

Topeka Housing
Authority Phase I
EPC

M&V

This document identifies the options to be applied, defines the baseline (or how it will be determined), identifies metering requirements, and outlines specific methodologies associated with implementing the plan.

Plan v1

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1 ENERGY CONSERVATION MEASURE INTENT

This Measurement and Verification (M&V) Plan for the Topeka Housing Authority (THA) describes an M&V approach designed to reliably determine the actual energy and water savings associated with the Energy Performance Contract (EPC). The EPC contains a significant number of Energy Conservation Measures (ECMs) designed to reduce the energy and water use of the Housing Authority.

ECM descriptions, their intended result, and any planned changes to baseline conditions are detailed in the Investment Grade Audit and bid specifications.

The commissioning procedures that will be used to verify the successful implementation of each Phase I ECM are detailed in the commissioning plan presented below.

1.1 ECM SUMMARY

The following section lists the Phase I ECMs, as well as a summary of the sites where each ECM is installed, cost and annual savings.

ECM 1.1 & 1.2 – Low Flow Fixture Installation

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

ECM 2.1 – In-Unit Lighting Retrofit

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

ECM 2.2 – Heat Lamp Timers

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

ECM 2.3 – Common Area & Exterior Lighting Retrofit

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

ECM 2.4 – Safe-T Range Controls

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

ECM 2.5 – Refrigerators

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

ECM 3.1 – Attic Insulation

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

ECM 3.2 – Infiltration Reduction

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

ECM 4.1 – Central Air Handling Unit Replacement and HVAC Controls Upgrade

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

ECM 4.2 – Central Plant Boiler Replacement

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

ECM 4.3 – Central Plant Chiller Replacement

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

ECM 4.4 – Convert Electric Resistance Heat to Heat Pumps

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	-	-	-

ECM 4.5 – Aquatherms

Site Name	Energy Conservation Measure (ECM) Description		Water/Sewer			Electricity			Natural Gas			Total Energy Savings (\$)
			(Gallons)	Rate	(\$)	(kWh)	Rate	(\$)	(CCF)	Rate	(\$)	
Deer Creek Village	Aquatherm	1-305	-	-	-	-	-	-	4,779	0.8648	4,133	4,133

ECM 5.1 – Photovoltaic Systems

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

2 SELECTED IPMVP OPTION AND MEASUREMENT BOUNDARY

The table below shows which IPMVP option has been selected for each project number. IPMVP option descriptions are detailed in section 2.1.

Site Name	Verification Protocol		
	Water & Sewage	Electricity	Natural Gas
Pine Ridge Manor	C	A	A
Marshall Square	C	A	A
Polk Plaza	C	A	C
Tennessee Town I	C	A	A
Deer Creek Village	C	A	A
Western Plaza	C	A	A
Tyler Towers	C	A	C
Jackson Towers	C	A	C
Tennessee Town II	C	A	A
Echo Ridge	C	A	A

Table 1 - IPMVP Option Selection

The measurement boundary of the savings determination for each site includes all utility meters associated with each project number. In the case of the high rises, a project often has one master electricity, natural gas, and water meter. In the case of the row type homes and dispersed sites, many meters are associated with each project number.

There is a strong correlation between savings protocols selected for THA’s EPC program and the subsidy incentives approved by HUD. Our goal is to produce an accurate report that does not create an undue administrative burden for THA and simplifies the HUD review process to the greatest extent possible. In light of this, we have attempted to develop an M&V reporting model that ties savings determination to subsidy benefit, so that the savings determined by this model are directly related to the subsidy benefit realized by THA.

2.1 OVERVIEW OF SAVINGS VERIFICATION PROTOCOLS

The Efficiency Valuation Organization (EVO) publishes the International Performance Measurement and Verification Protocol (IPMVP) to increase investment in energy and water efficiency, demand management and renewable energy projects around the world. The IPMVP allows building owners, energy service companies, and financiers of energy efficiency projects to quantify the energy savings performance of energy conservation measures (ECMs). It provides an overview of current best practice techniques available for verifying savings from both traditionally funded and third-party-financed energy and water efficiency projects.

M&V Option	How Savings Are Calculated	Typical Applications
<p>Option A - Partially Measured Retrofit Isolation Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous. Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings.</p>	<p>Engineering calculations using short term or continuous post-retrofit measurements and stipulations.</p>	<p>Lighting retrofit where power draw is measured periodically.</p>
<p>Option B - Retrofit Isolation Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.</p>	<p>Engineering calculations using short term or continuous measurements</p>	<p>Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the base year this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use.</p>
<p>Option C - Whole Building Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.</p>	<p>Analysis of whole facility utility meter or sub-meter data</p>	<p>Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month base year period and throughout the post-retrofit period.</p>
<p>Option D - Calibrated Simulation Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.</p>	<p>Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.</p>	<p>Multifaceted energy management program affecting many systems in a building but where no base year data are available. Post-retrofit period energy use is measured by the gas and electric utility meters. Base year energy use is determined by simulation using a model calibrated by the post-retrofit period utility data.</p>

2.2 OVERVIEW OF PUBLIC HOUSING EPC SUBSIDY INCENTIVES

Under the HUD Public Housing EPC program, a PHA may propose to HUD to follow one or more of the available EPC incentives, provided that multiple incentives do not apply to the same ECMs. To varying degrees, THA is utilizing the Subsidy Add-on and Resident Paid Utility incentives. HUD must approve the use of the incentives, including the length of the contract period.

Subsidy Add-On (PHA-Paid Utilities)

In lieu of freezing consumption baselines, PHAs can request additional operating subsidy in the form of an add-on, as described in 24 CFR § 990.185(a)(3)(i). The additional subsidy is for amortization of the loan of the EPC and other direct costs related to the conservation project during the term of the contract. Add-on eligibility is

limited to the lesser of project costs or savings. PHAs are not permitted retain any of the savings associated with over-performance of ECMs (i.e. savings generated in excess of those needed to match project costs). However, project costs can be increased to add ECMs or project phases to capture these savings. HUD approval is required for a project expansion.

Annual HUD Reporting / M&V Requirements -

- A savings verification report must be submitted to the HUD field office annually. This report should be prepared in accordance with the verification protocols approved by HUD and quantify the savings realized over the calendar year. Since add-on eligibility is the lesser of program costs or savings, HUD may adjust future add-on eligibility for savings shortfall(s) identified in previous periods.

Resident Paid Utilities

This approach allows a PHA to exclude from its operating fund rental income calculations any rents received that are a result of decreased utility allowances resulting from decreased consumption. The PHA must exclude from its calculation of rental income the increased rental income due to the difference between the baseline allowance and the revised allowances of the projects for the duration of the contract period. The funding period for the resident-paid utility incentive is from July 1 through June 30 of a given calendar year.

Annual HUD Reporting / M&V Requirements -

Unlike other incentives, the value of this rental income adjustment is not a function of actual utility savings; it is derived from a decrease in resident paid utility allowances and the corresponding increase in net rental income. Assuming that the subsidy adjustment is properly completed, there is little savings risk. However, there are still some important M&V considerations.

- Physical inspections are needed to ensure that installed ECMs are still in place and operating in accordance with original specifications. This ensures the integrity of the utility allowance be provided to residents.
- Documentation to support that at least 75% of the energy savings is being utilized as payment for the project costs.

2.3 COORDINATION WITH PUBLIC HOUSING AUTHORITY (PHA)/HUD REQUIREMENTS

Calculation of Energy Normalized Savings shall comply with HUD requirements. PHA/HUD Utility Accounting Methods will be coordinated with M&V methodologies *in general* as described below and in specific in the Analysis Procedure section of this plan.

Energy Savings Add-On Subsidy (PHA-Paid)

The calculation of add-on subsidy eligibility is based on field measurement of the key performance parameters which define the energy use of the ECM's affect system(s). The field measurements are conducted on a HUD prescribed statistical sample basis (see Section 6). The validity of this type of verification is dependent upon physical inspection of installed ECMs and partial field measurement. THA's EPC add-on eligibility is the lesser of program costs related to the add-on ECM or associated savings.

If, based on our verification process, add-on savings fall short of the HUD approved amount as entered into form HUD-52723, part A (formula expenses) on line 8 (energy loan amortization), the following year's add-on will be reduced by the amount of the shortfall. Verification is completed after the add-on funding period is over. Verification of 2017 savings, for example, will take place in 2018, so it will not be possible to adjust the 2017 add-on at that point, so the shortfall should be recaptured by HUD in 2018. If savings verification is completed

after the 2018 subsidy request has been submitted, a subsidy revision should be prepared to ensure the integrity of this process.

Resident Paid Utilities

Quantifying the value of resident paid utility savings will not be based on the actual savings achieved, since THA does not actually pay these bills and funding for resident pad utility allowances are not based on actual expense. The expense, to HUD and THA, associated with resident paid utilities takes the form of resident paid utility allowances. Allowances are calculated in a manner most consistent with an “Option A” IPMVP verification protocol, so HUD has employs a similar methodology to the calculation and verification of EPC savings.

Verification of resident paid utility savings will involve valuing HUD approved savings at current rates and physical inspection of units to ensure that the EPC Option A measures installed are still in place and performing to original specifications. In accordance with HUD M&V guidelines, inspections will be based on a statistical sample of units; not all units (see Section 6).

<i>Topeka Housing Authority: ECM & Utility Account vs. Cost Avoidance Method Coordination</i>			
<i>PHA/HUD Energy Conservation Incentive</i>	<i>Utility Allowance Waiver (not applicable to this job)</i>	<i>Add-On Subsidy (for PHA paid accounts)</i>	<i>Rolling Base Year</i>
<i>M&V Method</i>	-	<i>Add-On Subsidy Savings Verification Method</i>	-
<i>Operating Subsidy Coordination</i>	-	<i>Used with additional operating subsidy supporting amortization of ECMs via non-HUD loan</i>	-
<i>Utility Payment Coordination</i>	-	<i>Authority-Provided Utility via either master-metered, master-metered via checkmeters, or individual meters</i>	<i>Authority-Provided Utility via either master-metered, master-metered via checkmeters, or individual meters</i>
<i>HUD Form Coordination</i>	-	<i>HUD-52723 Part D Energy Add-On for loan amortization</i>	<i>HUD-52722 lines 2, 3, and 4</i>
<i>DOE FEMP M&V Options</i>	-	<i>Option A for electricity</i>	<i>Option C for water, sewer, and gas</i>
<i>Industry Standard General M&V Description</i>	-	<i>Option A Stipulated Savings for electricity</i>	<i>Option C Whole Building Utility Bill Analysis for water, sewer, and gas</i>
<i>Duration of Monitoring</i>	-	<i>On-Going for duration of reporting period</i>	<i>On-Going for duration of reporting period</i>

Table 2 - M&V Method Coordination

3 BASELINE: PERIOD, ENERGY, AND CONDITIONS

The Baseline Period is defined as the adjusted, average energy consumption from July 1st, 2011 through June 30th, 2015 (see Appendix B), per the energy costs and utility unit costs provided by the Housing Authority, and as defined in the Technical Analysis section presented in this plan.

3.1 BASELINE INDEPENDENT VARIABLE DATA

The only independent variable data used in this M&V plan is ambient daily temperature (Heating Degree Days – HDD). The HDD data associated with the energy data during the reporting period is presented in the table below.

	2011	2012	2013	2014	2015
Jan		886	940	1156	1028
Feb		740	849	1061	1056
Mar		237	764	710	556
Apr		166	440	311	228
May		16	132	95	93
Jun		8	5	0	0
Jul	0	0	0	0	
Aug	0	0	0	0	
Sep	89	53	14	47	
Oct	249	320	300	204	
Nov	592	514	678	777	
Dec	886	881	1106	883	

Table 3 - Topeka HDD July 2011 – June 2015 (base 65°F)

Source: weatherdatadepot.com

3.2 BASELINE OPERATING PARAMETERS – STATIC FACTORS

The baseline operating parameters are the facilities and systems operations measured and/or observed before the commencement of the EPC retrofit work, or as defined by HUD guidelines. All building systems (lighting, heating, cooling, ventilation, envelope, and controls) were observed to be operated and maintained according to sound engineering practice.

The data summarized will be used in the calculation of the baseline energy consumption and for calculating baseline adjustments for changes in facility operation that occur during the EPC. The following data was collected with the assistance of THA:

- All buildings operate 24 hours a day, seven days a week, 365 days a year.
- All buildings are occupied at the occupancy rates documented in the EPC.

4 REPORTING PERIOD

The reporting period will begin October 1st, 2017, and will run through September, 2032. An M&V report will be issued in March of each reporting year, covering the previous calendar year. July 1st to June 30th utility data will be used for all Frozen Rolling Base and Resident Paid Utility savings reporting. January 1st to December 31st will be used for all Add-On Subsidy savings reporting.

5 BASIS FOR ADJUSTMENT

Adjustments need to be made to reporting period energy use data in order to accurately compare reporting period energy use to baseline period energy use (see the normalized savings discussion in the Analysis Procedure section below).

There are two types of adjustments that will be made in the course of calculating the reporting period energy use: *routine* and *non-routine*. Routine adjustments are those for energy governing factors that are expected to change regularly during the reporting period. Non-routine adjustments are those made when static factors (see section 3) change during the reporting period.

Routine adjustments will consist solely of adjustments made for variation in weather conditions. Adjustments will be made to the reporting period building energy use equation established for each project number (see the Analysis Procedure section). These adjustments will normalize the reporting period heating degree day (HDD) values to the baseline period HDD values (see table 4). The Resident Paid Utility incentive amount will be adjusted for current period occupancy.

Non-routine adjustment will be made to the reporting period building energy use equation established for each project number (see the Analysis Procedure section) if any static factor changes significantly during the reporting period. Give the historical and projected consistency among THA occupancy rates, operating hours, and other static factors, an adjustment of this nature is not anticipated.

All baseline adjustments will be conducted in accordance with HUDs baseline adjustment guidance document.

6 ANALYSIS PROCEDURE (OPTION C & A)

THA has allocated significant resources to ensuring M&V activities are conducted thoroughly, for both tracking and diagnostic purposes. An independent third party will conduct M&V activities. Additionally, THA maintenance and finance staff are being trained to integrate select M&V tasks into their annual operating procedures.

Each M&V savings report will establish normalized savings for each project number over a full cycle (1 calendar year) of the reporting period. As stated in IPMVP 2010, normalized savings are:

- Unaffected by reporting-period conditions since the fixed set of conditions are established once and not changed.
- Can be directly compared with savings predicted under the same set of fixed conditions.
- Can only be reported after a full cycle of reporting-period energy use, so that the mathematical correlation between reporting-period energy and operating conditions can be derived.

6.1 OPTION C METHODOLOGY

Normalized savings will be calculated by establishing an energy use equation for each project, for each utility type consumed, for every full cycle of the reporting period. The energy use equation will relate the dependent variable, total project energy (or water) use, to independent variables whose variability is known to impact significantly building energy use. For the purposes of this M&V plan, independent variables will be limited to HDDs in most cases (see below for exceptions).

The energy use for each project will be the sum of all meters associated with that project number, of a particular utility type. In the case of row type home developments and dispersed housing, this will result in many (at times hundreds) of meters aggregated into a single data set. In these cases, individual meter data will be harmonized into a single date range for each billing period, which will then be regressed to the associated weather data. The harmonization process must preserve all consumption data, and accurately allocate consumption to the proper monthly period. Weather data will be secured from a local Topeka weather source recognized and supported by the National Oceanic and Atmospheric Administration (NOAA).

Each project energy use equation will be calculated using a weighted ordinary least squares regression. This basic form of multiple linear regression allows for analysis of a dependent variable (that is, annual project electricity, natural gas, or water use energy use), as a function of heating degree days. The linear regression will yield an equation of the form:

$$\text{Annual Project Energy Use} = C_0 + C_1 * \text{Characteristic}_1$$

In this equation, C_0 represents a constant, with the other C value representing an equation coefficient for the HDDs. For each reporting period, there will be 12 months of data collected and included in the regression analysis.

At times, the energy use data may be influenced by more than one independent variable. Specifically, it is anticipated that Cooling Degree Days may also have a strong correlation with electricity and water use. In this case, it is acceptable to use a multivariable regression model, which may also reflect change points in the data. In such a case, the equation will look like:

$$\text{Annual Project Energy Use} = C_0 + C_1 * \text{Characteristic}_1 + C_2 * \text{Characteristic}_2 \dots$$

When other independent variables besides HDDs are included, these independent variables **will not** be adjusted to the baseline period. Only reporting period values will be used.

The energy use equation that is selected to model reporting period energy use must be the one that provides an acceptable and best fit to the data. A best fit is defined as the model that produces a Coefficient of Multiple Determination (R2) that is closest to 1.0. R2 is defined as:

$$R2 = 1 - \frac{\sum_n (y - \hat{y})^2}{\sum_n (y - \bar{y})^2}$$

In this equation, N is the number of observations in the model and y is an individual observation in the data set (the $\bar{}$ over a variable indicated that variables mean values, and a $\hat{}$ over a variable indicates that variable's value that is predicted by the model).

Once the project energy use equation is established for each utility type, the HDD adjustment will be performed. This is accomplished by using average HDD bin data from the baseline period (July 2011 – July 2014) with the energy use equations to calculate a full cycle (one calendar year) of normalized energy use.

Finally, normalized savings will be calculated using the following equation:

$$\text{Normalized Savings} = \text{Baseline Energy Use} - (\text{Reporting Period Energy Use} \pm \text{Routine Adjustments} \pm \text{Non-Routine Adjustments to fixed conditions})$$

Additionally, 10 third party unit site inspections will be conducted at each AMP covered by the Option C M&V approach annually to confirm the presence and functionality of the installed ECMs. An inspection of 100% of the installed ECM central plant equipment will also be conducted.

6.2 OPTION A METHODOLOGY

All sites will utilize an Option A M&V methodology for electricity consumption for all related ECMs. Pine Ridge Manor, Marshall Square, Tennessee Town I, Deer Creek Village, Western Plaza, Tennessee Town II, and Echo Ridge will also use Option A M&V methodology for natural gas consumption. Option A Savings are based on field measurement of the key performance parameters which define the energy use of the ECM’s affect system(s). The field measurements are conducted on a sample basis.

Minimum HUD requirements require M&V site verification activities will be performed in order to establish a confidence level of 80% with a precision of 10% regarding performance and operation parameters. This sampling approach will be based on an AMP by AMP basis and must be random, not the total # of units for which Option A is applied to. This results in the following number of units to be inspected for the sites that undergo Option A M&V:

Project / AMP	Site #	Site Name	Unit Count (Total)	80% /10% Sample Size
KS002000001	KS02-01.0	Pine Ridge Manor	211	35
KS002000001	KS02-09.0	Marshall Square	26	17
KS002000002	KS02-03.0	Polk Plaza	109	30
KS002000002	KS02-08.0	Tennessee Town I	25	16
KS002000003	KS02-04.1	Deer Creek Village	92	29
KS002000003	KS02-04.2	Western Plaza	22	15
KS002000004	KS02-04.0	Tyler Towers	75	27
KS002000005	KS02-02.0	Jackson Towers	102	30
KS002000007	KS02-07.0	Tennessee Town II	16	12
KS002000008	KS02-10.0	Echo Ridge	66	26

Specific field measurement methodology for all Option A ECMs must abide by the sample size requirements required by HUD. **If more than a 10% deficiency rate is found in an Option A ECM, claimed savings must be**

adjusted downwards. Any changes to the annual stipulated consumption values must be discussed in the annual M&V report that the PHA transmits to HUD.

7 ENERGY PRICES

The energy prices used to value resident paid savings are based on 2014-2015 Topeka published utility tariff rates. The energy prices used to value authority paid savings tie to the form HUD-52722 for each project number. For electricity, a blended rate is used to capture demand and consumption costs in one \$/kWh rate. The table below details the 2015 energy prices that will be used as a baseline pricing for the value savings for each project. These baseline period rates will be escalated by 3.0% annually.

	PHA Paid Utilities					
	Actual Average Rates			Marginal Rates		
	Ties to form(s) HUD 52722			Excluding Fixed Charges		
	07/01/14	to	06/30/15	07/01/14	to	06/30/15
Water/Sewer (Gallons)	Electricity (kWh)	Natural Gas (CCF)	Water/Sewer (Gallons)	Electricity (kWh)	Natural Gas (CCF)	
KS002000001	\$ 0.0086	\$ 0.1351	\$ 1.2693	\$ 0.0078	\$ 0.1215	\$ 1.1424
KS002000002	0.0092	0.0793	0.6510	0.0082	0.0714	0.5859
KS002000003	0.0092	0.1450	1.1578	0.0083	0.1305	1.0420
KS002000004	0.0094	0.0770	0.6415	0.0084	0.0693	0.5773
KS002000005	0.0105	0.0634	0.6240	0.0094	0.0570	0.5616
KS002000007	0.0094	-	-	0.0084	-	-
KS002000008	0.0089	0.1304	-	0.0080	0.1173	-

Table 4 - Energy Prices

8 METERING SPECIFICATIONS

All meters used by this M&V plan are utility owned meters, maintained and calibrated by the respective utilities. Billing data will be collected and reported on a billing period basis, as determined by the relevant utility.

9 M&V RESPONSIBILITIES AND INSPECTION PLAN

This Measurement and Verification Plan will be carried out jointly by THA and a third party M&V agent. As such, the two groups have varying responsibilities across the required M&V tasks. These responsibilities are summarized in the table below.

M&V Activity	Responsible Party	Date Due
Development of M&V Plan	Group14 Engineering	HUD EPC Submission
Phase I ECM Commissioning Activities	Group 14 Engineering	End of Construction

Compilation of aggregated occupancy data, by APM, by calendar year in excel.	THA Staff	February 1 st of the following calendar year.
Compilation of aggregated monthly utility data, by APM, by utility type (water, gas, and electric,) in excel. The aggregation of monthly utility data must for the requirements presented in the Analysis Procedure section.	THA Staff	Monthly
M&V Site Verification Activities	M&V Agent	Third Party will be responsible for completing annual M&V Inspections See Inspection Schedule below for more detail.
M&V Annual Report	M&V Agent	March of the following calendar year.
Corrective action to maintain the durability of energy savings.	THA and Contractors.	On-going

M&V Site Verification Activities are presented below, by site, ECM, M&V Option, and subsidy type:

Site Name	Energy Conservation Measure (ECM) Description	Funding Source			M&V Protocol			Random 80/10 Verification Parameter Every 5 Years	Random 80/10 Operational Verification Annually	Random 80/10 Operational Verification Every 5 Years				
		AF	PHA Frozen Base	AA	PHA Add-On	R	Resident				C	COCC	CF	Capital Fund
		W/S	Elec	Gas	W/S	Elec	Gas							
Pine Ridge Manor	LF Kitchen Aerators	AA	-	R	C	-	A	•		•				
Pine Ridge Manor	LF Bathroom Aerators	AA	-	R	C	-	A	•		•				
Pine Ridge Manor	LF Showerheads	AA	-	R	C	-	A	•		•				
Pine Ridge Manor	Common Area Lighting	-	AA	-	-	A	-		•					
Pine Ridge Manor	In Unit Lighting	-	R	-	-	A	-	•						
Pine Ridge Manor	Energy Star Refrigerators	-	R	-	-	A	-	•						
Pine Ridge Manor	Bldg Envelope Upgrade	-	-	R	-	-	A	•						
Pine Ridge Manor	Attic Insulation	-	-	R	-	-	A	•						
Pine Ridge Manor	Aquatherm	-	-	R	-	-	A	•						
Pine Ridge Manor														
Marshall Square	LF Kitchen Aerators	AA	R	-	C	A	-	•		•				
Marshall Square	LF Bathroom Aerators	AA	R	-	C	A	-	•		•				
Marshall Square	LF Showerheads	AA	R	-	C	A	-	•		•				
Marshall Square	Common Area Lighting	-	AA	-	-	A	-		•					
Marshall Square	In Unit Lighting	-	R	-	-	A	-	•						
Marshall Square	Exterior Lighting	-	AA	-	-	A	-		•					
Marshall Square	Safe-T Range Element	-	R	-	-	A	-	•						
Marshall Square	Unit Heating	-	R	-	-	A	-	•						
Marshall Square	Bldg Envelope Upgrade	-	R	-	-	A	-	•						
Marshall Square	Attic Insulation	-	R	-	-	A	-	•						
Marshall Square														
Polk Plaza	LF Kitchen Aerators	AA	-	AA	C	-	C			•				

Polk Plaza	LF Bathroom Aerators	AA	-	AA	C	-	C			•
Polk Plaza	LF Showerheads	AA	-	AA	C	-	C			•
Polk Plaza	Common Area Lighting	-	AA	-	-	A	-		•	
Polk Plaza	In Unit Lighting	-	AA	-	-	A	-		•	
Polk Plaza	Exterior Lighting	-	AA	-	-	A	-		•	
Polk Plaza	Exhaust Fan Motor Upgrade	-	AA	-	-	A	-		•	
Polk Plaza	Replace Window AC w/ Multizone	-	AA	AA	-	A	C		•	•
Polk Plaza	Air Handling Unit	-	AA	AA	-	A	C		•	•
Polk Plaza										
Tennessee Town I	LF Kitchen Aerators	AA	-	R	C	-	A		•	•
Tennessee Town I	LF Bathroom Aerators	AA	-	R	C	-	A		•	•
Tennessee Town I	LF Showerheads	AA	-	R	C	-	A		•	•
Tennessee Town I	Common Area Lighting	-	AA	-	-	A	-		•	
Tennessee Town I	Exterior Lighting	-	AA	-	-	A	-		•	
Tennessee Town I	Safe-T Range Element	-	R	-	-	A	-		•	
Tennessee Town I	Bldg Envelope Upgrade	-	-	R	-	-	A		•	
Tennessee Town I										
Deer Creek Village	LF Kitchen Aerators	AA	-	R	C	-	A		•	•
Deer Creek Village	LF Bathroom Aerators	AA	-	R	C	-	A		•	•
Deer Creek Village	LF Showerheads	AA	-	R	C	-	A		•	•
Deer Creek Village	Common Area Lighting	-	AA	-	-	A	-		•	
Deer Creek Village	In Unit Lighting	-	R	-	-	A	-		•	
Deer Creek Village	Exterior Lighting	-	AA	-	-	A	-		•	
Deer Creek Village	Energy Star Refrigerators	-	AA	-	-	A	-		•	
Deer Creek Village	Bldg Envelope Upgrade	-	-	R	-	-	A		•	
Deer Creek Village	Attic Insulation	-	-	R	-	-	A		•	
Deer Creek Village	Aquatherm	-	-	R	-	-	A		•	
Deer Creek Village										
Western Plaza	LF Kitchen Aerators	AA	-	R	C	-	A		•	•
Western Plaza	LF Bathroom Aerators	AA	-	R	C	-	A		•	•

Western Plaza	LF Showerheads	AA	-	R	C	-	A	•		•
Western Plaza	In Unit Lighting	-	R	-	-	A	-	•		
Western Plaza	Bldg Envelope Upgrade	-	-	R	-	-	A	•		
Western Plaza	Attic Insulation	-	-	R	-	-	A	•		
Western Plaza										
Tyler Towers	LF Kitchen Aerators	AA	-	AA	C	-	C			•
Tyler Towers	LF Bathroom Aerators	AA	-	AA	C	-	C			•
Tyler Towers	LF Showerheads	AA	-	AA	C	-	C			•
Tyler Towers	Common Area Lighting	-	AA	-	-	A	-		•	
Tyler Towers	In Unit Lighting	-	AA	-	-	A	-		•	
Tyler Towers	Exterior Lighting	-	AA	-	-	A	-		•	
Tyler Towers	Heat Lamp Timers	-	AA	-	-	A	-		•	
Tyler Towers	Heating/Cooling Plant Controls	-	AA	AA	-	A	C		•	•
Tyler Towers	Fan Coil Motors & Controls	-	AA	-	-	A	-		•	
Tyler Towers	Exhaust Fan Motor Upgrade	-	AA	-	-	A	-		•	
Tyler Towers	DHW Pump Upgrade	-	AA	-	-	A	-		•	
Tyler Towers										
Jackson Towers	LF Kitchen Aerators	AA	-	AA	C	-	C			•
Jackson Towers	LF Bathroom Aerators	AA	-	AA	C	-	C			•
Jackson Towers	LF Showerheads	AA	-	AA	C	-	C			•
Jackson Towers	Common Area Lighting	-	AA	-	-	A	-		•	
Jackson Towers	In Unit Lighting	-	AA	-	-	A	-		•	
Jackson Towers	Exterior Lighting	-	AA	-	-	A	-		•	
Jackson Towers	Chiller	-	AA	-	-	A	-		•	
Jackson Towers	Space Heating Plant	-	-	AA	-	-	C			•
Jackson Towers										
Tennessee Town II	LF Kitchen Aerators	AA	-	R	C	-	A	•		•
Tennessee Town II	LF Bathroom Aerators	AA	-	R	C	-	A	•		•
Tennessee Town II	LF Showerheads	AA	-	R	C	-	A	•		•
Tennessee Town II	In Unit Lighting	-	R	-	-	A	-	•		

Tennessee Town II	Safe-T Range Element	-	R	-	-	A	-	•		
Tennessee Town II										
Echo Ridge	LF Kitchen Aerators	AA	R	-	C	A	-	•		•
Echo Ridge	LF Bathroom Aerators	AA	R	-	C	A	-	•		•
Echo Ridge	LF Showerheads	AA	R	-	C	A	-	•		•
Echo Ridge	Safe-T Range Element	-	R	-	-	A	-	•		
Echo Ridge										

10 REPORT FORMAT

The M&V agent will generate an annual M&V report consisting of the following:

- All normalized savings calculations and results, presented by project number and utility type.
- A summary of M&V site verification activities. This will include an issues log that documents all deficiencies, as well as particular and process remediation recommendations.
- A summary of other diagnostic M&V activities, associated deficiencies, and recommended remediation.
- A corrective action plan that covers all recommended remediation steps.
- The report must be reviewed and approved by HUD

APPENDIX B: BASELINE CONSUMPTION AND COST

Please refer to the HUD approved Baseline data in the EPC Phase I submission for baseline consumption and cost

NOTE: Baseline data will be provided to the selected M&V agent/company/firm. If base line data is required to accurately and competitively submit a response to THA's Request for Proposal (RFP) for M&V services, please request such data in accordance with the RFP instructions regarding questions.