Generator Heat Pump

Measurement and Verification report

Report Date: 2/17/2020

Produced by:

ECM Holding Group, LLC.
2559 Badger Avenue
Oshkosh, WI 54904
920-267-6111

ENERGY CONSERVATION MEASURES

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Generator Types Included

Generator	KW	Heat Pump Type
CAT	1500 KW	indoor heat pump
Cummins 1	1100 KW	inside generator enclosure heatpump
Cummins 2	750 KW	outside generator enclosure heat pump

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920 267 6111

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Project Summary

The generators selected were chosen due to the size and predicted usage. This was the perfect scenario to showcase the 3 possible options for Generator Heat Pumps. One of the generators (CAT) was an interior generator and had the heat pump install inside as well. Another (Cummins 1) was an outside generator and had the heat pump installed outside of the generator enclosure using a NEMA-4 fabricated enclosure. The final Generator (Cummins 2) was an outside generator and the heat pump was installed inside the generator enclosure due to the large amount of space inside the enclosure. M&V was performed pre and post heat pump install on each generator and is analyzed in this report.

Proposed Savings Estimation

Existing				Estimated
Engine make/model	Generator engine kW (nameplate)	Total block heater kW	Est. Energy consumption kWh/yr	Energy Savings kWh/yr
Cat 3512	1500	6	42,048	36,836
Cummins	750	4	28,032	24,557
Cummins	1100	4.9	34,339	29,127

Project Measurement and Verification

Measurement and verification was performed for 2 weeks in June and 2 weeks in July before the heat pump install. 6 months of post install data was recorded and used to determine the annual usage on the heat pumps and the block heaters. Savings is derived from the pre annualized usage data minus the post annualized usage data.

Data logged (PRE):

- Block Heater Amperage
- Coolant Temperature
- Ambient Temperature

Data logged (POST):

- Block Heater Amperage
- Coolant Temperature
- Ambient Temperature
- Heat Pump Amperage

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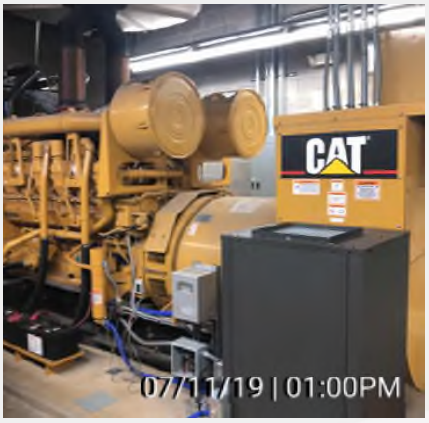
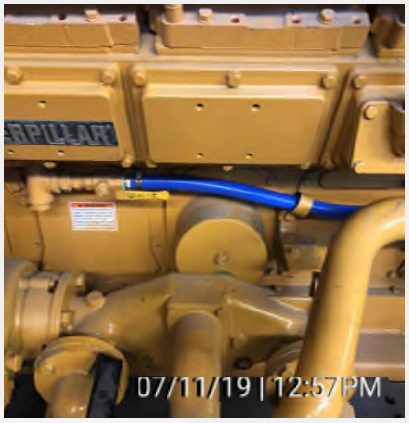




2 Week Data Analysis (2 weeks pre, 2 weeks post)

	Average Engine Temp	Average Ambient Temp	KWH Used	Runtime (hrs)
Block Heaters (Pre)	98.37	75.85	1,503.61	156.26
Block Heaters (Post)	96.29	79.68	-	-
Heat Pump	96.29	79.68	266.35	33.43
Reduction (Pre - Post)			1,237.26	122.83

The 2 weeks of Pre data was analyzed against 2 weeks of Post data during a similar time of year to determine a preliminary savings analysis.

Annualized Data (annualized from 2 week analysis)

	Average Engine Temp	Average Ambient Temp	KWH Used Per Year	Annual Runtime (hrs)
Block Heaters (Pre)	98.37	75.85	43,940.76	4,566.42
Block Heaters (Post)	96.29	79.68	-	-
Heat Pump	96.29	79.68	6,456.67	810.27
Reduction (Pre - Post)			37,484.09	3,756.16

The 2 week data was then used in conjuction with the runtime to project out to 1 year of data.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Pre Block Heater kWh	7,536.32	6,361.83	3,987.47	2,508.62	2,135.44	494.54	442.45	1,794.36	1,972.43	2,990.60	4,454.97	6,748.94	**41,427.95**
Pre Average Coolant Temp	95.70	94.08	94.08	94.08	94.08	98.00	98.87	94.08	94.08	94.08	94.08	94.08	
Pre Average Ambient Temp	71.21	63.69	68.72	74.15	76.76	74.34	77.50	76.76	74.15	68.72	63.69	71.29	
Post Block Heater kWh	0.60	2.80	2.80	2.80	2.80	2.80	2.25	3.13	2.42	6.58	2.16	2.46	**33.59**
Post Average Coolant Temp	95.70	94.08	94.08	94.08	94.08	94.08	96.84	96.06	96.32	83.00	95.23	95.42	
Post Average Ambient Temp	71.21	63.69	68.72	74.15	76.76	81.04	81.04	76.76	74.15	68.72	63.69	71.29	
Post Heat Pump kWh	172.07	735.23	852.18	270.57	270.57	315.98	315.98	310.00	310.00	270.57	852.18	735.23	**5,410.56**
Morgantown WV Weather data average	30.00	33.00	40.50	51.50	60.50	69.50	73.00	72.00	65.50	54.00	43.50	33.50	
Savings	**7,363.65**	**5,623.79**	**3,132.49**	**2,235.25**	**1,862.07**	**175.76**	**124.22**	**1,481.23**	**1,660.01**	**2,713.45**	**3,600.63**	**6,011.25**	**35,983.80**

Percent Savings **86.86%**

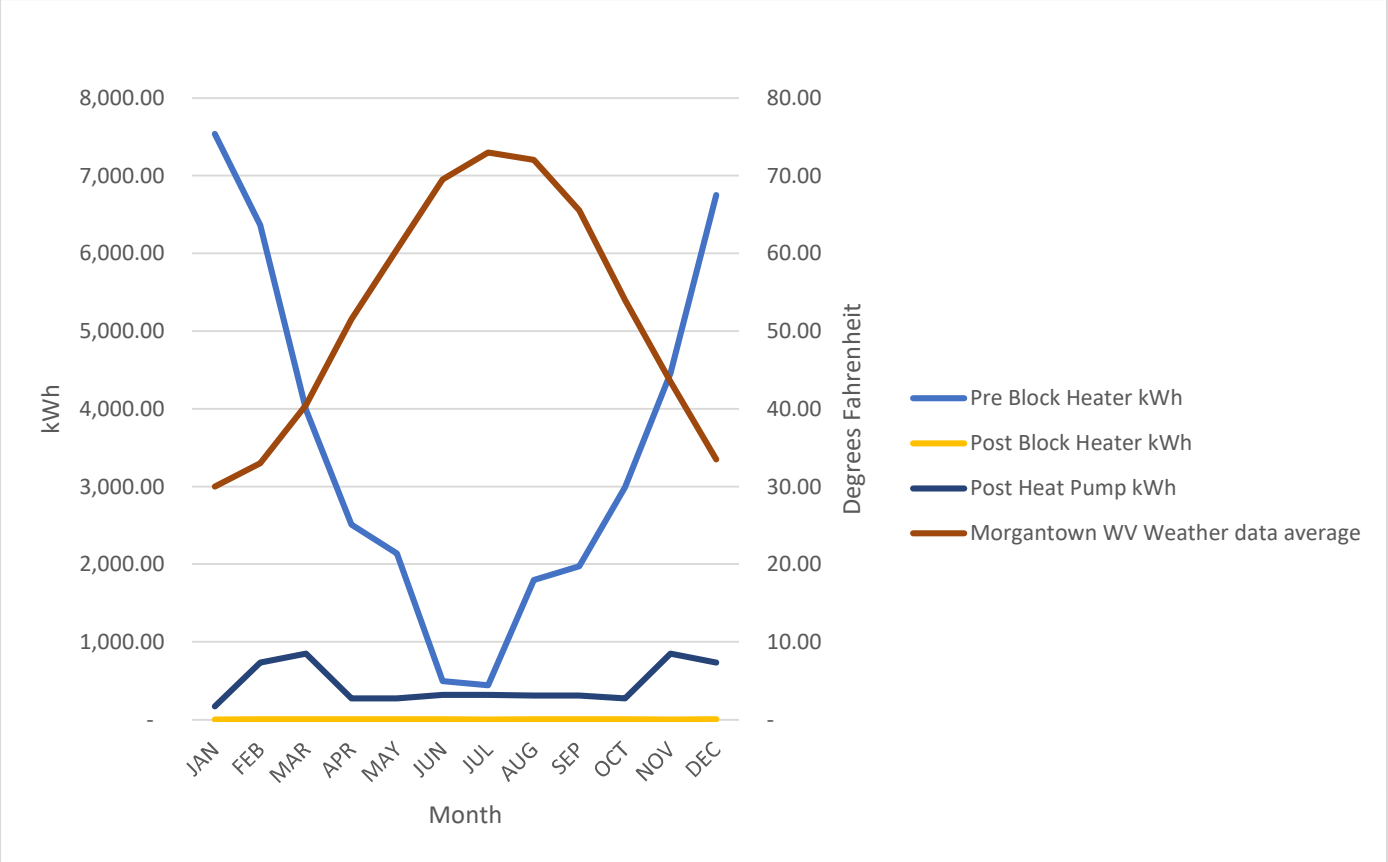
The full pre and post data was added up analyzed with some assumptions to determine final savings achieved.

The block heater kWh post is very low. This is due to the fact that this unit is indoors and has supplemental ambient heat.

Assumed values
Averaged values
*Assumed values *This data was manually entered due to logger malfunction. Based on other logged and averaged data for this unit.

ENERGY CONSERVATION MEASURES

CAT



The graph above shows the weather data curve that was used to normalize some of the block heater data.

The block heater pre-data can be seen projected as the inverse of the weather data curve, but is a slightly steeper curve. It is clear that the block heaters run heavily in everything but the summer months, with the winter months being the highest usage.

The post block heater kWh used is seen as mostly null here. The reason for this is due to the fact that the generator is indoors and thus has some supplemental heat and the ambient temperature never falls low enough for the block heaters to engage.

The heat pump usage is a double peaked line due to the highest usages being in the spring and fall. In the summer, the heat pump usage is low due to warmer temperatures outside. And in the winter the usage is low due to the block heaters taking some of the burden due to very low outside air temps falling below the heat pump minimum operating temperature.

The high peak on the heat pump in the fall is a higher usage than is actually the case.

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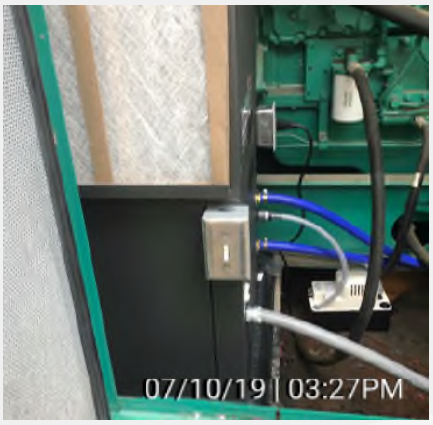

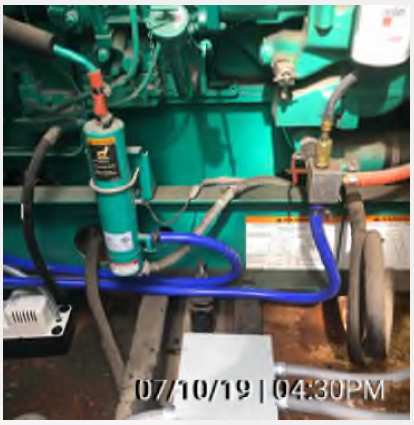

2 Week Data Analysis (2 weeks pre, 2 weeks post)

	Average Engine Temp	Average Ambient Temp	KWH Used	Runtime (hrs)
Block Heaters (Pre)	95.26	79.57	467.30	58.88
Block Heaters (Post)	97.99	78.42	-	-
Heat Pump	99.77	80.19	86.42	37.39
Reduction (Pre - Post)			380.88	21.49

The 2 weeks of Pre data was analyzed against 2 weeks of Post data during a similar time of year to determine a preliminary savings analysis.

Annualized Data (annualized from 2 week analysis)

	Average Engine Temp	Average Ambient Temp	KWH Used Per Year	Annual Runtime (hrs)
Block Heaters (Pre)	95.26	79.57	13,656.05	1,720.78
Block Heaters (Post)	97.99	78.42	-	-
Heat Pump	97.99	78.42	2,002.28	866.35
Reduction (Pre - Post)			11,653.77	854.43

The 2 week data was then used in conjuction with the runtime to project out to 1 year of data.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Pre Block Heater kWh	6,123.51	5,169.20	3,239.95	2,038.34	1,735.11	423.81	359.50	1,457.98	1,602.66	2,429.96	3,619.81	5,483.74	**33,683.58**
Pre Average Coolant Temp	140.21	111.31	111.31	111.31	111.31	91.21	93.60	111.31	111.31	111.31	111.31	111.31	
Pre Average Ambient Temp	42.82	34.74	42.63	54.21	63.68	75.06	79.76	76.01	73.69	62.33	43.82	40.74	
Post Block Heater kWh	420.26	504.15	450.13	450.13	360.11	193.28	360.11	2.84	2.98	15.22	1,415.82	1,729.23	**5,904.25**
Post Average Coolant Temp	140.21	111.31	111.31	111.31	111.31	95.72	97.06	97.97	98.06	96.72	127.27	137.46	
Post Average Ambient Temp	42.82	34.74	42.63	54.21	63.68	73.16	76.84	76.01	73.69	62.33	43.82	40.74	
Post Heat Pump kWh	2.44	80.06	332.01	807.27	807.27	196.85	196.85	499.73	464.09	807.27	332.01	80.06	**4,605.91**
Morgantown WV Weather data average	30.00	33.00	40.50	51.50	60.50	69.50	73.00	72.00	65.50	54.00	43.50	33.50	
Savings	**5,700.81**	**4,584.99**	**2,457.81**	**780.94**	**567.74**	**33.68**	**(197.46)**	**955.41**	**1,135.60**	**1,607.48**	**1,871.98**	**3,674.45**	**23,173.41**
											Percent Savings		**68.80%**

The full pre and post data was added up analyzed with some assumptions to determine final savings achieved.

The savings in the month of July were negative due to the fact that the installation of the heat pump was not fully completed as of the beginning of the month and thus the block heater kWh data logged was higher than it actually should be in the following July.

Assumed values
Averaged values

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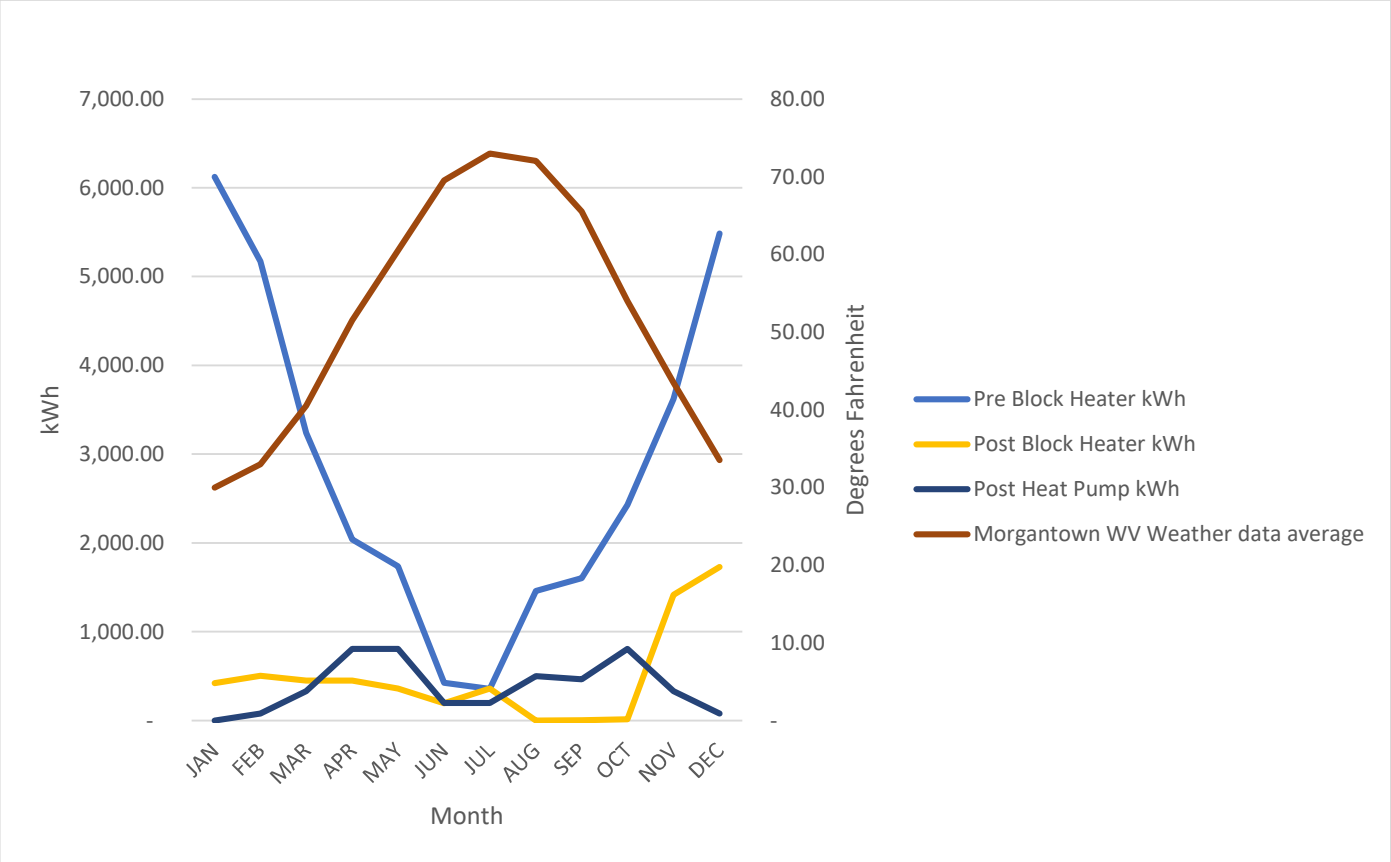
CUMMINS 1



The graph above shows the weather data curve that was used to normalize some of the block heater data.

The block heater pre-data can be seen projected as the inverse of the weather data curve, but is a slightly steeper curve. It is clear that the block heaters run heavily in everything but the summer months, with the winter months being the highest usage.

The post block heater kWh used is seen as a mostly low usage line here. The usage increases in the winter months due to the temperature sometimes dipping below the minimum threshhold of the Heat Pump operating range.

The heat pump usage is a double peaked line due to the highest usages being in the spring and fall. In the summer, the heat pump usage is low due to warmer temperatures outside. And in the winter the usage is low due to the block heaters taking some of the burden due to very low outside air temps falling below the heat pump minimum operating temperature.

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2 Week Data Analysis (2 weeks pre, 2 weeks post)

	Average Engine Temp	Average Ambient Temp	KWH Used	Runtime (hrs)
Block Heaters (Pre)	105.33	82.14	662.56	62.71
Block Heaters (Post)	99.77	80.19	61.48	14.46
Heat Pump	99.77	80.19	164.52	73.23
Reduction (Pre - Post)			436.56	(24.98)

The 2 weeks of Pre data was analyzed against 2 weeks of Post data during a similar time of year to determine a preliminary savings analysis.

Annualized Data (annualized from 2 week analysis)

	Average Engine Temp	Average Ambient Temp	KWH Used Per Year	Annual Runtime (hrs)
Block Heaters (Pre)	105.33	82.14	32,127.32	3,040.68
Block Heaters (Post)	99.77	80.19	1,490.54	350.52
Heat Pump	99.77	80.19	3,988.00	1,775.19
Reduction (Pre - Post)			26,648.78	914.97

The 2 week data was then used in conjuction with the runtime to project out to 1 year of data.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Pre Block Heater kWh	6,849.23	5,781.82	3,623.93	2,279.91	1,940.75	423.06	402.11	1,630.77	1,792.60	2,717.95	4,048.81	6,133.64	**37,624.56**
Pre Average Coolant Temp	97.06	98.37	98.37	98.37	98.37	105.11	105.91	98.37	98.37	98.37	98.37	98.37	
Pre Average Ambient Temp	44.83	35.45	43.50	55.32	64.98	77.10	81.70	77.34	75.87	63.86	45.79	43.03	
Post Block Heater kWh	130.69	353.25	309.10	264.94	220.78	176.63	176.63	353.25	556.19	615.73	759.38	782.62	**4,699.19**
Post Average Coolant Temp	97.06	98.37	98.37	98.37	98.37	98.37	98.37	99.87	100.59	99.91	97.14	95.67	
Post Average Ambient Temp	44.83	35.45	43.50	55.32	64.98	74.65	78.41	77.34	75.87	63.86	45.79	43.03	
Post Heat Pump kWh	62.23	378.88	881.74	723.73	723.73	188.88	188.88	1,131.71	909.33	723.73	881.74	378.88	**7,173.46**
Morgantown WV Weather data average Temp	30.00	33.00	40.50	51.50	60.50	69.50	73.00	72.00	65.50	54.00	43.50	33.50	
Savings	**6,656.31**	**5,049.68**	**2,433.09**	**1,291.24**	**996.24**	**57.55**	**36.60**	**145.81**	**327.08**	**1,378.49**	**2,407.68**	**4,972.14**	**25,751.92**
											Percent Savings		**68.44%**

The full pre and post data was added up analyzed with some assumptions to determine final savings achieved.

The savings on this one were right in line with the projected savings. However, the heat pump usage in the month of January was low due to the data logging during that time period being only a portion of the month. Actual usage would be higher.

Assumed values
Averaged values

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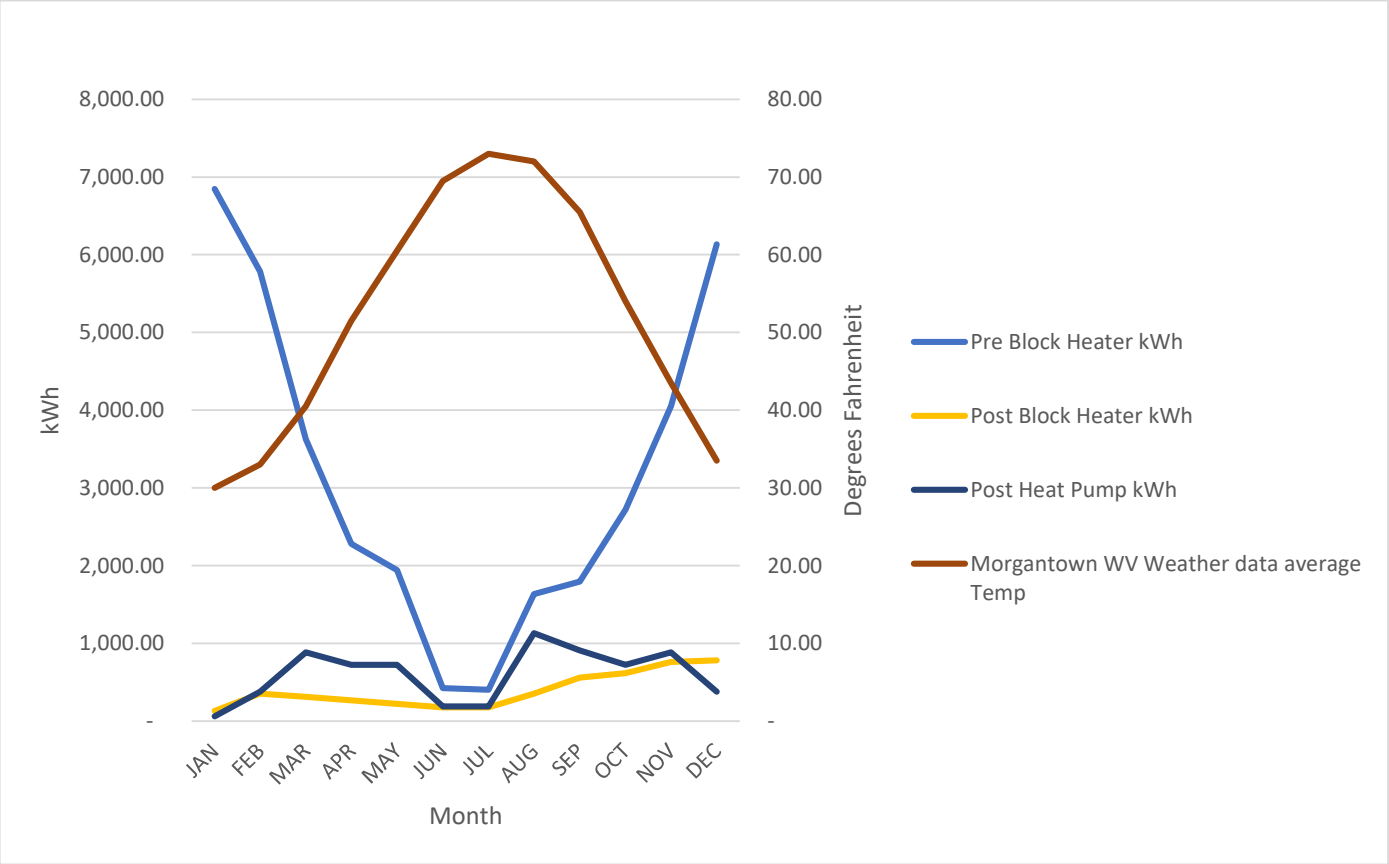
CUMMINS 2



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Total Savings Table

	Estimated		Measurement and Verification					
	Baseline Usage kWh	Quoted Savings kWh	Pre Block Heater kWh	Post Block Heater kWh	Post Heat Pump kWh	kWh Saved		$ Saved
CAT	42,048.00	36,835.80	41,427.95	33.59	5,394.65	35,999.71	$	2,339.98
Cummins 1	34,339.00	26,014.80	33,683.58	5,904.25	4,605.91	23,173.41	$	1,506.27
Cummins 2	28,032.00	21,939.00	37,624.56	4,699.19	7,173.46	25,751.92	$	1,673.87
Total	**104,419.00**	**84,789.60**	**112,736.09**	**10,637.03**	**17,174.02**	**84,925.04**	**$**	**5,520.13**

The projected savings are determined to have been exceeded. The original savings projections were 81,468.05 kWh. The original savings dollars were $5,110.

The analysis was done on a monthly basis using real data and some projections determined using the real data. Some of the projected data was normalized using annual weather data averages that were derived from actual climate data sourced from usclimatedata.com. Their data is actual normals from 1981 to 2010.