ENTERGY SOLUTIONS

AN ENTERGY ARKANSAS PROGRAM

Measurement & Verification Report

Heat Pump Retrofit on Emergency Generator

Option A – Retrofit Isolation: Key Parameter Measurement

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PREPARED FOR ENTERGY SOLUTIONS LARGE COMMERCIAL & INDUSTRIAL PROGRAM

Date: 08/16/2019

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Executive Summary

This measurement and verification (M&V) report presents the method for calculating the energy savings from heat pump retrofit on an emergency generator in Little Rock, AR. This report was developed following the guidelines of the International Performance Measurement and Verification Protocol (IPMVP) Option A – Key Parameter Measurement. Using this option, savings were determined by performing field measurements of the existing conditions and taking post-measurements after the project was implemented.

The purpose of this document is to quantify the savings and incentive reported under the ENTERGY SOLUTIONS Large Commercial & Industrial Program. The incentive is to be paid to the customer based on energy saved by this project.

SAVINGS & INCENTIVE

The savings associated with this project are 5.6338 peak kW and 87,371.7449 annual kWh. Under special approval, the incentive amount for this project is equal to the cost of implementing the project at $25,235.

The facility obtains electricity at $0.07/kWh therefore this project is expected to save $5,941.28 the first year after implementation.

ESTIMATED USEFUL LIFE

The Estimated Useful Life (EUL) for this project is 16.0 years based on the measure heat pump replacement measure from the AR TRM V8.0.

PROJECT DESCRIPTION & PURPOSE

The customer has (2) back up diesel electricity generators to support their operations in times of grid power outages. These generators had strip electric heaters that helped maintain the engine block at optimum temperatures for quick start up. The energy conservation measure (ECM) being implemented at this facility was to retrofit the electric heaters with heat pumps specifically designed to work on emergency generators.

The existing equipment affected was:

(2) Kohler 2250RE0ZDC 2,250 kW stationary diesel generators with 12 kW heaters

The new equipment was:

(2) DH-24 2-ton heat pumps

This ECM saved energy by more efficiently producing heat necessary to maintain engine block temperature on the diesel engine generators. Therefore, the key variables that affected the realization of energy savings included energy consumed by the electric heaters/heat pumps and ambient temperature.

Measurement & Verification Procedure

This M&V report was created following the approved M&V Plan. Please refer to this plan for details on Measurement Boundary, Baseline Period, Reporting Period, and Analysis Procedure.

DEVIATIONS FROM M&V PLAN & PROTOCOLS

The following adjustments, assumptions & estimated values/Savings Calculations were applied to the M&V Plan.

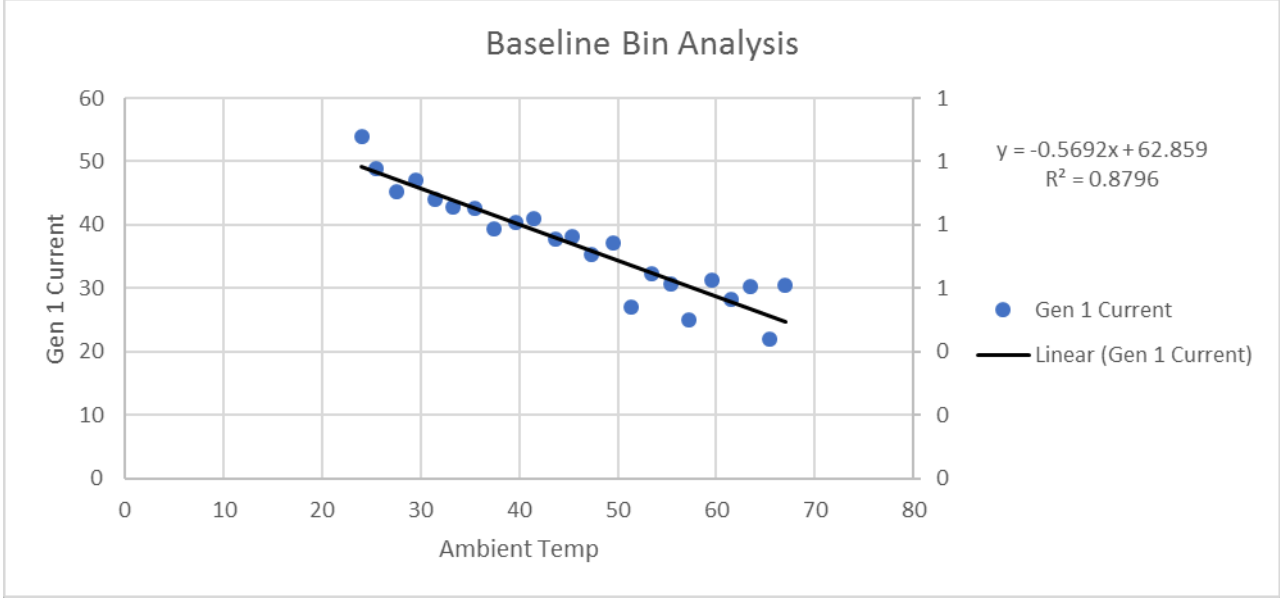
1) Ambient temperature data in the baseline and post-retrofit was obtained from NOAA database for Little Rock location instead of logging at 1 min interval.
2) It was observed from post-retrofit data that engine needs heating up to 95°F ambient temperature. Hence, the assumption that the electric heater was off above 80°F ambient temperature was changed to 95°F.
3) Ambient temperature data range available in the baseline logging period spans only between 20-70°F. The bin analysis created for this data was extrapolated for the entire annual range of temperature data.
4) Ambient temperature data range available in the post-retrofit logging period spans only between 65-95°F. The bin analysis created for this data was extrapolated for the entire annual range of temperature data.

SAVINGS CALCULATIONS

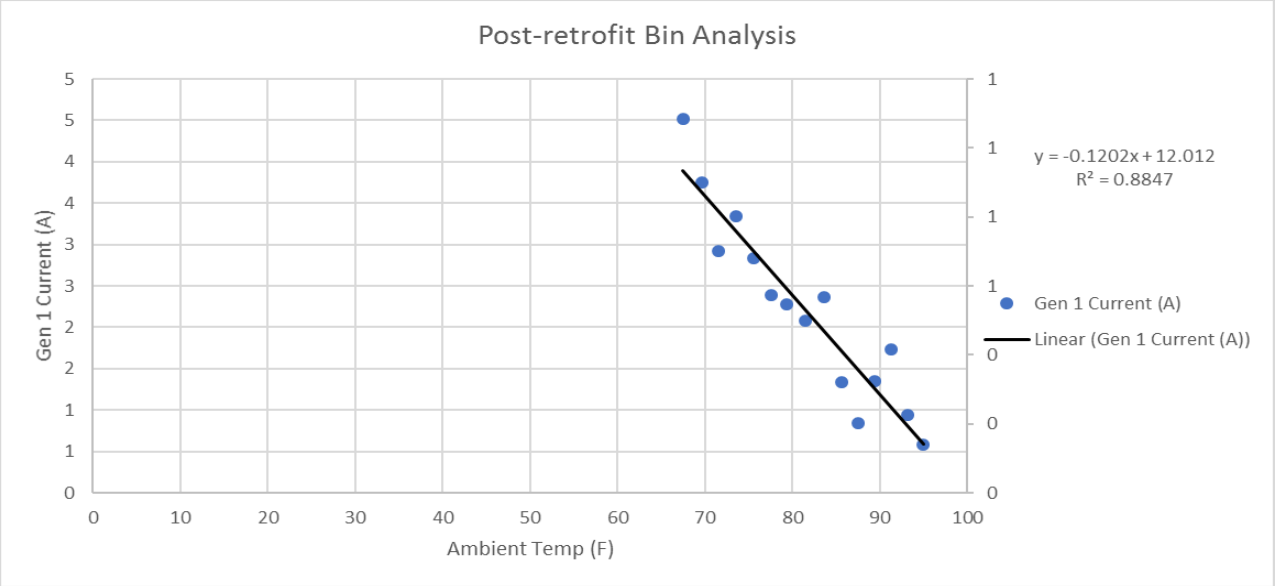
The following calculations were used to determine the peak demand kW and annual energy kWh savings associated with this project.

1) Bin analysis for relation between current & ambient air temperature

Logged Current & NOAA ambient air temperature data in the baseline period was used to build a bin analysis. This analysis was used to create a correlation using a linear regression analysis. The following chart shows the linear regression.



Similarly, logged current and NOAA ambient air temperature data was used to build a bin analysis and a linear regression correlation in the post-retrofit case.



2) Baseline & post-retrofit hourly energy consumption

TMY3 hourly ambient air temperature data for Little Rock was used to normalize baseline & post-retrofit hourly current drawn by the equipment. This hourly modeled current data was converted to kW using the following equations.

Baseline: P = I * V/1000

Post Retrofit: P = I * V * P.F./1000

Where,

P = power drawn by the equipment in (kW)

V = spot measured voltage in baseline/ post retrofit condition (V)

I = hourly modeled current (I)

P.F. = power factor measured in post retrofit

The table below shows a sample of the modeled kW for some hours.

Day	Hour	OAT (F)	post kW for 2 generators	Baseline kW for 2 generators
1/1/1982	1.00	41	2.6007	16.702
1/1/1982	2.00	40	2.6448	16.9425
1/1/1982	3.00	36	2.8213	17.9047
1/1/1982	4.00	35	2.8654	18.1453
1/1/1982	5.00	32	2.9978	18.8669
1/1/1982	6.00	31	3.0419	19.1074
1/1/1982	7.00	30	3.0861	19.348
1/1/1982	8.00	30	3.0861	19.348
1/1/1982	9.00	33	2.9537	18.6264
1/1/1982	10.00	36	2.8213	17.9047
1/1/1982	11.00	39	2.6889	17.1831
1/1/1982	12.00	40	2.6448	16.9425
1/1/1982	13.00	41	2.6007	16.702
1/1/1982	14.00	43	2.5124	16.2209
1/1/1982	15.00	43	2.5124	16.2209
1/1/1982	16.00	42	2.5565	16.4615
1/1/1982	17.00	40	2.6448	16.9425
1/1/1982	18.00	37	2.7772	17.6642
1/1/1982	19.00	35	2.8654	18.1453
1/1/1982	20.00	36	2.8213	17.9047
1/1/1982	21.00	37	2.7772	17.6642
1/1/1982	22.00	36	2.8213	17.9047
1/1/1982	23.00	36	2.8213	17.9047
1/1/1982	24.00	33	2.9537	18.6264
1/2/1982	1.00	33	2.9537	18.6264
1/2/1982	2.00	34	2.9096	18.3858
1/2/1982	3.00	34	2.9096	18.3858
1/2/1982	4.00	34	2.9096	18.3858
1/2/1982	5.00	34	2.9096	18.3858
1/2/1982	6.00	34	2.9096	18.3858

3) Annual Energy Savings

Energy Savings (kWh) = [$\sum$Modeled Hourly Load(kW)$_{baseline}$ - $\sum$Modeled Hourly Load(kW)$_{post\text{-}retrofit}$] *2

Energy Savings (kWh) = [51,045.2 -7,359.3] *2

Energy Savings (kWh) = 87,371.7449

Note that energy savings were calculated by multiplying energy savings from (1) generator by 2 since both generators were identical.

4) Demand Savings

Peak demand savings were calculated by averaging demand between 1pm to 8pm, Monday to Friday during summer peak months (June to Sept).

Demand Savings = [Peak Demand in Baseline – Peak Demand in post retrofit] *2

Demand Savings = [3.1660 – 0.3491] *2

Demand Savings = 5.6338

Note that demand savings were calculated by multiplying demand savings from (1) generator by 2 since both the generators were identical.

QUALITY ASSURANCE

The following chart contains a history of this document.

Measurement & Verification Document Log

Item	Issue Date	Author/Reviewer	Notes
1	08/08/2019	Kaustubh Gosavi	Draft
2	08/12/2019	Raul Guaracha	First review
3	08/15/2019	Kaustubh Gosavi	Changes made per reviewer
4	08/16/2019	Raul Guaracha	Final review
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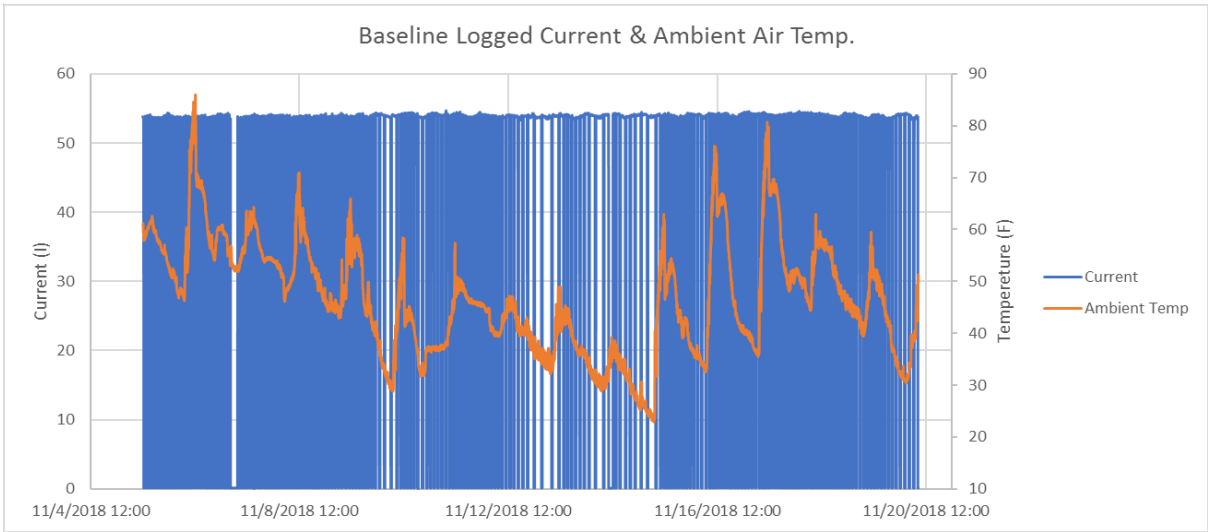
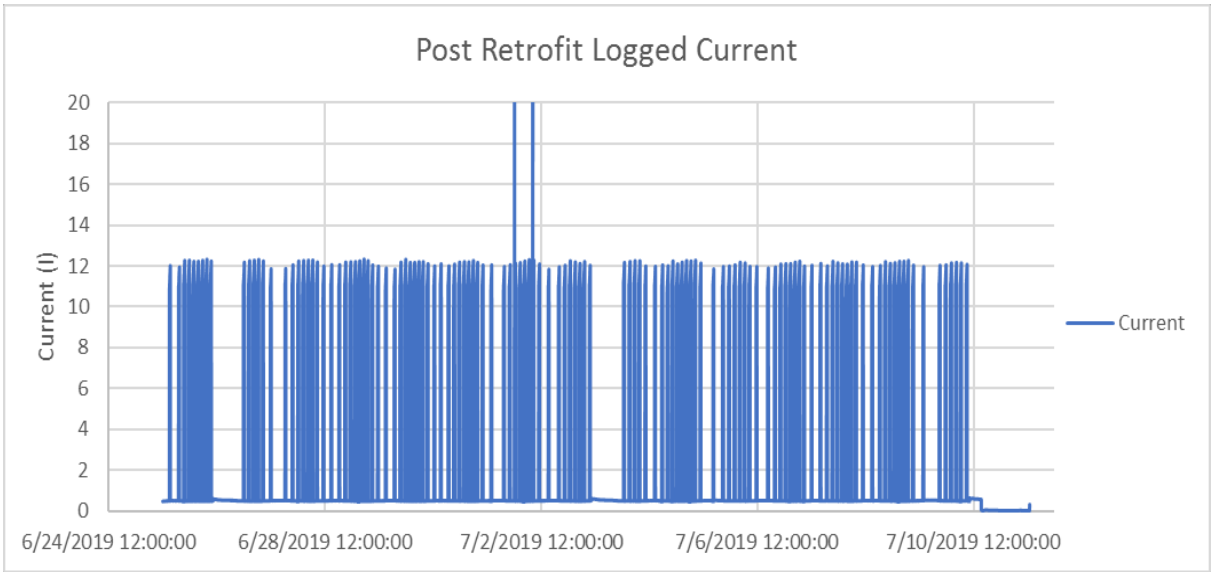
Appendix A. Measured Data and Bin Analysis





Spot Measurements		
	Voltage (v)	P.F.
Baseline	211.3	N/A
Post Retrofit	211	0.87

Bin Start	Bin End	Ambient Temp	Gen 1 Current
22	24	24	54
24	26	26	49
26	28	28	45
28	30	30	47
30	32	31	44
32	34	33	43
34	36	36	43
36	38	37	39
38	40	40	40
40	42	41	41
42	44	44	38
44	46	45	38
46	48	47	35
48	50	50	37
50	52	51	27
52	54	53	32
54	56	55	31
56	58	57	25
58	60	60	31
60	62	61	28
62	64	64	30
64	66	65	22
66	68	67	30

Baseline bin analysis data

Bin Start	Bin End	Ambient Temp (F)	Gen 1 Current (A)
64	66	no data	no data
66	68	68	5
68	70	70	4
70	72	72	3
72	74	74	3
74	76	76	3
76	78	78	2
78	80	79	2
80	82	82	2
82	84	84	2
84	86	86	1
86	88	88	1
88	90	89	1
90	92	91	2
92	94	93	1
94	96	95	1

Post-retrofit bin analysis data

Appendix B. Meter Specifications

Current and temperature logging

Overview

The HOBO UX120-006M Analog Data Logger is a high-performance, LCD display data logger for building performance monitoring applications.

As Onset's highest-accuracy data logger, it provides twice the accuracy of previous models, a deployment-friendly LCD, and flexible support up to four external sensors for measuring temperature, current, CO2, voltage, and more.

The data logger is ideal for energy audits, building commissioning studies, equipment scheduling, and more.

Highlighted Features

- Twice the accuracy over previous models with 16-bit resolution
- Flexible support for a wide range of external sensors
- LCD confirms logger operation and displays near real-time measurement data
- Provides minimum, maximum, average and standard deviation logging options
- On-screen alarms notify you when a sensor reading exceeds set thresholds
- Stores 1.9 million measurements for longer deployments between offloads
- Compatible with HOBOware and HOBOware Pro software for logger setup, graphing and analysis

In what environment does this data logger operate?

This data logger operates in an indoor environment.

What measurements does this data logger support?

The UX120-006M data logger supports the following measurements: 4-20mA, AC Current, AC Voltage, Air Velocity, Carbon Dioxide, Compressed Air Flow, DC Current, DC Voltage, Differential Pressure, Gauge Pressure, Kilowatts (kW), Temperature and Volatile Organic Comp.

Voltage & P.F. Spot Measurement:

FEATURE	ACD-10 PLUS	ACD-10 TRMS-PLUS
True-rms	-	•
AC Voltage	4.000 V, 40.00 V, 400.0 V, 600 V	
DC Voltage	400.0 mV, 4.000 V, 40.00 V, 400.0 V, 600 V	
AC Current	40.00 A, 400.0 A, 600 A	
Resistance	400.0 µΩ, 4.000 Ω, 40.00 Ω, 400.0 Ω, 4.000 MΩ, 40.00 MΩ	
Capacitance	500.0 nF, 5.000 F, 50.00 CF, 500.0 µF, 3000 µF	
Frequency	40 Hz → 400 Hz with Jaw, 10 Hz → 100 kHz with test leads	
Temperature	-	-
Dual displays	-	-
Micro Amps	-	-
Accommodates conductors	up to 1.0" (25 mm) in diameter	

Specifications	
Display:	3-3/4 digits 4000 counts LCD display
Update rate:	3 per second nominal
Polarity:	Automatic
Operating temperature:	°C to 40 °C; < 80% RH for temperature up to 31 °C decreasing linearly to 50% RH at 40 °C
Altitude:	Operating below 2000m; Indoor use
Storage temperature:	-20 °C to 60 °C, < 80% RH (with battery removed)
Temperature coefficient:	nominal 0.15 x (specified accuracy)/°C @(0 °C ~ 18 °C or 28 °C ~ 40 °C)
Low battery:	Below approx. 2.4V
Power supply:	3V coin battery IEC-CR2032
Power consumption:	2.8 mA typical except that 3.3 mA typical for ACA function
APO timing:	Idle for 30 minutes
APO consumption:	5 µA typical
Jaw opening & conductor diameter:	max 26 mm
Special features:	30ms Max Hold; Data Hold; Relative Zero mode