{TOTAL}$ – Total number of refrigerators to be replaced**

The following table lists the value for each of these variables used to calculate the savings expected for each of these properties:

| Site Name | Refrigerator Model Number | Count | Adjusted Energy Rating |
|---|---|---|---|
| Pine Ridge Manor | CTX14CABARWW | 1 | 686 kWh/yr |
| Pine Ridge Manor | CTX14CABDRWW | 1 | 686 kWh/yr |
| Pine Ridge Manor | CTX14CABFRWW | 1 | 686 kWh/yr |
| Pine Ridge Manor | CTX14CABJRWW | 1 | 686 kWh/yr |
| Pine Ridge Manor | CTX14CABNRWW | 6 | 686 kWh/yr |
| Pine Ridge Manor | CTX16BYTGRWW | 1 | 706 kWh/yr |
| Pine Ridge Manor | CTX16CABBLWW | 1 | 718 kWh/yr |
| Pine Ridge Manor | CTX16CABBRWW | 1 | 718 kWh/yr |
| Pine Ridge Manor | CTX16CABNLWW | 1 | 718 kWh/yr |
| Pine Ridge Manor | CTX16CYBJRWW | 2 | 718 kWh/yr |
| Pine Ridge Manor | CTX16CYBSRWW | 1 | 718 kWh/yr |
| Pine Ridge Manor | CTX16CYSFLWW | 1 | 766 kWh/yr |

## 5.3 Envelope

### 5.3.1 Attic Insulation – ECM 3.1

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Pine Ridge Manor | KS002000001 | 211 | In1 | Unit attic insulation level increased to R-38 and air seal attic penetrations |
| Marshall Square | KS002000001 | 26 | In1 | Unit attic insulation level increased to R-38 and air seal attic penetrations |
| Deer Creek Village | KS002000003 | 92 | In1 | Unit attic insulation level increased to R-38 and air seal attic penetrations |
| Western Plaza | KS002000003 | 22 | In1 | Unit attic insulation level increased to R-38 and air seal attic penetrations |

At the above sites, some duct and wiring penetrations at the attic floor are not air-sealed, creating thermal bridging. It is recommended that attic penetrations – including flues, ductwork, electrical penetrations, plumbing penetrations, and any gaps near the roof edge – be thoroughly air sealed with foam insulation.

The energy audits indicated an average level of R-10 insulation in the attic of each of the buildings at the above sites. The insulation level should be increased to R-38. All air gaps greater than 1 square inch in the attic floor should be sealed with spray foam insulation.

The following specifications apply.

- 013300 – SUBMITTAL PROCEDURES
- 014000 – QUALITY REQUIREMENTS
- 017823 – OPERATION AND MAINTENANCE DATA
- 017839 – PROJECT RECORD DOCUMENTS
- 017900 – DEMONSTRATION AND TRAINING
- 019113 – GENERAL COMMISSIONING REQUIREMENTS
- 072100 – THERMAL INSULATION

**Pricing and Installation Notes to Contractor:**

The sites may have varying levels of insulation. The contractor should take this into consideration when anticipating the expected amount of additional insulation needed at each site. It is the contractor's responsibility to document the existing insulation levels and air sealing needs at each site. At some sites, there may not be an attic for each unit due to multistory buildings. In this case, the contractor should provide a deduct where the attic insulation is not needed.

**Improvements to Operations and Maintenance:**

The addressing of shingle, penetration, and repair issues should extend the life of the roof and minimize future roof-related operations and maintenance issues.

**Impacts to Residents:**

The increased insulation level in the attic should make occupants more comfortable due to reduced radiant heat loss.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Pine Ridge Manor | Attic Insulation | 1-303 | - | - | - | - | - | - | 12,748 | 0.8668 | 11,050 | 11,050 |
| Marshall Square | Attic Insulation | 1-303 | - | - | - | 23,495 | 0.1283 | 3,014 | - | - | - | 3,014 |
| Deer Creek Village | Attic Insulation | 1-303 | - | - | - | - | - | - | 3,476 | 0.8648 | 3,006 | 3,006 |
| Western Plaza | Attic Insulation | 1-303 | - | - | - | - | - | - | 750 | 0.8527 | 640 | 640 |

**Calculation Methodology:**

The efficiency of the baseline heating system was found by the weighted average (by installed capacity) of the efficiencies of all the models of furnace found at the property. The net heating load and savings are calculated within the Utility Allowance Calculator. The savings are based on the following formulas:

$$Heating\ Load = \frac{24\frac{hr}{day} \times HDD \times Peak}{\Delta T}$$

**HDD – Annual heating degree days for Topeka @65 ºF = 5228**

**ΔT – Temperature difference between inside and outside (at peak low) = 70ºF**

$$Peak = Perimeter + Walls + Windows + Doors + Roof + Infiltration$$

where Walls, Windows, Doors, and Roof are calculated as

$$Area \times Uvalue \times \Delta T$$

$$Perimeter = Linear\ Ft \times Heat\ Loss\ Coefficient \times \Delta T$$

$$Infiltration = c_p \times Leakage\ Area \times \Delta T$$

**$c_p$ – Sensible heat of air = 1.08$\frac{Btu}{CFM \times F}$**

$$Roof\% = \frac{Roof_{ex} - Roof_{new}}{Peak_{ex} - Peak_{new}}$$

**$Roof_{ex}$ – Existing roof as above**

**$Roof_{new}$ – New roof as above, takes into account any anticipated changes in the u-value due to recommended improvements**

**$Peak_{ex}$ – Existing peak load as above**

**$Peak_{new}$ – New peak load as above, takes into account any anticipated changes in the peak load due to all recommended envelope improvements**

$$Total\ Savings = \frac{Existing\ Heating\ Load}{Existing\ Average\ Heating\ Efficiency} - \frac{Replacement\ Heating\ Load}{Replacement\ Efficiency}$$

**Replacement Heating Load – Takes into account any anticipated changes in the heating load due to recommended envelope improvements**

$$Attic\ Insulation\ Savings = Roof\% \times (Total\ Savings - Heating\ Savings)$$

**Heating Savings – Savings already attributed to Aquatherms/Heat Pumps**

The following table lists the value for each of these variables used to calculate the savings expected for each of these properties:

| Site Name | Existing Roof U-value | New Roof U-value | Eff_ex | Eff_new |
|---|---|---|---|---|
| Pine Ridge Manor | 0.08 | 0.03 | 78% | 88% |
| Marshall Square | 0.08 | 0.03 | COP 1 | COP 2.78 |
| Deer Creek Village | 0.08 | 0.03 | 78% | 88% |
| Western Plaza | 0.08 | 0.03 | 78% | 88% |

### 5.3.2 Infiltration Reduction – ECM 3.2

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Pine Ridge Manor | KS002000001 | 211 | I1 | Reduce building infiltration |
| Marshall Square | KS002000001 | 26 | I2 | Reduce building infiltration |
| Tennessee Town I | KS002000002 | 25 | I1 | Reduce building infiltration |
| Deer Creek Village | KS002000003 | 92 | I1 | Reduce building infiltration |
| Western Plaza | KS002000003 | 22 | I1 | Reduce building infiltration |

In general most sites already have door and window weather stripping. However, there were multiple sources of infiltration identified at audited units throughout the site.

The following scope items should be evaluated by the installing contractor and executed as needed:

- Seal attic hatch - Weatherstrip the attic access hatch or door. Cut 1x3 boards to fit the perimeter of the opening and nail them on with 6d finish nails. Apply self-adhesive foam weather strip tape to the top edge of the stop.
- Seal duct boots to wall, ceiling, or floor - Using mastic or caulk, seal the duct boot to the ceiling or floor. Seal any visible seams in the inside of the boot.
- Seal top plates - Seal top plates to interior drywall at attic/exterior wall interfaces. This air sealing is to take place in the attic.
- Exterior wall electrical boxes - Seal electrical boxes and switches on exterior walls using foam gaskets.
- Attic electrical and plumbing penetrations - Check for gaps in the attic that facilitate air movement by checking for dirty insulation. Seal the gaps with caulk or expanding foam. When complete and dry, push the insulation back into place.
- Furnace and/or water heater flues (attic penetrations) - Cut aluminum flashing to fit around the flue. For round flues, cut half circles out of two pieces so they overlap about 3 inches in the middle. Press the flashing metal into a bead of high-temperature caulk and staple or nail it into place. If there's no wood, staple or nail it directly to the drywall, but be sure not to staple or nail through the drywall. Seal the gap between the flue and metal flashing with special high-temperature caulk. Don't use spray foam. Form an insulation dam to prevent insulation from contacting the flue pipe. Cut enough aluminum from the coil to wrap around the flue plus 6 inches. Cut slots 1 inch deep and a few inches

apart along the top and bend the tabs in. Cut slots about 2 inches deep along the bottom and bend out the tabs. Wrap the dam around the flue and secure the bottom by stapling through the tabs. Put insulation back right up against the dam.

The following specifications apply.

- 013300 – SUBMITTAL PROCEDURES
- 014000 – QUALITY REQUIREMENTS
- 017823 – OPERATION AND MAINTENANCE DATA
- 017900 – DEMONSTRATION AND TRAINING
- 019113 – GENERAL COMMISSIONING REQUIREMENTS

**Improvements to Operations and Maintenance:**

This measure will have no impact on operating or maintenance costs. No repairs are required for this measure to be effective and no new skills are required.

**Impacts to Residents:**

Helps to eliminate drafts, allowing residents to be more comfortable.

**Pricing and Site Specific Installation Notes to Contractor:**

Location of needed weather stripping and air insulation are site specific. Contractor is ultimately responsible for locating all necessary infiltration-reduction needs.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Pine Ridge Manor | Bldg Envelope Upgrade | 1-302 | - | - | - | - | - | - | 20,083 | 0.8668 | 17,408 | 17,408 |
| Marshall Square | Bldg Envelope Upgrade | 1-302 | - | - | - | 52,033 | 0.1283 | 6,676 | - | - | - | 6,676 |
| Tennessee Town I | Bldg Envelope Upgrade | 1-302 | - | - | - | - | - | - | 1,925 | 0.9373 | 1,804 | 1,804 |
| Deer Creek Village | Bldg Envelope Upgrade | 1-302 | - | - | - | - | - | - | 12,261 | 0.8648 | 10,604 | 10,604 |
| Western Plaza | Bldg Envelope Upgrade | 1-302 | - | - | - | - | - | - | 2,910 | 0.8527 | 2,482 | 2,482 |

**Calculation Methodology:**

The efficiency of the baseline heating system was found by the weighted average (by installed capacity) of the efficiencies of all the models of furnace found at the property. The net heating load and savings are calculated within the Utility Allowance Calculator. The savings are based on the following formulas:

$$Heating\ Load = \frac{24\frac{hr}{day} \times HDD \times Peak}{\Delta T}$$

**HDD – Annual heating degree days for Topeka @65 °F = 5228**

**ΔT – Temperature difference between inside and outside (at peak low) = 70°F**

$$Peak = Perimeter + Walls + Windows + Doors + Roof + Infiltration$$

where Walls, Windows, Doors, and Roof are calculated as

$$Area \times Uvalue \times \Delta T$$

$$Perimeter = Linear\ Ft \times Heat\ Loss\ Coefficient \times \Delta T$$

$$Infiltration = c_p \times Leakage\ Area \times \Delta T$$

**$c_p$ – Sensible heat of air = 1.08$\frac{Btu}{CFM \times F}$**

$$Inf\% = \frac{Inf_{ex} - Inf_{new}}{Peak_{ex} - Peak_{new}}$$

**$Inf_{ex}$ – Existing infiltration as above**

**$Inf_{new}$ – New infiltration as above, takes into account any anticipated changes in the leakage area due to recommended improvements**

**$Peak_{ex}$ – Existing peak load as above**

**$Peak_{new}$ – New peak load as above, takes into account any anticipated changes in the peak load due to recommended envelope improvements**

$$Total\ Savings = \frac{Existing\ Heating\ Load}{Existing\ Average\ Heating\ Efficiency} - \frac{Replacement\ Heating\ Load}{Replacement\ Efficiency}$$

**Replacement Heating Load – Takes into account any anticipated changes in the heating load due to recommended envelope improvements**

$$Infiltration\ Savings = Inf\% \times (Total\ Savings - Heating\ Savings)$$

**Heating Savings – Savings already attributed to Aquatherms/Heat Pumps**

The following table lists the value for each of these variables used to calculate the savings expected for each of these properties:

| Site Name | Existing Leakage Area | New Leakage Area | Eff_ex | Eff_new |
|---|---|---|---|---|
| Pine Ridge Manor | 0.09 | 0.06 | 78% | 88% |
| Marshall Square | 0.09 | 0.06 | COP 1 | COP 2.78 |
| Tennessee Town I | 0.09 | 0.06 | 78% | 88% |
| Deer Creek Village | 0.09 | 0.06 | 78% | 88% |
| Western Plaza | 0.09 | 0.06 | 78% | 88% |

## 5.4 Mechanical

### 5.4.1 Central Air Handing Unit Replacement and HVAC Controls Upgrade – ECM 4.1

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Polk Plaza | KS002000002 | 1 | AHU1 | Convert the older air handler from a multi-zone constant volume systems to variable air volume systems. |

At Polk Plaza there is one large multi-zone hot deck/cold deck air handling unit. This unit has a total of three zones that feed the first floor common areas. The unit is equipped with a hot water coil serviced from the boilers in the adjacent room. A direct expansion coil is serviced by a 44 ton R-22 remote condensing unit on the North side of the building.

This ECM incorporates the upgrade and replacement of the air handling unit, remote condensing unit, system controls and piping insulation.

Please consider the following while pricing the project:

1. A new air handling unit shall replace the hot/cold deck air handling unit. The air handling unit shall be equipped with a Dx Coil and be capable of 100% economizer operation.
2. New VAVs shall connect to the combined existing hot/cold deck duct work and be equipped with a hot water re-heat coil fed from the hot water system. Hot water coils to be adequately sized to eliminate the need for an additional coil pump.
3. The remote condensing unit shall have a minimum EER 11 and IPLV of 15.5. Refrigeration piping shall meet the manufacturer's requirements. Contractor to include in the pricing the replacement of the refrigeration piping as the unit will be replaced to meet the EPA refrigerant requirements.
4. The plant shall also have a new control system. The new control system shall replace the current control system by controlling the AHU's, VAV's, condensing unit and boilers. The system shall meet the following system sequences/requirements:
    a. AHU:
        i. Comparative economizer operation allowing for the economizer to operate until the outside air temperature is greater than the return air temperature when there is a call for cooling.
        ii. Discharge air temperature reset to be field adjustable. System will be modeled around a 55F-65F reset. The heating discharged would be assumed to be around 90F.
        iii. Incorporate a zone space night time setback of 65F (adj) for heating and 80F (adj) for cooling.
        iv. Daytime setpoints of 72F (adj) with a 5F dead band.
        v. Optimized morning warm-up.
    b. Boiler
        i. Hot water rest controlling the mixing valve to maintain a recommended hot water loop temperature of reset of HWS120F-180F when OAT 65F-0F. The heat shall be locked out at OAT 65F (adj). Optimize to mitigate the use of personal electric heaters in the units while still maintaining approximately 115F of entering water on the radiators furthest from the hot water plant.

c. All control components shall be tested to ensure that they operate properly and are calibrated properly.

5. Replace all heating/cooling system loop pump motors with premium-efficiency motors of equal size. Motors should be rated for inverter duty.
6. Provide and install VFD for each motor. VFD installation should include a means for bypassing the VFD, should it malfunction.
7. Install a differential pressure (DP) sensor as near the end of the system as possible. The sensor should be located in a section of straight pipe not less than 2 inches in diameter, with 40 inches of straight pipe on either side. The DP sensor should be installed out of sight and access of residents.
8. Configure the piping to maintain the minimum required flow by installing bypass controls near the end of the piping riser runs.
9. Provide and post instructions near the VFD that explain how to operate the system and specifically how to change DP setpoints. Instructions should be protected by a water-resistant cover through which instructions are visible.
10. Load and ventilation calculations shall also be performed and available for the owner and commissioning agents review.
11. The Contractor shall provide a full and operational system including but not limited to the equipment, dedicated power supplies, piping/supports, anchors, pumps, boilers and associated controls.
12. The Contractor shall be responsible for the demolition, removal and proper disposal of all of the existing equipment to be replaced. Any regulated materials shall comply with state and federal regulations.
13. The Contractor shall secure all permits and inspections required for demolition and installation.
14. The Contractor shall work with and assist the Owner's Commissioning Agent to commission the plant operation.
15. The Contractor shall be responsible for the design and construction of the installation in its entirety, and shall secure the services of qualified professionals as required to complete this scope of work.
16. Insulate all exposed existing and new piping.
17. Contractor should train THA personnel on how to operate the new equipment.
18. The following performance-based specification sections are related to this scope of work (note: some information in the specifications may relate to other scopes of work and may not be germane to this scope of work):
    - 013300 – SUBMITTAL PROCEDURES
    - 014000 – QUALITY REQUIREMENTS
    - 017823 – OPERATION AND MAINTENANCE DATA
    - 017839 – PROJECT RECORD DOCUMENTS
    - 017900 – DEMONSTRATION AND TRAINING
    - 019113 – GENERAL COMMISSIONING REQUIREMENTS
    - 230923 SF - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
    - 237313 SF - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS
    - All other applicable division 22 and 23 specs.

**Improvements to Operations and Maintenance:**

The new equipment will restart the clock on the life cycle of the mechanical equipment. In addition to the equipment being newer lowering the number of services calls, the newer equipment will have a higher level of control and reduced energy consumption.

**Benefit to Residents:**

The increased control of the air handling unit and hot water plant will provide for a more comfortable area in the first floor common areas.

**Pricing and Site Specific Installation Notes to Contractor:**

Price project with current AHU plant size. Before final equipment selection, contractor shall be responsible for load calculation and equipment sizing per specifications. **It should be noted that the contractor is ultimately responsible for verifying site conditions.** Contractor will be responsible for issuing a deduct if plant has been reduced significantly in size.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Polk Plaza | Air Handling Unit | 1-304 | - | - | - | 9,700 | 0.0793 | 769 | 9,634 | 0.6510 | 6,272 | 7,041 |

**Calculation Methodology:**

These savings were calculated using an energy model. Please see Section 2, General Assumptions for more information. The following assumptions were made:

| Assumption | Polk Plaza |
|---|---|
| Weather File | TMY2\TOPEKAKS.bin |
| Construction | EPDM roof, double windows in aluminum frames |
| Building Area | 73,400 |
| Existing Space Heating System Efficiency | 80% |
| AHU (before) | Multizone AHU, constant volume fan, EER 8 |
| AHU (ECM) | VAV AHU, EER 11, functioning economizer |
| Boiler Plant (before) | HW fixed 180F, loop scheduled |
| Boiler Plant (ECM) | HW lockout at 65F, OA reset 180F @ 0F to 120F @ 60F |

### 5.4.2 Central Plant Boiler Replacement – ECM 4.2

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Jackson Towers | KS002000005 | 1 | B1 | Install New Modular Condensing Space Heating Boiler Plant with Setpoint Enable and OA Reset Controls |

Jackson Towers are served by 2 atmospheric, natural gas Ajax boilers (1,600 MBH output each). There are 2 constant volume space heating distribution pumps (10 hp each). The boilers are also controlled in part by the Solidyne M2 controls system

This ECM includes replacing both space heating boilers with 2 modulating power draft boilers (minimum 4:1 turn down ratio). The new boilers shall be designed so that each can handle 2/3 of peak heating load. Heat loss calculations shall be performed to determine the necessary capacity of the new boilers without oversizing.

The new system scope should include the following:

1. A new boiler control system shall be installed to operate the boilers and pumps with the following sequence of control:
    a. *Enable boilers when the outside air temperature falls below 62 F (adj.). Disable boilers when outside air temperature rises above 65 F (adj.). Stage and modulate boilers using manufacturer's controls to meet the HWST setpoint. Close isolation valve when respective boiler is not enabled.*
    b. *The HWST Setpoint shall be reset according to a linear outdoor air reset schedule in which the design hot water temperature, 180 F (Adj.), is delivered at the design outdoor air condition, 0 F (Adj.), and a lower, 120 F (Adj.) HWS is delivered at the high outdoor air temperature, 60 F (Adj.). This reset is to be optimized to maintain at least 115F at the furthest FCU.*
    c. *The HW circulation pumps shall stage run a constant speed. Pumps shall activate on outside air temperature and enable with the boilers.*
2. Combustion air intakes and flues shall be installed for the new power vent boilers and terminated per the manufacturer's recommended installation guidelines. Once direct vent combustion air is in place, the existing combustion air openings shall be sealed off and insulation shall be added to the exterior wall if needed.
3. The contractor needs to confirm the flue termination meets the manufacturer's clearance requirements. Flue paths should be approved by the owner prior to installation.
4. Contractor shall perform a load calculation to the owner and right size the equipment. A like for like replacement will not be accepted.
5. The Contractor shall provide a full and operational system including but not limited to the electrical work, flues, combustion air, natural gas piping, equipment and piping supports, anchors, pumps, boilers and associated controls.
6. The Contractor shall be responsible for the demolition, removal and proper disposal of all of the existing equipment to be replaced. Any regulated materials shall comply with state and federal regulations.
7. The Contractor shall secure all permits and inspections required for demolition and installation.
8. The Contractor shall work with and assist the Owner's Commissioning Agent to commission the plant operation.

9. The Contractor shall be responsible for the design and construction of the installation in its entirety, and shall secure the services of qualified professionals as required to complete this scope of work.
10. The Contractor shall coordinate and program the boiler plant controls. At a minimum, this should include optimized control of the supply water temperature based on the condenser water system setpoint and an outside air lockout control. The Contractor shall document all installed setpoints, provide documentation to the owner, and fully train the Owner on setpoint adjustment.
11. Insulate all exposed existing and new piping.
12. Contractor should train THA personnel on how to operate the boiler plant.
13. Refer to performance-based specifications of this report.
1. The following performance-based specification sections are related to this scope of work (note: some information in the specifications may relate to other scopes of work and may not be germane to this scope of work):
    - 013300 – SUBMITTAL PROCEDURES
    - 014000 – QUALITY REQUIREMENTS
    - 017823 – OPERATION AND MAINTENANCE DATA
    - 017839 – PROJECT RECORD DOCUMENTS
    - 017900 – DEMONSTRATION AND TRAINING
    - 019113 – GENERAL COMMISSIONING REQUIREMENTS
    - 230923 SF - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
    - 235216 SF - CONDENSING BOILERS
    - All other applicable division 22 and 23 specs.

**Improvements to Operations and Maintenance:**

New boilers will extend the lifecycle of the plant, and will reduce the number of maintenance and repair work orders.

**Pricing and Site Specific Installation Notes to Contractor:**

Price project with current boiler plant size. Before final equipment selection, contractor shall be responsible for load calculation and equipment sizing per specifications. **It should be noted that the contractor is ultimately responsible for verifying site conditions.** Contractor will be responsible for issuing a deduct if plant has been reduced significantly in size.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Jackson Towers | Space Heating Plant | 1-306 | - | - | - | - | - | - | 5,614 | 0.6240 | 3,503 | 3,503 |

**Calculation Methodology:**

These savings were calculated using an energy model. Please see Section 2, General Assumptions for more information. The following assumptions were made:

| Assumption | Constitution |
|---|---|
| Weather File | TMY2\TOPEKAKS.bin |
| Construction | EPDM roof, double windows in aluminum frames |
| Building Area | 71,400 |

| | |
|---|---|
| Existing Space Heating System Efficiency | 75% |
| Controls (before) | HW fixed 180F, loop on standby |
| Controls (ECM) | HW lockout at 65F, OA reset 180F @ 0F to 120F @ 60F |
| New System Efficiency | 85% |

### 5.4.3 Central Plant Chiller Replacement – ECM 4.3

| Site Name | Project # | Count and Descriptions |
|---|---|---|
| Jackson Towers | KS002000005 | 1 CH1 Install a new chiller |

The current chilled water plant consists of two 120 ton Carrier Reciprocating Chillers and a remote air cooled condensing unit. Replace the existing 1992 Carrier chiller with an appropriately sized air-cooled chiller. The COP of the new chiller should be at a minimum of 3.19 and have an IPLV of 14.5.

Please consider the following while pricing:

1. The contractor shall provide a fully operational chilled water system including but not limited to the electrical work, equipment, piping, pumps, and all associated controls.
2. This project is considered a design build project and the contractor is responsible for all necessary design responsibilities to meet the expectations outlined in this scope of work. A load calculation, piping layout and drawings are part of the design scope of work. Design to be submitted to the owner for review prior to ordering equipment.
3. The new plant controls shall integrate with the existing Solidyne M2 Controls and meet the following sequence requirements. The following sequences are recommendation though and do not account for all of the minor sequence changes associated with the controls operation:
    a. The controls shall also be able to meet the following sequences of operation.
        i. *Enable chiller when the outside air temperature rises above 75 F (adj.). Ensure that there is a 10 F (adj.) dead band to ensure that simultaneous heating and cooling does not occur. Stage and modulate chiller using manufacturer's controls to meet the CHWS setpoint.*
        ii. *The CHWS Setpoint shall be reset according to a linear outdoor air reset schedule in which the design chilled water supply temperature, 45 F (Adj.), is delivered at the design outdoor air condition, 95 F (Adj.), and a higher, 55 F (Adj.) CHWS is delivered at the lower outdoor air temperature, 75 F (Adj.). Reset shall be adjust to ensure that the fan coil unit furthest from the chiller is producing approximately 65 F air on a 75 F day.*
    b. Careful consideration shall be given to the location of the outdoor temperature sensor so that it is sensing true ambient conditions. Reset shall be tuned during cold and warm conditions to provide maximum comfort and efficiency.
    c. Control drawings and or narrative shall be submitted to the owner prior to ordering the equipment for approval.

4. The Contractor shall be responsible for the demolition, removal and proper disposal of all of the existing equipment to be replaced. This includes but is not limited to any regulated materials such as asbestos, lead, etc. Regulated materials shall be disposed of in accordance with local and federal regulations.
5. The Contractor shall secure all permits and inspections required for demolition and installation.
6. The new chiller shall include a factory start-up. This factory start-up shall include at least one return trip for the purposes of tuning and optimizing plant operation.
7. Piping & Pumping shall meet the following requirements:
    a. One line piping diagram shall be provided to owner prior to ordering any equipment.
    b. Insulate all exposed piping.
8. If applicable, the Contractor shall work with and assist the Owner's Commissioning Agent to commission the plant operation.
9. Install a means of water treatment and hire a qualified firm to flush and treat the both the newly installed components and hydronic heat piping. The means of water treatment installed shall be based on the results of a water quality test conducted by the contractor or it's sub, and be provided to the Owner and CxA for approval.
10. One full hard copy of O&M's shall be present at the site and electronic O&M's presented to the owner upon completion of the project.
2. The following performance-based specification sections are related to this scope of work (note: some information in the specifications may relate to other scopes of work and may not be germane to this scope of work):
    - 013300 – SUBMITTAL PROCEDURES
    - 014000 – QUALITY REQUIREMENTS
    - 017823 – OPERATION AND MAINTENANCE DATA
    - 017839 – PROJECT RECORD DOCUMENTS
    - 017900 – DEMONSTRATION AND TRAINING
    - 019113 – GENERAL COMMISSIONING REQUIREMENTS
    - 230923 SF - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
    - All other applicable division 22 and 23 specs.

**Improvements to Operations and Maintenance:**

A new air cooled chiller will place a reset on the chiller life cycle currently at 24 yrs of age and showing signs with several noticeable repairs. Limiting the amount of refrigerant piping to the exterior of the building will decrease the life safety concerns with the possibility of a leak in the mechanical room and lower maintenance repairs in the future.

**Pricing and Site Specific Installation Notes to Contractor:**

Price project with current plant size. Before final equipment selection, contractor shall be responsible for load calculation and equipment sizing per specifications. **It should be noted that the contractor is ultimately responsible for verifying site conditions.** Contractor will be responsible for issuing a deduct if plant has been reduced significantly in size.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Jackson Towers | Chiller 1-207 | - | - | - | 274,700 | 0.0634 | 17,408 | - | - | - | 17,408 |

**Calculation Methodology:**
These savings were calculated using an energy model. Please see Section 2, General Assumptions for more information. The following assumptions were made:

| Assumption | Constitution |
|---|---|
| Weather File | TMY2\TOPEKAKS.bin |
| Construction | EPDM roof, double windows in aluminum frames |
| Building Area | 71,400 |
| Existing Chiller System Efficiency | COP 1.92 |
| Controls (before) | CHW fixed 44F, loop on standby |
| Controls (ECM) | CHW lockout at 75F, OA reset 45F @ 95F to 55F @ 75F |
| New System Efficiency | COP 3.19 |

### 5.4.4 Convert Electric Resistance Heat to Heat Pumps – ECM 4.4

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Marshall Square | KS002000001 | 26 | HP | 9.5 HSPF heat pumps |

The space conditioning system at these properties consists of a split AC system with electric resistance heating located in a closet in each unit. The air-cooled condensing units currently provide cooling-only. The replacement of these systems with split heat pump systems is recommended. The new systems should be rated to achieve 9.5 HSPF (and 16 SEER in cooling mode). Because the current systems use R-22 refrigerant, a new indoor unit and refrigerant piping will likely be required. Because of the EPA phase out of R-22 this will eventually be necessary anyway, but will increase installation cost. It is recommended that thermostats are installed to take full advantage of the energy efficiency performance of the new system.

Please consider the following when assembling pricing:

- Additional wires may need to be run between the furnace and new thermostat. This cost must be included in the bid.
- Provide a non-programmable digital thermostat with the ability to take advantage of the staging and the ability to operate in fan only mode.
- A Manual J compliant load calculation and Manual S compliant sizing must be performed to properly size the new heat pumps. All load and sizing calculations shall be submitted to the owner and commissioning agent for approval before any equipment is ordered. Please also remember to take into consideration the size of the existing fan coil unit and utilize it again if possible.
- A sticker prompt should be included to encourage a 66°F nighttime set point and a 70°F daytime set point for heating. The sticker design will be provided by the owner, but the contractor will be responsible for printing and installing the prompt.
- All visible and accessible ducts shall be sealed with a SMACNA approved material.
- Install turning vanes in all T and elbow duct fittings accessible from the furnace. Turning vanes can be single wall.
- All equipment shall be started per manufacturer requirements. Also include documentation of proper airflow, filtration, gas pressure, temperature rise, and controls configuration. Start-up documentation

shall be left on site and submitted to the owner and commissioning agent. A sample start up report shall be included in the bid specifications.

- The following performance-based specification sections are related to this scope of work (note: some information in the specifications may relate to other scopes of work and may not be germane to this scope of work):
    - 013300 – SUBMITTAL PROCEDURES
    - 014000 – QUALITY REQUIREMENTS
    - 017823 – OPERATION AND MAINTENANCE DATA
    - 017900 – DEMONSTRATION AND TRAINING
    - 019113 – GENERAL COMMISSIONING REQUIREMENTS
    - 238126 SF - SPLIT-SYSTEM AIR-CONDITIONERS & HEAT PUMPS
    - 238219 SF - FAN COIL UNITS
    - 235400 – FURNACES (HEATPUMP)
    - All other applicable division 22 and 23 specs.

**Improvements to Operations and Maintenance:**

New heat pumps will push back the date at which the unit HVAC equipment would have to be replaced due to reaching end of life cycle, and will reduce the number of heating/cooling-related calls experienced. Additionally, all furnaces will be provided by the same manufacturer, improving the ease of maintenance and repair.

**Impacts to Residents:**

The new heat pump will likely be capable of more even heating output than the current equipment, keeping the residents more comfortable. Installation of digital thermostats will allow for more accurate thermal control. Any sites that see airflow rebalancing will improve thermal comfort.

**Pricing and Site Specific Installation Notes to Contractor:**

Size furnaces the heat at 30 btu/SF for pricing purposes. Before final equipment selection, contractor shall be responsible for load calculation and equipment sizing per specifications. **It should be noted that the contractor is ultimately responsible for verifying site conditions.**

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) |
| Marshall Square | Unit Heating | 1-301 | - | - | - | 152,681 | 0.1283 | 19,589 | - | - | - |

**Calculation Methodology:**
The net heating load and savings are calculated within the Utility Allowance Calculator. The savings are based on the following formulas:

$$Heating\ Load = \frac{24\frac{hr}{day} \times HDD \times Peak}{\Delta T}$$

**HDD – Annual heating degree days for Topeka @65 °F = 5228**

**ΔT – Temperature difference between inside and outside (at peak low) = 70°F**

$$Peak = Perimeter + Walls + Windows + Doors + Roof + Infiltration$$

where Walls, Windows, Doors, and Roof are calculated as

$$Area \times Uvalue \times \Delta T$$

$$Perimeter = Linear\ Ft \times Heat\ Loss\ Coefficient \times \Delta T$$

$$Infiltration = c_p \times Leakage\ Area \times \Delta T$$

**$c_p$ – Sensible heat of air = 1.08$\frac{Btu}{CFM \times F}$**

$$Savings = \left(\frac{Ex\ Heat\ Load}{Exisitng\ COP} - Ex\ Heat\ Load\right) - \left(\frac{New\ Heat\ Load}{New\ COP} - New\ Heat\ Load\right) - Envelope\ Savings$$

**Envelope Savings – Savings already attributed to envelope improvements**

**New Heating Load – Takes into account any anticipated changes in the heating load due to recommended envelope improvements**

**New COP – 2.78**

### 5.4.5 Aquatherms – ECM 4.5

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Deer Creek Village | KS002000003 | 50 | A1 | Aquatherm systems with EF 0.67 DHW heaters |

The Aquatherm system utilizes a domestic water heater as the primary source of heat and instead of a gas heating furnace replacement a high efficiency fan coil unit with a domestic water rated heating coil is installed. This measure is intended as a means for the housing authority to both save on first installation costs and simplify maintenance.

Please consider the following when assembling pricing:

- The fan coil units shall have a low loss cabinet, domestic water rated heating coil, pump timer and EC motor. First Company fan coil units should be utilized as a basis of design.
- Water haters should be sized to accommodate both the reduced domestic hot water needs (from replacing the shower heads and aerators) and the increased needs of the fan coil unit. Water heaters shall be sized to maximize the efficiency at 140F and Energy Star rated models that have a minimum Energy Factor (EF) of .67.
- Water heaters must be installed per code requirements of the Authority Having Jurisdiction. Include an emergency drain pan piped to a floor drain or acceptable location approved by the owner. Also include an expansion tank on the cold water line. Expansion tank and water heater need to be installed with a proper means of isolation.
- Additional wires may need to be run between the Aquatherm and new thermostat. This cost must be included in the bid.
- Provide a non-programmable thermostat with the ability to take advantage of the staging and the ability to operate in fan only mode.
- Aquatherm Fan Coil Units need to be installed per code. This includes meeting any dedicated power requirements. Any costs associated with code requirements of the Authority Having Jurisdiction must be included in the bid.
- A Manual J compliant load calculation and Manual S compliant sizing must be performed to properly size the new furnaces. The load calculation should assume the infiltration reduction and attic insulation measures listed in this report have been performed. All load and sizing calculations shall be submitted to the owner and commissioning agent for approval before any equipment is ordered. It was noted during the audit that most units were oversized. **Do NOT bid like for like capacities with existing equipment before evaluating loads.** Some of the original plans are available for the properties and when available will be utilized as a means of reference for the sizing of the equipment.
- A sticker prompt should be included to encourage a 66°F nighttime set point and a 70°F daytime set point for heating. The sticker design will be provided by the owner, but the contractor will be responsible for printing and installing the prompt.

- Include a detailed description of the proposed flue routing for the new condensing water with the bid that meets code and manufacturer requirements. Exterior flue penetrations should be capped with a bird screen and be out of reach of any residents. The proposed flue route will need to be approved by the commissioning agent and owner.
- Verify that gas piping and pressure meet manufacturer requirements. Any cost for modifications must be included in bid.
- All visible and accessible ducts shall be sealed with a SMACNA approved material.
- Install turning vanes in all T and elbow duct fittings accessible from the furnace. Turning vanes can be single wall.
- All equipment shall be started per manufacturer requirements. Also include documentation of proper airflow, filtration, gas pressure, temperature rise, and controls configuration. Start-up documentation shall be left on site and submitted to the owner and commissioning agent. A sample start up report shall be included in the bid specifications.
- The following performance-based specification sections are related to this scope of work (note: some information in the specifications may relate to other scopes of work and may not be germane to this scope of work):
    - 013300 – SUBMITTAL PROCEDURES
    - 014000 – QUALITY REQUIREMENTS
    - 017823 – OPERATION AND MAINTENANCE DATA
    - 017900 – DEMONSTRATION AND TRAINING
    - 019113 – GENERAL COMMISSIONING REQUIREMENTS
    - 238126 SF - SPLIT-SYSTEM AIR-CONDITIONERS & HEAT PUMPS
    - 238219 SF - FAN COIL UNITS
    - 235400 – FURNACES (HEATPUMP)
    - All other applicable division 22 and 23 specs.

**Improvements to Operations and Maintenance:**

By providing one source of heat per unit the complexity of the system is reduced. This allows for a lower skill level of maintenance worker to diagnose no heat calls possible reducing service calls. Upgrading to EC motors also allow for better modulation in times of low demand possibly reducing the filter changes required. One possible maintenance concession would be a reduction in water heater life expectancy.

**Impacts to Residents:**

A properly sized Aquatherm fan coil unit with an EC motor will offer a more even space temperature with a less air noise.

**Pricing and Site Specific Installation Notes to Contractor:**

Size Aquatherms at 30 btu/SF for pricing purposes. Before final equipment selection, contractor shall be responsible for load calculation and equipment sizing per specifications. **It should be noted that the contractor is ultimately responsible for verifying site conditions.**

The following addresses should receive the retrofit. Other units are excluded in order to avoid replacement of any water heater or furnace that has more than 30% of its estimated useful life left:

| Site Name | Unit # | Street # | Street Name | Bedrooms | Water Heater | Furnace |
|---|---|---|---|---|---|---|
| **Deer Creek** | 471DC | 2320 | B BURR | 1 | 1994 | 2002 |
| **Deer Creek** | 472DC | 2320 | A BURR | 1 | 2007 | 2002 |
| **Deer Creek** | 469DC | 2322 | A BURR | 1 | 2005 | 2002 |
| **Deer Creek** | 481DC | 2401 | SE COLONIAL | 2 | 1991 | 2002 |
| **Deer Creek** | 464DC | 2404 | SE COLONIAL | 2 | 2003 | 2002 |
| **Deer Creek** | 483DC | 2405 | SE COLONIAL | 3 | 2002 | 2002 |
| **Deer Creek** | 462DC | 2408 | SE COLONIAL | 2 | 2003 | 2002 |
| **Deer Creek** | 486DC | 2411 | SE COLONIAL | 3 | 1996 | 2002 |
| **Deer Creek** | 460DC | 2412 | SE COLONIAL | 2 | 2002 | 2002 |
| **Deer Creek** | 487DC | 2413 | SE COLONIAL | 5 | 1998 | 2002 |
| **Deer Creek** | 459DC | 2414 | SE COLONIAL | 2 | 2007 | 2002 |
| **Deer Creek** | 458DC | 2416 | SE COLONIAL | 2 | 1999 | 2002 |
| **Deer Creek** | 457DC | 2418 | SE COLONIAL | 2 | 2006 | 2002 |
| **Deer Creek** | 456DC | 2420 | SE COLONIAL | 2 | 1999 | 2002 |
| **Deer Creek** | 455DC | 2422 | SE COLONIAL | 2 | 1999 | 2002 |
| **Deer Creek** | 492DC | 2423 | SE COLONIAL | 3 | 2004 | 2002 |
| **Deer Creek** | 453DC | 2426 | SE COLONIAL | 3 | 1997 | 2002 |
| **Deer Creek** | 452DC | 2428 | SE COLONIAL | 3 | 2000 | 2002 |
| **Deer Creek** | 478DC | 2429 | SE COLONIAL | 3 | 1999 | 2002 |
| **Deer Creek** | 451DC | 2430 | SE COLONIAL | 3 | 1994 | 2002 |
| **Deer Creek** | 450DC | 2432 | SE COLONIAL | 3 | 1991 | 2002 |
| **Deer Creek** | 446DC | 2436 | SE COLONIAL | 2 | 2005 | 2002 |
| **Deer Creek** | 474DC | 2437 | SE COLONIAL | 2 | 2000 | 2002 |
| **Deer Creek** | 445DC | 2438 | SE COLONIAL | 2 | 2002 | 2002 |
| **Deer Creek** | 444DC | 2440 | SE COLONIAL DR | 2 | 1998 | 2002 |
| **Deer Creek** | 443DC | 2442 | SE COLONIAL | 2 | 2003 | 2002 |
| **Deer Creek** | 498DC | 2443 | SE COLONIAL | 3 | 2000 | 2002 |
| **Deer Creek** | 494DC | 2447 | SE COLONIAL | 2 | 1994 | 2002 |
| **Deer Creek** | 434DC | 2448 | SE COLONIAL | 2 | 2000 | 2002 |
| **Deer Creek** | 495DC | 2449 | SE COLONIAL | 2 | 2007 | 2002 |
| **Deer Creek** | 496DC | 2451 | SE COLONIAL | 2 | 2004 | 2002 |
| **Deer Creek** | 501DC | 2455 | SE COLONIAL | 3 | 2000 | 2002 |
| **Deer Creek** | 500DC | 2457 | B COLONIAL | 1 | 1994 | 2002 |
| **Deer Creek** | 424DC | 2458 | SE COLONIAL DRIVE | 2 | 1991 | 2002 |
| **Deer Creek** | 507DC | 2459 | SE COLONIAL | 2 | 2007 | 2002 |
| **Deer Creek** | 425DC | 2460 | SE COLONIAL DRIVE | 2 | 2002 | 2002 |
| **Deer Creek** | 508DC | 2461 | SE COLONIAL | 2 | 1991 | 2002 |
| **Deer Creek** | 426DC | 2462 | SE COLONIAL DRIVE | 2 | 2007 | 2002 |
| **Deer Creek** | 427DC | 2464 | A SE COLONIAL | 1 | 2006 | 2002 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Deer Creek** | 429DC | 2466 | A SE COLONIAL | 1 | 2003 | 2002 |
| **Deer Creek** | 430DC | 2466 | B SE COLONIAL | 1 | 1999 | 2002 |
| **Deer Creek** | 438DC | 2474 | SE COLONIAL | 2 | 2002 | 2002 |
| **Deer Creek** | 506DC | 2475 | SE COLONIAL | 2 | 2007 | 2002 |
| **Deer Creek** | 439DC | 2476 | SE COLONIAL | 2 | 2003 | 2002 |
| **Deer Creek** | 505DC | 2477 | SE COLONIAL | 2 | 2002 | 2002 |
| **Deer Creek** | 440DC | 2478 | SE COLONIAL | 2 | 2006 | 2002 |
| **Deer Creek** | 504DC | 2479 | SE COLONIAL | 2 | 2000 | 2002 |
| **Deer Creek** | 465DC | 2519 | SE BURR | 3 | 2004 | 2002 |
| **Deer Creek** | 467DC | 2523 | SE BURR | 2 | 2004 | 2002 |
| **Deer Creek** | 468DC | 2525 | SE BURR | 2 | 1999 | 2001 |

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (MCF) | Rate | ($) | ($) |
| Deer Creek Village | Aquatherm | 1-305 | - | - | - | - | - | - | 408 | 8.6480 | 3,524 | 3,524 |

**Calculation Methodology:**

The weighted average (based on MBH of capacity) of the water heater efficiencies was calculated for each of the sites. The new water heaters will operate at 0.67 EF. The net domestic water heating load and savings are calculated within the Utility Allowance Calculator. The savings are based on the following formulas:

$$DHW\ Load = (DHW\ Temp - City\ Temp) \times 8.33 \frac{BTU}{gal^{\circ}\mathrm{F}} \times Ann\ Cons \times \%DHW$$

**DHW Temp – Temperature to heat the DHW = 120°F**

**City Temp – Temperature of mains water in Topeka = 55 °F**

**Ann Cons – Annual water consumption by residents at the site, *gal***

**% DHW = Percent of water consumption attributed to DHW**

$$DHW\ Tank = DHW\ Load \times 5\%$$

**DHW Tank – Tank losses**

$$DHW\ Flue = DHW\ Load \times 5\%$$

**DHW Flue – Tank losses**

$$DHW\ Burner = (DHW\ Load + DHW\ Tank) \times (100\% - Eff)$$

**DHW Burner – Burner losses**

**Eff – Average combustion efficiency**

$$DHW\ Gas = (DHW\ Load + DHW\ Tank + DHW\ Flue + DHW\ Burner)$$

$$Savings = DHW\ Gas_{new} - DHW\ Gas_{ex} - LowFlow\ Savings$$

**DHW $Gas_{new}$ – Annual energy use by the new water heaters (including new DHW Load from Low Flow and new Eff)**

**DHW $Gas_{ex}$ – Annual energy use by the existing water heaters**

**Low Flow Savings – Savings attributed to low-flow fixtures**

The efficiency of the baseline heating system was found by the weighted average (by installed capacity) of the efficiencies of all the models of furnace found at the property. The Aquatherms will operate at the efficiency of the DHW heater. The net heating load and savings are calculated within the Utility Allowance Calculator. The savings are based on the following formulas:

$$Heating\ Load = \frac{24\frac{hr}{day} \times HDD \times Peak}{\Delta T}$$

**HDD – Annual heating degree days for Topeka @65 °F = 5228**

**ΔT – Temperature difference between inside and outside (at peak low) = 70°F**

$$Peak = Perimeter + Walls + Windows + Doors + Roof + Infiltration$$

where Walls, Windows, Doors, and Roof are calculated as

$$Area \times Uvalue \times \Delta T$$

$$Perimeter = Linear\ Ft \times Heat\ Loss\ Coefficient \times \Delta T$$

$$Infiltration = c_p \times Leakage\ Area \times \Delta T$$

**$c_p$ – Sensible heat of air = 1.08$\frac{Btu}{CFM \times F}$**

$$Savings = \frac{Existing\ Heating\ Load}{Existing\ Average\ Heating\ Efficiency} - \frac{Replacement\ Heating\ Load}{Replacement\ Efficiency} - Envelope\ Savings$$

**Envelope Savings – Savings already attributed to envelope improvements**

**Replacement Heating Load – Takes into account any anticipated changes in the heating load due to recommended envelope improvements**

**Replacement burner efficiency – 88%**

## 5.5 Renewable Energy

### 5.5.1 Photovoltaic Systems – ECM 5.1

| Site Name | Project # | Count and Descriptions | | |
|---|---|---|---|---|
| Polk Plaza | KS002000002 | 1 | PV1 | Install a roof mounted photovoltaic system and replace roof |

At Polk Plaza, a roof top mounted PV system is recommended. with a goal of maximizing efficiency and sizing the system to offset as much of the buildings load as possible without generating excess electricity (“kWh”). The age of the roof necessitates its replacement with a new EPDM roof as part of the Solar PV installation.

The following performance-based specification sections are related to this scope of work (note: some information in the specifications may relate to other scopes of work and may not be germane to this scope of work):

- 013300 – SUBMITTAL PROCEDURES
- 014000 – QUALITY REQUIREMENTS
- 017823 – OPERATION AND MAINTENANCE DATA
- 017900 – DEMONSTRATION AND TRAINING
- 019113 – GENERAL COMMISSIONING REQUIREMENTS
- ROOF REPLACEMENT
- MINIMUM SOLAR TECHNICAL SPECIFICATION

**Improvements to Operations and Maintenance:**

The installation of PV systems will have little impact on the operations and maintenance (“O&M”) of the site. PV systems require very little O&M on a routine basis and THA is seeking pricing for a third party local solar contractor to provide annual O&M.

**Impacts to Residents:**

The PV systems will have no impact on the residents other than potentially providing a sense of pride that their homes are being powered with clean renewable energy.

**Pricing and Site Specific Installation Notes to Contractor:**

**Polk Plaza**

Details regarding the roof replacement at Polk Plaza are as follows. Note that all roof construction scope will need to be coordinated with the solar installation to preserve all specification requirements and full warranty terms.

**Description**

A. The Polk Tower Reroof is located at 1312 SW Polk St in Topeka, KS.

B. The project consists of installing a Thermoplastic Polyolefin Mechanically Attached Roofing System as outlined below:

   Apply the TPO Mechanically Attached Roofing System in conjunction with 3” polyiso insulation and ½” SecureRock after tearing off the existing Duro-Last roof and insulation to expose the concrete deck for verification of suitable substrate, as specified in the Division 07 - ROOF REPLACEMENT specification**.**

**Extent of Work**

A. Provide all labor, material, tools, equipment, and supervision necessary to complete the installation of the .060" thick white reinforced TPO (Thermoplastic Polyolefin) membrane Mechanically Attached Roofing System, including flashings and insulation as specified in Division 07 – ROOF REPLACMENT and as indicated on the drawings in accordance with the manufacturer's most current specifications and details.

B. The roofing contractor shall be fully knowledgeable of all requirements of the contract documents and shall make themselves aware of all job site conditions that will affect their work.

C. The roofing contractor shall confirm all given information and advise the building owner, prior to bid, of any conflicts that will affect their cost proposal.

D. If there is intent to submit a bid using a roofing system other than the approved manufacturer, a detail description showing equivalency should be submitted. Bids that fail to detail all information as requested will be subject to rejection. Alternate bids stating "as per plans and specs" will be unacceptable.

**Submittals**

A. Prior to starting work, the roofing contractor must submit the following:

1. Shop drawings showing layout, details of construction and identification of materials.
2. Sample of the manufacturer's Membrane System Warranty.
3. Submit a letter of certification from the manufacturer which certifies the roofing contractor is authorized to install the manufacturer's roofing system and lists foremen who have received training from the manufacturer along with the dates training was received.
4. Certification from the membrane manufacturer indicating the fasteners are capable of providing a static backout resistance of 10 inch pounds minimum is required.
5. Certification from the membrane manufacturer indicating the membrane thickness over the reinforcing scrim (top ply membrane thickness) is nominal .015" (15 mil).
6. Certification of the manufacturer's warranty reserve.

B. Upon completion of the installed work, submit copies of the manufacturer's final inspection to the specifier prior to the issuance of the manufacturer's warranty.

**Scope of Work**

1. Prepare work area for installation of new roofing.
2. Tear off and dispose of exiting rubber roof and insulation down to concrete deck.
3. Install new 1.5 density tapered EPS insulation system tapered to drains with a 1" start. 1/8" taper per foot.
4. Install a new ¼" SecureRock Hard Board.
5. Install new White 60mil TPO
6. Install new curbs and stack flashings.
7. Replace all metal caps, and metal edging as needed.
8. Install new walk-pad walkway from roof hatch to elevator room.
9. Provide a 20 year Manufacturers full system warranty.

**General Notes**

*Scope and pricing approach:* This ECM requires a solar contractor(s) to provide a design assist approach where the solar contractor is required to provide a turnkey design, engineering, procurement, and construction (EPC) approach including:

Roof Top System

All required design, permitting, applications, and other requirements required by the jurisdiction having local authority as well as utility companies

Procurement and construction of the complete PV system

Interconnection

Required meters

*Sizing:* The systems should be design and sized to offset as much of the load of the building as possible without the generation of additional electricity which would go back to the grid through net metering or a similar program (if applicable).

*Warranty:*

2 years materials and workmanship

Solar panel performance of 90 percent of nameplate at year 10 and 80 percent of nameplate at year 25 via pass through of module manufacturer warranty

20-year inverter warranty

*Rebates / Incentives / Tax Credits:* The solar contractor is to work with THA in maximizing and securing any utility rebates, renewable energy credits, and potentially monetizing any available tax credits.

*Ownership Structure:* Pricing and analysis for this ECM should assume THA owns the PV systems outright and there is no third party ownership or power purchase agreement ("PPA").

*Operations and Maintenance:* This ECM requires an annual O&M contract for 20 years where the solar contract is to provide pricing for such services.

**Savings:**

| Site Name | Energy Conservation Measure (ECM) Description | Water/Sewer | | | Electricity | | | Natural Gas | | | Total Energy Savings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (Gallons) | Rate | ($) | (kWh) | Rate | ($) | (CCF) | Rate | ($) | ($) |
| Polk Plaza | Solar - PV 1-208 | - | - | - | 31,000 | 0.0793 | 2,459 | - | - | - | 2,459 |