NYSERDA P-12 Schools: Green and Clean Energy Solutions

Cortland Enlarged City School District

Submitted to:
NYSERDA

Submitted from:
M/E Engineering, P.C.
60 Lakefront Boulevard, Suite 320
Buffalo, NY 14202

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M/E Reference 211078

BUFFALO · ROCHESTER · SYRACUSE · CAPITAL DISTRICT
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EXECUTIVE SUMMARY

This Energy Plan is intended to investigate and evaluate Energy Conservation Measures for Cortland Enlarged School District Buildings, including the Junior Senior High School, Randall Middle School, Barry Primary School, Smith Intermediate School and District Office / Bus Garage. M/E Engineering, P.C. performed a site inspection on October 21, 2021. For the purposes of this study, existing HVAC, lighting, electrical, domestic hot water and envelope systems were surveyed. The walk-through entailed observing existing systems and their operations, including obtaining equipment nameplate data, reviewing drawings, discussing concerns of the building owner, and verifying operational schedules. Several Energy Conservation Measures have been evaluated, and are summarized below.

Table 1: JR/SR High School - Energy Efficiency Measure Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings (mmBtu)	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
1	Lighting and Lighting Controls	12,938	3.78	$981	-382	-$182	5.92	$799	$48,137	60.3
2	Envelope Improvements	11,875	2.92	$901	5,166	$2,464	557.13	$3,365	$3,636,521	1080.8
3	Occupied / Unoccupied Controls	8,799	1.12	$667	0	$0	30.03	$667	$90,000	134.9
4a	Install High Efficiency Boiler	0	0.00	$0	22,500	$10,732	2250.00	$10,732	$495,150	46.1
4b	Install Ground Source Heat Pump (GSHP)	-685,849	121.43	-$52,014	90,000	$42,928	6659.20	-$9,086	$4,085,000	-449.6
5	Solar Thermal Heat Recovery Opportunities	0	0.00	$0	651	$311	65.14	$311	$53,716	172.9
6	Outdoor Air Energy Recovery Opportunities	400	-0.72	$30	9	$4	2.27	$35	$14,407	416.1
7	Kitchen Hood Controls	5,550	0.33	$421	1,658	$791	184.71	$1,212	$14,070	11.6
9	Solar PV	2,057,442	1,725.00	$156,034	0	$0	7022.05	$156,034	$4,140,000	26.5

Table 2: Randall Middle School - Energy Efficiency Measure Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings (mmBtu)	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	11,274	0.91	$972	2,260	$1,285	264.47	$2,258	$1,172,471	519.4
7	Kitchen Hood Controls	2,405	0.16	$207	658	$374	73.97	$581	$13,504	23.2
9	Solar PV	268,909	225.00	$23,194	0	$0	917.79	$23,194	$540,000	23.3

Table 3: Barry Primary School - Energy Efficiency Measure Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings (mmBtu)	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	11,433	1.44	$969	3,233	$1,675	362.33	$2,643	$1,807,535	683.8
3	Occupied / Unoccupied Controls	8,799	1.12	$745	0	$0	30.03	$745	$50,000	67.1
4a	Install High Efficiency Steam Boiler	0	0.00	$0	5,357	$2,775	535.68	$2,775	$138,975	50.1
4b	Convert to High Efficiency Hot Water Boilers & Distribution	0	0.00	$0	10,714	$5,550	1071.36	$5,550	$1,995,150	359.5
4c	Install Central Ground Source Heat Pump (GSHP) System	-230,249	4.53	-$19,508	32,141	$16,650	2428.24	-$2,858	$3,690,000	-1291.0
4d	Install Terminal Ground Source Heat Pump (GSHP) System	-230,249	4.53	-$19,508	32,141	$16,650	2428.24	-$2,858	$3,250,000	-1137.1
5	Solar Thermal Heat Recovery Opportunities	0	0.00	$0	300	$155	29.96	$155	$24,792	159.7
7	Kitchen Hood Controls	2,878	0.16	$244	877	$454	97.50	$698	$13,504	19.3
8	Steam Trap Replacement	0	0.00	$0	4,999	$2,590	499.93	$2,590	$2,800	1.1
9	Solar PV	262,398	220.00	$22,232	0	$0	895.56	$22,232	$528,000	23.7

Table 4: Smith Intermediate School - Energy Efficiency Measure Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings (mmBtu)	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	0	1.27	$0	2,926	$1,511	292.60	$1,511	$1,604,315	1061.7
3	Occupied / Unoccupied Controls	8,799	1.12	$766	0	$0	30.03	$766	$50,000	65.3
4a	Install High Efficiency Boiler	0	0.00	$0	5,356	$2,766	535.55	$2,766	$138,975	50.2
4b	Convert to Condensing Hot Water Boilers & Distribution	0	0.00	$0	10,711	$5,531	1071.10	$5,531	$1,995,150	360.7
4c	Install Central Ground Source Heat Pump (GSHP) System	-231,509	2.59	-$20,148	32,141	$16,598	2423.94	-$3,550	$3,690,000	-1039.4
4d	Install Terminal Ground Source Heat Pump (GSHP) System	-231,413	4.53	-$20,140	32,141	$16,598	2424.27	-$3,542	$3,250,000	-917.6
5	Solar Thermal Heat Recovery Opportunities	0	0.00	$0	300	$155	29.96	$155	$24,792	160.2
7	Kitchen Hood Controls	2,878	0.16	$251	877	$453	97.50	$703	$13,504	19.2
8	Steam Trap Replacement	0	0.00	$0	4,999	$2,582	499.93	$2,582	$2,800	1.1
9	Solar PV	215,126	180.00	$18,723	0	$0	734.23	$18,723	$432,000	23.1

Table 5: District Offices/Bus Garage - Energy Efficiency Measure Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings (mmBtu)	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	1,754	0.52	$157	1,684	$1,210	174.35	$1,367	$621,662	454.8
4a	Air Source Heat Pump (VRF)	-53,919	0.71	-$4,821	673	$483	-116.77	-$4,338	$121,400	-28.0
4b	Install Ground Source Heat Pump (GSHP) System	-92,559	-391.68	-$8,276	12,053	$8,663	889.38	$387	$472,050	1219.7
9	Solar PV	208,727	175.00	$18,664	0	$0	712.39	$18,664	$420,000	22.5

Several of the energy efficiency measures evaluated for this project would improve the comfort and energy usage of the buildings. Kitchen hood controls and steam trap replacement are recommend since the payback for these measures is typically less than 20 years and will improve the energy efficient of the building. Heating and cooling plant upgrades are viable options, with the geothermal portion supporting NYS electrification and de-carbonization goals. We would encourage the implementation of Photovoltaic power generation to help offset the increased electrical demand, however the land availability may reduce the potential for production.

The majority of these measures show a long payback. This is due to a variety of reasons, the foremost being that full replacement (in lieu of incremental) and measure specific infrastructure upgrades have been included in the cost analysis. If we were to consider or compare to a code compliant replacement, and consider only incremental cost, the paybacks would be much lower. In addition, the operating hours are relatively limited due to the building type of K-12 schools. Additionally, the GSHP measures include the addition of cooling to areas that may have not been cooled previously, which includes a cost premium and an energy penalty. If cooling is desired, it would make the GSHP measures more viable. Lastly, the cost of natural gas vs electric per unit of energy is relatively low. For example, the district has a cost of $5.17/kbtu of natural gas and $23.25/kbtu electric. Leveraging incentive programs will offset the first cost and ultimately reduce the payback of the project measures as well.

NYSERDA PROJECT SUMMARY SHEET

PROJECT SUMMARY SHEET
FOR: CORTLAND ENLARGED CITY SCHOOL DISTRICT

NEW YORK STATE OF OPPORTUNITY | NYSERDA

BASELINE ENERGY SUMMARY - JR/SR HIGH SCHOOL

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	Total Baseline Use (MMBtu)
Baseline Energy Use	2,074,344	101,815	0	0	0	0	0	0	0	17,259.2
										Total Annual Cost ($)
Average Utility Rate	$0.08	$0.48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Baseline Annual Cost	$157,316	$48,564	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$205,880

ENERGY SAVINGS SUMMARY - JR/SR HIGH SCHOOL

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric: Supply Savings (kWh)	Electric: Demand Savings (kW)	Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
EEM-1 Lighting and Lighting Controls	NR	NGas	12,938	4	5.9	0.3%	$799	0.4%	$48,137	60.3
EEM-2 Envelope Improvements	NR	NGas	11,875	3	557.1	3.5%	$3,365	1.6%	$3,636,521	1080.8
EEM-3 Occupied / Unoccupied Controls	NR	NGas	8,799	1	30.0	0.3%	$667	0.3%	$90,000	134.9
EEM-4a Install High Efficiency Boiler	NR	NGas	0	0	2,250.0	13.0%	$10,732	5.2%	$495,150	46.1
EEM-4b Install Ground Source Heat Pump (GSHP)	NR	NGas	-685,849	121	6,659.2	25.0%	-$9,086	-4.4%	$4,085,000	-449.6
EEM-5 Solar Thermal Heat Recovery Opportunities	NR	NGas	0	0	65.1	0.4%	$311	0.2%	$53,716	172.9
EEM-6 Outdoor Air Energy Recovery Opportunities	NR	NGas	400	-1	2.3	0.0%	$35	0.0%	$14,407	416.1
EEM-7 Kitchen Hood Controls	R	NGas	5,550	0	184.7	1.2%	$1,212	0.6%	$14,070	11.6
EEM-9 Solar PV	R	NGas	2,057,442	1,725	7,022.0	81.4%	$156,034	75.8%	$4,140,000	26.5
		TOTAL (All):	1,411,154	1,854	16,776	125.1%	$164,068	79.7%	$12,577,001	76.7
		TOTAL (Recommended Only):	**2,062,992**	**1,725**	**7,207**	**82.5%**	**$157,246**	**76.4%**	**$4,154,070**	**26.4**

Measure Status [1]

I	Implemented
R	Recommended
RS	Further Study Recommended
NR	Not Recommended
RME	Recommeded Mutually Exclusive
ME	Mutually Exclusive to Recommended Option
RNE	Recommended Non-Energy

Fuel Saved

Elec	Electric
NGas	Natural Gas
Oil2	#2 Oil
Oil4	#4 Oil
Oil6	#6 Oil
Steam	District Steam
LPG	Propane
Coal	Coal
Other	Other

MMBtu Conversion Facto

Btu	1,000,000
kWh	0.003412
therms	0.1
#2 gallon	0.139
#4 gallon	0.1467
#6 gallon	0.15
Steam lbs.	0.0012
LPG gallon	0.0915
Coal tons	24

Notes:
[2] Fuel Savings Type: Indicate the reported MMBtu savings fuel type. Select the predominant fuel type if there are MMBtu savings frommultiple fuel sources
[3] EnergySavings to Total Fuel Baseline Use is a comparison of the total electric & fuel savings to the total baseline energy use
[4] CostSavings to Total Annual Cost is a comparison of the total annual cost savings to the total baseline annual energy cost

Instructions:
* Fill in the light blue cells, as appropriate. White cells will auto-calculate.
* Energy savings must be presented as savings at the customer's utilitymeter(s), not at the individual building or tenant space
* Update the baseline energyuse conversion factors in the 'References' tab, as necessary
* Unhide rows to enter more measures, as necessary

PROJECT SUMMARY SHEET
FOR: CORTLAND ENLARGED CITY SCHOOL DISTRICT

NEW YORK STATE OF OPPORTUNITY | NYSERDA

BASELINE ENERGY SUMMARY - RANDALL MIDDLE SCHOOL

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	Total Baseline Use (MMBtu)
Baseline Energy Use	271,436	28,494	0	0	0	0	0	0	0	3,775.5
										Total Annual Cost ($)
Average Utility Rate	$0.09	$0.57	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Baseline Annual Cost	$23,412	$16,204	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$39,616

ENERGY SAVINGS SUMMARY - RANDALL MIDDLE SCHOOL

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric: Supply Savings (kWh)	Electric: Demand Savings (kW)	Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
EEM-2 Envelope Improvements	NR	NGas	11,274	1	264.5	8.0%	$2,258	5.7%	$1,172,471	519.4
EEM-7 Kitchen Hood Controls	R	NGas	2,405	0.2	74.0	2.2%	$581	1.5%	$13,504	23.2
EEM-9 Solar PV	R	NGas	268,909	225.0	917.8	48.6%	$23,194	58.5%	$540,000	23.3
		TOTAL (All):	206,796	226	1,256	52.0%	$26,033	65.7%	$1,725,975	66.3
		TOTAL (Recommended Only):	**271,314**	**225**	**992**	**50.8%**	**$23,775**	**60.0%**	**$553,504**	**23.3**

PROJECT SUMMARY SHEET

FOR: CORTLAND ENLARGED CITY SCHOOL DISTRICT

BASELINE ENERGY SUMMARY - BARRY PRIMARY SCHOOL

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	Total Baseline Use (MMBtu)
Baseline Energy Use	268,170	48,841	0	0	0	0	0	0	0	5,799.1
										Total Annual Cost ($)
Average Utility Rate	$0.08	$0.52	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Baseline Annual Cost	$22,721	$25,301	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$48,022

ENERGY SAVINGS SUMMARY - BARRY PRIMARY SCHOOL

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric Supply Savings (kWh)	Electric Demand Savings (kW)	Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
EEM-2 Envelope Improvements	NR	NGas	11,432.8	1.4	362.3	6.9%	$2,643	5.5%	$1,807,535	683.8
EEM-3 Occupied / Unoccupied Controls	NR	NGas	8,798.5	1.1	30.0	1.0%	$745	1.6%	$50,000	67.1
EEM-4a Install High Efficiency Steam Boiler	NR	NGas	0.0	0.0	535.7	9.2%	$2,775	5.8%	$138,975	50.1
EEM-4b Convert to High Efficiency Hot Water Boilers & Distribution	NR	NGas	0.0	0.0	1,071.4	18.5%	$5,550	11.6%	$1,995,150	359.5
EEM-4c Install Central Ground Source Heat Pump (GSHP)	NR	NGas	-230,248.9	4.5	2,428.2	28.3%	-$2,858	-6.0%	$3,690,000	-1291.0
EEM-4d Install Terminal Ground Source Heat Pump (GSHP)	NR	NGas	-230,248.9	4.5	2,428.2	28.3%	-$2,858	-6.0%	$3,250,000	-1137.1
EEM-5 Solar Thermal Heat Recovery Opportunities	NR	NGas	0.0	0.0	30.0	0.5%	$155	0.3%	$24,792	159.7
EEM-7 Kitchen Hood Controls	R	NGas	2,878.4	0.2	97.5	1.9%	$698	1.5%	$13,504	19.3
EEM-8 Steam Trap Replacement	R	NGas	0.0	0.0	499.9	8.6%	$2,590	5.4%	$2,800	1.1
EEM-9 Solar PV	R	NGas	262,398.0	220.0	895.6	30.9%	$22,232	46.3%	$528,000	23.7
		TOTAL (All):	-174,990	232	8,379	134.2%	$31,672	66.0%	$11,500,756	363.1
		TOTAL (Recommended Only):	**265,276**	**220**	**1,493**	**41.4%**	**$25,520**	**53.1%**	**$544,304**	**21.3**

PROJECT SUMMARY SHEET

FOR: CORTLAND ENLARGED CITY SCHOOL DISTRICT

BASELINE ENERGY SUMMARY - SMITH INTERMEDIATE SCHOOL

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	Total Baseline Use (MMBtu)
Baseline Energy Use	225,599	50,056	0	0	0	0	0	0	0	5,775.3
										Total Annual Cost ($)
Average Utility Rate	$0.09	$0.52	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Baseline Annual Cost	$19,634	$25,850	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$45,484

ENERGY SAVINGS SUMMARY - SMITH INTERMEDIATE SCHOOL

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric Supply Savings (kWh)	Electric Demand Savings (kW)	Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
EEM-2 Envelope Improvements	NR	NGas	0.0	1.3	292.6	5.1%	$1,511	3.3%	$1,604,315	1061.7
EEM-3 Occupied / Unoccupied Controls	NR	NGas	8,798.5	1.1	30.0	1.0%	$766	1.7%	$50,000	65.3
EEM-4a Install High Efficiency Steam Boiler	NR	NGas	0.0	0.0	535.6	9.3%	$2,766	6.1%	$138,975	50.2
EEM-4b Convert to High Efficiency Hot Water Boilers & Distribution	NR	NGas	0.0	0.0	1,071.1	18.5%	$5,531	12.2%	$1,995,150	360.7
EEM-4c Install Central Ground Source Heat Pump (GSHP)	NR	NGas	-231,509.2	2.6	2,423.9	28.3%	-$3,550	-7.8%	$3,690,000	-1039.4
EEM-4d Install Terminal Ground Source Heat Pump (GSHP)	NR	NGas	-231,412.9	4.5	2,424.3	28.3%	-$3,542	-7.8%	$3,250,000	-917.6
EEM-5 Solar Thermal Heat Recovery Opportunities	NR	NGas	0.0	0.0	30.0	0.5%	$155	0.3%	$24,792	160.2
EEM-7 Kitchen Hood Controls	R	NGas	2,878.4	0.2	97.5	1.9%	$703	1.5%	$13,504	19.2
EEM-8 Steam Trap Replacement	R	NGas	0.0	0.0	499.9	8.7%	$2,582	5.7%	$2,800	1.1
EEM-9 Solar PV	R	NGas	215,126.0	180.0	734.2	25.4%	$18,723	41.2%	$432,000	23.1
		TOTAL (All):	-236,119	190	8,139	127.0%	$25,644	56.4%	$11,201,536	436.8
		TOTAL (Recommended Only):	**218,004**	**180**	**1,332**	**35.9%**	**$22,008**	**48.4%**	**$448,304**	**20.4**

PROJECT SUMMARY SHEET
FOR: CORTLAND ENLARGED CITY SCHOOL DISTRICT

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BASELINE ENERGY SUMMARY - DISTRICT OFFICES / BUS GARAGE

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	Total Baseline Use (MMBtu)
Baseline Energy Use	211,847	12,393	0	0	0	0	0	0	0	**1,962.1**
										Total Annual Cost ($)
Average Utility Rate	$0.09	$0.72	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Baseline Annual Cost	$18,943	$8,908	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**$27,851**

ENERGY SAVINGS SUMMARY - DISTRICT OFFICES / BUS GARAGE

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric		Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
			Supply Savings (kWh)	Demand Savings (kW)						
EEM-2 Envelope Improvements	NR	NGas	1,754	1	174.3	9.2%	$1,367	4.9%	$621,662	454.8
EEM-4a Air Source Heat Pump (VRF)	NR	NGas	-53,919	1	-116.8	-15.3%	-$4,338	-15.6%	$121,400	-28.0
EEM-4b Install Ground Source Heat Pump (GSHP)	NR	NGas	-92,559	-392	889.4	29.2%	$387	1.4%	$472,050	1219.7
EEM-9 Solar PV	R	NGas	208,727	175	712.4	72.6%	$18,664	67.0%	$420,000	22.5
		TOTAL (All):	64,004	-215	1,659	95.7%	$16,080	57.7%	$1,635,112	101.7
TOTAL (Recommended Only):			**208,727**	**175**	**712**	**72.6%**	**$18,664**	**67.0%**	**$420,000**	**22.5**

PROJECT OVERVIEW

The overall goal of this work plan is to complete a comprehensive analysis of the Cortland School District's buildings to identify options for energy improvements including upgrading / replacing the building HVAC systems, and to quantify the energy and cost impact of implementing the measures. This study is intended to focus on eligible areas of study under the NYSERDA P-12 Schools: Green and Clean Energy Solutions program, NYSERDA PON 4157, which consists of the investigation of opportunities to reduce energy and achieve carbon savings via load reduction and load shifting, and conversion to carbon free fuel. The study includes energy conservation measure analysis and strategic carbon footprint reduction planning, the integration of renewable generation, and the feasibility of incorporating clean heating and cooling technologies. An additional objective is for the district to make use of the study as a roadmap to aid in identifying and planning for potential future capital projects, including potential clean energy projects. These services will include calculating the annual energy savings associated with various energy conservation measures, determining an estimated first cost, simple payback, estimated maintenance impact, and basic feasibility associated with each measure.

CONTACT SHEET

Buildings

Junior Senior High School
8 Valley View Drive
Cortland, New York

Randall Middle School
31 Randall Street
Cortland, New York

Barry Primary School
20 Raymond Ave
Cortland, New York

Smith Intermediate School
33 Wheeler Avenue
Cortland, New York

District Office/Bus Garage
1 Valley View Drive
Cortland, New York

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EXISTING CONDITIONS

Jr/Sr High School

The Jr/Sr High School is a three-story structure of approximately 208,000 gross square feet. There are two above-grade floors and a basement. The original building was built in 1964, and there have been various additions and renovations to the building over time with the latest 2017 capital improvement project including a renovation of the auditorium completed in 2020. The building contains one auditorium, two gymnasiums, offices, classrooms, cafeteria, kitchen, and support spaces (electrical/mechanical, storage, corridor, restroom, etc.).

The building construction is generally masonry with limited insulation, a brick façade, and EPDM roofing. The building has operable windows with a combination of single and double paned glazing panels and aluminum frames. Most windows have been replaced, but not all. No thermal scans have been done to investigate for envelope problem areas. Typical operating hours are Monday-Friday 7AM-4PM with staff arriving early, reduced occupancy and hours of operation in the summer months (summer school), and extended hours for evening and weekend events.

The lighting is a combination of fluorescent and LED with vacancy and occupancy controls in the majority of the building and manual switches in other areas (approximately 20% left to convert - cafeteria, stairwells, library, as well as the outdoor field lighting). The LED lighting is controlled by Enlighted Controls. The electrical service has been replaced under the last project.

The HVAC systems generally consist of air handling units with hot water heat, chilled water cooling, and hot water reheat (1998 vintage). There are some unit ventilators, unit heaters, convectors, and perimeter radiation. Split A/C units serve select areas such as computer labs offices and interior classrooms. Heat is provided via hot water natural gas boilers (12,247 kbtu Cleaver Brooks boiler, 1998 vintage). Chilled water provided by a Trane water cooled chiller (2017 vintage) paired with an Evapco cooling tower on the roof. Variable speed drives have been installed on most equipment. Domestic hot water is provided by a series of instantaneous natural gas Rinnai heaters installed under the last EPC. Storage for domestic hot water is 1986 vintage. Plumbing fixtures have a combination of manual and automatic/metered trim and flush valves. Booster pumps are used to boost city pressure. The dust collector is in need of replacement. A direct digital control building management system is present in the building with Niagara Framework, however there are still some pneumatic controls left in the building. The building utilizes day/night/weekend/holiday scheduling for thermostats. The age of the systems in the building varies as many capital improvement and energy performance contract projects were performed over a number of years.

Randall Middle School

The Randall Middle School is a three-story structure (basement, first floor, second floor) of approximately 52,500 gross square feet. The original building was built in 1926, and there have been various additions and renovations to the building over time with the latest capital improvement projects occurring in 2014. The building contains a cafeteria, a gymnasium, offices, classrooms, cafeteria, kitchen, and support spaces (electrical/mechanical, storage, corridor, restroom, etc.).

The building construction is generally masonry with limited insulation, a brick façade, and EPDM roofing. The building has operable windows with a combination of single and double paned glazing panels and aluminum frames. Some glazing is original to the building and some has been replaced. Exterior doors are in need of replacement. Typical operating hours are Monday-Friday 8AM-5PM with staff arriving early, reduced occupancy and hours of operation in the summer months, and extended hours for evening and weekend events.

The majority of lighting is LED with occupancy controls (wireless). There are some non-LED fixtures and some manual switching but the percentage is low. Exterior lighting is LED.

The HVAC systems generally consist of classroom unit ventilators with perimeter radiation, with an air handling units for the gymnasium, and Daikin split systems for computer labs and offices. Heat is provided via two Camus 3,000 kbtu hot water natural gas condensing boilers. The majority of the building is heated and ventilated only. The original system was steam and was replaced with hot water heat under a recent project. Domestic hot water is provided via a natural gas fired water heater with storage. Plumbing fixtures are a combination of manual and automatic (battery) / metered trim and flush valves. A number of toilets are elementary style which need to be replaced with standard size/height. A direct digital control building management system is present in the building. The age of the systems in the building varies widely as a number of capital improvement and energy performance contract projects were performed over a number of years.

Barry Primary School

The Barry Primary School (sister school to Smith Intermediate) is a one-story structure of approximately 65,800 gross square feet. The original building was built in 1957, and there have been various additions and renovations to the building over time with the latest capital improvement projects occurring in 2019. The building contains a café/auditorium, gymnasium, offices, classrooms, kitchen, and support spaces (electrical/mechanical, storage, corridor, restroom, etc.).

The building construction is generally masonry with limited insulation, a brick façade, some louvered-style paneling over unfaced concrete, and EPDM roofing. The building has operable windows with a combination of single and double paned glazing panels and aluminum frames. Exterior doors are in need of replacement. Typical operating hours are Monday-Friday 8AM-5PM with staff arriving early, reduced occupancy and hours of operation in the summer months, and extended hours for evening and weekend events.

The lighting is a combination of fluorescent and LED with occupancy controls and some manual switches. Exterior lighting is LED.

The HVAC systems generally consist of classroom unit ventilators that utilize transfer ducts to the corridor and gravity ventilators to exhaust air, with perimeter radiation in classrooms, and air handling units for select areas such as the café/auditorium, and gymnasium. These air handling units (3 in total) are 1957 vintage. Heat is provided via steam boilers that were replaced in 1992. The building is heated and ventilated only with the exception of select areas including a split A/C systems serving the offices and a computer lab. Domestic hot water is provided via a gas fired hot water heater, and plumbing fixtures are a combination of manual and automatic/metered trim and flush valves. A direct digital control building management system is present in the building. Pneumatics are also present, actively serving the AHU's some fintube, ad some cabinet unit heaters. This building also contains a "cluster" area which is a timber framed open concept learning space and is heated by hot water heat with a heat exchanger and duplex pump set off the building's steam system.

Smith Intermediate School

The Smith Intermediate School (sister school to Barry Primary School) is a one-story structure of approximately 56,400 gross square feet. The original building was built in 1957, and there have been various additions and renovations to the building over time with the latest capital improvement projects occurring in 2019. The building contains a café/auditorium, gymnasium, offices, classrooms, kitchen, and support spaces (electrical/mechanical, storage, corridor, restroom, etc.).

The building construction is generally masonry with limited insulation, a partial brick façade, some wood paneling and unfaced concrete, and EPDM roofing. The building has operable windows with a combination of single and double paned glazing panels and aluminum frames. Exterior doors are in need of replacement. Typical operating hours are Monday-Friday 8AM-5PM with staff arriving early, reduced occupancy and hours of operation in the summer months, and extended hours for evening and weekend events.

The lighting is a combination of fluorescent and LED with occupancy controls and some manual switches (hallway and exterior lighting are in need of replacement).

The HVAC systems generally consist of classroom unit ventilators that utilize transfer ducts to the corridor and gravity ventilators to exhaust air, with perimeter radiation in classrooms, and air handling units for select areas such as the café/auditorium, and gymnasium. These air handling units (3 in total) are 1957 vintage. Heat is provided via steam boilers original to the building. The building offices do not have air conditioning as this building's occupancy was intended for 10 months out of the year. With staff now expected for 12 months, air conditioning will be desired. The building is heated and ventilated only with the exception of select areas including a split A/C systems serving a computer lab. Domestic hot water is provided via a gas fired hot water heater, and plumbing fixtures are a combination of manual and automatic/metered trim and flush valves. A direct digital control building management system is present in the building. Pneumatics are also present, actively serving the AHU's some fintube, ad some cabinet unit heaters.

District Offices/Bus Garage

The District Offices and bus garage is a two-story structure of approximately 19,500 gross square feet. The original building was built in 1970. The building contains offices, bus garage, maintenance area, and support spaces (electrical/mechanical, storage, corridor, restroom, etc.).

The building construction is steel framed with metal paneled insulated walls and a metal roof with insulation below the deck between the roof's structural members. The heat loss of the roof is apparent with the formation of ice dams and significant icicles in the winter months. The building has operable casement windows on the first floor with aluminum frames. Typical operating hours are Monday-Friday 6AM-6PM with reduced occupancy and hours of operation in the summer months, and extended hours for evening and weekend events.

The lighting is a combination of fluorescent and LED with some occupancy controls in certain areas and manual switches in other areas.

The HVAC systems serving the office area consist of a multizone air handling unit with three zones and heat pump split A/C systems for heating and cooling of select areas. There is also some hot water fintube heat. A natural gas fired hot water boiler provides hot water heat as needed. The bus garage utilizes overhead gas fired infrared heat. The boiler is oversized due to the addition of the infrared system and therefore tends to operate on low and cycle often. The garage has local CO sensing. Busses are occasionally run in the garage and the doors are propped open for ventilation (no vehicle capture systems). There is no mechanical means of ventilation for the garage area. Domestic hot water is provided via a natural gas fired water heater. A direct digital control building management system is present in the building. A pressure booster system is used to boost the city water pressure. VSDs were installed on the existing pressure booster system. A bus wash storage system is on site in the garage.

UTILITY ANALYSIS

Utility Rates

Utilities to the district are being delivered via National Grid and National Gas for electric and natural gas respectively. The utility rates utilized for the calculations are indicated in the summary table below which is based on utility bills. Due to low 2020-2021 occupancy, November 2018 - October 2019 utility bills were utilized for generating average combined rates for electric and natural gas below.

Table 6: Utility Rate Summary

Nov 2018-October 2019	*Gas*			*Elec*			*Total*
Building	*Therm*	*Cost*	*$/therm*	*kwh*	*Cost*	*$/kwh*	*Cost*
JR/SR High School	101,815	$48,564	$ 0.4770	2,074,344	$157,316	$0.0758	$205,880
Randall Middle School	28,494	$16,204	$ 0.5687	271,436	$23,412	$0.0863	$39,616
Barry Primary School	48,841	$25,301	$ 0.5180	268,170	$22,721	$0.0847	$48,022
Smith Intermediate School	50,056	$25,850	$ 0.5164	225,599	$19,634	$0.0870	$45,484
District Offices/Bus Garage	12,393	$8,908	$ 0.7188	211,847	$18,943	$0.0894	$27,851
Total	**241,599**	**$124,827**	**$ 0.5167**	**3,051,396**	**$242,026**	**$0.0793**	**$366,853**

Benchmarking

The calculated existing Energy Utilization Index (EUI) for the existing buildings are listed below. The national median EUI, according to Energy Star Portfolio Manager, for similar type buildings is 48.5 kBtu/sf for a K-12 school and 40.1 kBtu/sf for Mixed Use.

Table 7: Benchmarking Summary

Nov 2018-October 2019	*Floor Space*	*Energy Consumption*	*EUI*
Building	*square feet*	*kbtu*	*kbtu/sf*
JR/SR High School	207,878	17,259,162	83.03
Randall Middle School	52,480	3,775,540	71.94
Barry Primary School	65,840	5,799,096	88.08
Smith Intermediate School	56,358	5,775,344	102.48
District Offices/Bus Garage	19,500	1,962,122	100.62
Total	**402,056**	**34,571,263**	**85.99**

APPROACH / METHODOLOGY

The analysis to estimate annual energy consumption and cost was performed using NYS Technical Resource Manual (TRM) v 8.0 spreadsheet analysis unless otherwise noted below. Typically NYS Technical Resource Manual (TRM) 8.0 calculations often are more than adequate to address HVAC system comparisons so this was the traditional first choice. Alternatively, BIN data spreadsheet analysis could have been used where TRM was not appropriate i.e. additional detail and exceptional calculations, or a simplified eQuest whole building zoned block modeling for interactive measures or complex systems (i.e. hybrid system type not addressed by the TRM), with assumptions for components not yet designed. The intent is to capture the incremental savings of the measures identified for study.

The following energy conservation measures were evaluated:

- EEM-1 Lighting and Lighting Controls - This measure includes the evaluation of replacing fixtures with LED lighting, and the addition of occupancy sensors.
- EEM-2 Envelope Improvements - This measure included glazing upgrades, insulated metal panel upgrades, and roof upgrades. This measure required an inventory of existing glazing and frame types, insulated metal panel insulation thicknesses, and roof types and insulation thicknesses, and the associated square footages associated with each of these envelope components.
- EEM-3 Occupied / Unoccupied Controls - This measure includes upgrading pneumatic controls to DDC, and implementing temperature setback (occupied and unoccupied). The buildings contain direct digital controls, however further investigation was performed and discussion with the District's control contractor to determine if all spaces are controlled by the digital control system and if occupied setbacks are in place.
- EEM-4 Heating and Cooling Plant Upgrades - This measure investigates possible upgrades to improve plant efficiency. Ground or air source heat pump measures support NYS electrification and de-carbonization goals and is intended to provide the infrastructure to meet these future goals.
- EEM-5 Solar Thermal Heat Recovery Opportunities - This measure explores the feasibility of using solar thermal panels to preheat outdoor air. The roofs are relatively unobstructed from the sun, with limited trees and adjacent structures tall enough to shade the roof. This provides potential space to roof mount solar thermal collectors. Alternatively, wall mount systems could also be an option.
- EEM-6 Outdoor Air Energy Recovery Opportunities - The addition of enthalpy (heating and cooling) or sensible only (heating only) energy recovery cores to precondition outdoor air. There are a number of units not utilizing this technology and could provide a potential significant energy savings.
- EEM-7 Kitchen Hood Controls - Heat sensors may be installed along with variable speed drives and interlocked fully modulating outdoor air dampers to allow for automatic operation of the hoods and variable airflow according to sensed temperature. This will reduce both fan power and the required outdoor air. The impact of this effect on the outdoor air volume of the cafeteria to ensure that the adjacent space continues to be adequately ventilated will be included in the study.
- EEM-8 Steam Trap Replacement - Study to repair or replace non-functional, leaking or blow-through traps. When steam passes through the traps, it reduces the heating effectiveness. This is a natural gas energy benefit. An inventory of the existing traps was gathered via existing drawings, discussions with facility staff, and onsite investigation.
- EEM-9 Solar PV - The intent of this measure is to provide a preliminary overview of the anticipated physical size and required peak demand of a solar array after the energy consumption is reduced through the implementation of the energy conservation measures listed above. A spreadsheet analysis and industry standard tools (i.e. PV Watts) was utilized for this evaluation.

For each measure analyzed, the following has been provided:

- Measure Description. Brief description of each system, system comparison, and feasibility overview (i.e. pros / cons, project impact, etc.).
- Detailed annual energy and cost analysis complete with anticipated savings.
- High level budgetary order of magnitude opinion of probable construction cost using a combination of RS Means, project experience, and other industry standard methods. This includes a breakdown for equipment, material, and labor.
- Simplified annual maintenance costs estimated using RS Means Facilities Maintenance And Repair Costs as a guide. These will include the identification of differences between the HVAC systems only and will not identify all maintenance associated with the building.
- Simple payback of each measure.
- Measure reporting in tabular format utilizing NYSERDA's project summary template.

ENERGY ANALYSIS

EEM-1: LIGHTING AND LIGHTING CONTROLS

This measure is intended to include the evaluation of replacing fixtures with LED lighting, and the addition of occupancy sensors. An inventory of the existing light fixtures was performed, complete with an inventory of controls, space usage, square footage of rooms, and hours of operation in all spaces. This measure was performed for the JR/SR high school only, because the rest of the buildings have already been converted to 100% LED with occupancy/vacancy controls.

EEM-1: JR/SR High School, Lighting And Lighting Controls

The JR/SR High School's lighting is a combination of fluorescent and LED with vacancy and occupancy controls in the majority of the building and manual switches in other areas. Approximately 20% remains to be converted to LED, including the cafeteria, stairwells, library, as well as the outdoor field lighting. Replacing all existing fluorescent lighting with LED lighting technology provides energy savings by reducing the required input energy to obtain the same lighting levels. Typically outdoor field lighting does not have the operating hours to justify replacement based on energy savings.

Baseline Assumptions:

- Cafeteria: 0.50 W/SF lighting power density (LPD).
- Library: 0.95 W/SF lighting power density (LPD).
- Stairwells: 0.30 W/SF lighting power density (LPD).

Proposed Assumptions:

- Cafeteria: This was assumed to be a 40% improvement over existing conditions which is typical of LED conversions. This resulted in an LPD of 0.30 W/sf, a 10% credit for Occupancy Sensors resulted in an LPD of 0.27 W/sf.
- Library: This was assumed to be a 40% improvement over existing conditions which is typical of LED conversions. This resulted in an LPD of 0.57 W/sf and a 10% credit was taken for Occupancy Sensors resulting in an LPD of 0.51 W/sf.
- Stairwells: This was assumed to be a 40% improvement over existing conditions which is typical of LED conversions. This resulted in an LPD of 0.18 W/sf and a 10% credit was taken for Occupancy Sensors resulting in an LPD of 0.16 W/sf.

Table 8: EEM-1 Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
1	Lighting and Lighting Controls	12,938	3.78	$981.18	-382	-$182.40	5.92	$798.78	$48,137.26	60.3

The payback associated with providing high efficient LED lighting is 60 years without incentives. This measure is not recommended to be implemented. National Grid offers lighting incentives for LED fixtures that are listed are ENERGY Star or DLC listed.

EEM-2: ENVELOPE IMPROVEMENTS

EEM-2 JR/SR High School, Envelope Improvements - Roof, Windows

This measure is intended to include glazing upgrades, insulated metal panel upgrades, and roof upgrades. A detailed inventory of existing glazing and frame types, insulated metal panel insulation thicknesses, and roof types and insulation thicknesses, and the associated square footages associated with each of these envelope components. This measure addresses the replacement of the existing roof with a total of 6" of insulation and the replacement of single pane windows to double pane windows.

Baseline Assumptions:
- Built-up roof, 3" insulation, R=5
- Roof square footage calculated from plans, 140,000 sf
- Single pane window area approximated from site visit, 2,000 sf

Proposed Assumptions:
- Roof: 6 inches total of rigid insulation, R=5/inch, R=30 total
- Double pane window high performance windows, savings of 550 kWh/100SF and 62.3 therms/100SF for a school conditioned with AC and fuel heat per TRM

Values modeled the same in both:
- Roof square footage calculated from plans
- Cooling Efficiency 11.2 EER, 14.5 IPLV
- Heating Efficiency 80% Efficiency

Table 9: EEM-2 Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	11,875	2.92	$900.59	5,166	$2,464.09	557.13	$3,364.69	$3,636,521.20	1080.8

EEM-2 is not recommended because of the long payback.

EEM-2 Randall Middle School, Envelope Improvements - Roof, Windows

This measure is intended to include glazing upgrades, insulated metal panel upgrades, and roof upgrades. A detailed inventory of existing glazing and frame types, insulated metal panel insulation thicknesses, and roof types and insulation thicknesses, and the associated square footages associated with each of these envelope components. This measure addresses the replacement of the existing roof with a total of 6" of insulation and the replacement of single pane windows to double pane windows.

Baseline Assumptions:

- Built-up roof, 3" insulation, R=5
- Roof square footage calculated from plans, 43,000 sf
- Single pane window area approximated from site visit, 2,000 sf

Proposed Assumptions:

- Roof: 6 inches total of rigid insulation, R=5/inch, R=30 total
- Double pane window high performance windows, savings of 550 kWh/100SF and 62.3 therms/100SF for a school conditioned with AC and fuel heat per TRM

Values modeled the same in both:

- Roof square footage calculated from plans
- Cooling Efficiency 11 EER, 14.2 IPLV
- Heating Efficiency 95% Efficiency

Table 10: EEM-2 Summary - Randall Middle School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	11,274	0.91	$972.38	2,260	$1,285.16	264.47	$2,257.54	$1,172,470.94	519.4

EEM-2 is not recommended because of the long payback.

EEM-2 Barry Primary School, Envelope Improvements - Roof, Windows

This measure is intended to include glazing upgrades, insulated metal panel upgrades, and roof upgrades. A detailed inventory of existing glazing and frame types, insulated metal panel insulation thicknesses, and roof types and insulation thicknesses, and the associated square footages associated with each of these envelope components. This measure addresses the replacement of the existing roof with a total of 6" of insulation and the replacement of single pane windows to double pane windows.

Baseline Assumptions:

- Built-up roof, 3" insulation, R=5
- Roof square footage calculated from plans, 68,000 sf
- Single pane window area approximated from site visit, 2,000 sf

Proposed Assumptions:

- Roof: 6 inches total of rigid insulation, R=5/inch, R=30 total
- Double pane window high performance windows, savings of 550 kWh/100SF and 62.3 therms/100SF for a school conditioned with AC and fuel heat per TRM

Values modeled the same in both:

- Roof square footage calculated from plans
- Cooling Efficiency 11 EER, 14.2 IPLV
- Heating Efficiency 80% Efficiency

Table 11: EEM-2 Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	11,433	1.44	$968.65	3,233	$1,674.82	362.33	$2,643.47	$1,807,535.44	683.8

EEM-2 is not recommended because of the long payback.

EEM-2 Smith Intermediate School, Envelope Improvements - Roof, Windows

This measure is intended to include glazing upgrades, insulated metal panel upgrades, and roof upgrades. A detailed inventory of existing glazing and frame types, insulated metal panel insulation thicknesses, and roof types and insulation thicknesses, and the associated square footages associated with each of these envelope components. This measure addresses the replacement of the existing roof with a total of 6" of insulation and the replacement of single pane windows to double pane windows.

Baseline Assumptions:

- Built-up roof, 3" insulation, R=5
- Roof square footage calculated from plans, 60,000 sf
- Single pane window area approximated from site visit, 2,000 sf

Proposed Assumptions:

- Roof: 6 inches total of rigid insulation, R=5/inch, R=30 total
- Double pane window high performance windows, savings of 550 kWh/100SF and 62.3 therms/100SF for a school conditioned with AC and fuel heat per TRM

Values modeled the same in both:

- Roof square footage calculated from plans
- Cooling Efficiency 11 EER, 14.2 IPLV
- Heating Efficiency 80% Efficiency

Table 12: EEM-2 Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	0	1.27	$0.00	2,926	$1,511.05	292.60	$1,511.05	$1,604,314.80	1061.7

EEM-2 is not recommended because of the long payback.

EEM-2 District Offices/Bus Garage, Envelope Improvements - Roof, Windows

This measure is intended to include glazing upgrades, insulated metal panel upgrades, and roof upgrades. A detailed inventory of existing glazing and frame types, insulated metal panel insulation thicknesses, and roof types and insulation thicknesses, and the associated square footages associated with each of these envelope components. This measure addresses the replacement of the existing roof with a total of 8" of insulation and the replacement of single pane windows to double pane windows.

Baseline Assumptions:

- Metal roofing, 6" batt with vinyl backing vapor barrier, R-20
- Roof square footage calculated from plans, 24,000 sf
- Single pane window area approximated from site visit, 200 sf

Proposed Assumptions:

- 8" batt R=27
- Double pane window high performance windows, savings of 550 kWh/100SF and 62.3 therms/100SF for a school conditioned with AC and fuel heat per TRM

Values modeled the same in both:

- Roof square footage calculated from plans
- Cooling Efficiency 11 EER, 14.2 IPLV
- Heating Efficiency 80% Efficiency

Table 13: EEM-2 Summary - District Offices/Bus Garage

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
2	Envelope Improvements	1,754	0.52	$156.86	1,684	$1,210.16	174.35	$1,367.02	$621,661.92	454.8

EEM-2 is not recommended because of the long payback.

EEM-3: PNUEMATIC TO DDC CONTROLS

EEM-3 JR/SR High School, Pneumatic To DDC

Facility personnel have indicated that temperature setback is in place. The building contains pneumatic controls that serve approximately a half dozen air handling units. This measure is intended to identify and capture the energy savings associated with replacing the remaining pneumatic controls with Direct Digital Controls.

Baseline Assumptions:
- Air compressor: 80% loaded, 1 hp motor, 1 ACFM / minute, 80% motor efficiency

Proposed Assumptions:
- Assuming 15 control points per AHU at $1K per point to upgrade to DDC

Table 14: EEM-3 Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
3	Pneumatic To DDC Controls	8,799	1.12	$667.27	0	$0.00	30.03	$667.27	$90,000.00	134.9

EEM-3 is not recommended because of the long payback.

EEM-3 Barry Primary School, Pneumatic To DDC

Facility personnel explain that temperature setback is in place. The building contains pneumatic controls that serve some air handling equipment, fin tube radiation and cabinet unit heaters. This measure is intended to identify and capture the energy savings associated with replacing the remaining pneumatic controls with Direct Digital Controls.

Baseline Assumptions:

- Air compressor: 80% loaded, 1 hp motor, 1 ACFM / minute, 80% motor efficiency

Proposed Assumptions:

- Assuming 50 control points at $1K per point to upgrade to DDC

Table 15: EEM-3 Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
3	Pneumatic To DDC Controls	8,799	1.12	$745.47	0	$0.00	30.03	$745.47	$50,000.00	67.1

EEM-3 is not recommended because of the long payback.

EEM-3 Smith Intermediate School, Pneumatic To DDC

Facility personnel explain that temperature setback is in place. The building contains pneumatic controls that serve some air handling equipment, fin tube radiation and cabinet unit heaters. This measure is intended to identify and capture the energy savings associated with replacing the remaining pneumatic controls with Direct Digital Controls.

Baseline Assumptions:

- Air compressor: 80% loaded, 1 hp motor, 1 ACFM / minute, 80% motor efficiency

Proposed Assumptions:

- Assuming 50 control points at $1K per point to upgrade to DDC

Table 16: EEM-3 Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
3	Pneumatic To DDC Controls	8,799	1.12	$765.74	0	$0.00	30.03	$765.74	$50,000.00	65.3

EEM-3 is not recommended because of the long payback.

EEM-4: HEATING AND COOLING PLANT UPGRADES

This measure is intended to investigate possible upgrades to improve efficiency. Ground or air source heat pump measures support NYS electrification and de-carbonization goals and is intended to provide the infrastructure to meet these future goals.

These buildings utilize natural gas boilers. Barry and Smith have steam boilers and distribution systems. The JR/SR High School, Randall Middle, and the Bus Garage/District Offices utilize hot water boilers. The thermal efficiency of the steam boilers are likely less than 80%. The condensing hot water boilers vary with the return water temperature and firing rate, so it is possible that the hot water boilers may be operating at less than 90% efficiency. This measure is intended to review the energy savings associated with implementing a higher efficiency heating plant such as ground source heat pump technology or air source heat pumps.

The district has indicated that additional cooling is not desired with the exception of Smith Intermediate School where a request for cooling the offices is likely. The JR/SR High School utilizes chilled water cooling, and all buildings contain stand-alone split A/C cooling systems. This measure is intended to explore the feasibility of combining the existing systems to heat-pump type systems where the energy may be shared and the systems operate more efficiently.

For a GSHP well field, the typical is for closed loops at 400 ft deep, 6 inch diameter, 20 ft on center, and 2-2.5tons/well. Open loops (draw out of one, inject into another) are a possibility if there are significant amounts of ground water. These would be larger 8-10 inch diameter holes but likely not as deep. A third option for a shallower slinky design may be appropriate for smaller systems where horizontal space is available. A test well would assist in confirming well performance. There could be a potential for an unbalanced well field with loss of performance over time if the heating and cooling loads are not roughly similar, however to prevent this from occurring, the well field could be slightly oversized to compensate.

EEM-4 JR/SR High School, Heating and Cooling Plant Upgrades

EEM-4a: JR/SR High School, Install High Efficiency Boiler

This measure is to replace the hot water boiler with a higher efficiency natural gas fired boiler. The existing chiller will remain in use.

Baseline Assumptions:

- Existing Boiler efficiency 80%, 12,500 MBH capacity

Proposed Assumptions:

- Proposed Boiler efficiency 95%, 12,500 MBH capacity

Table 17: EEM-4a Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4a	Install High Efficiency Boiler	0	0.00	$0.00	22,500	$10,732.11	2250.00	$10,732.11	$495,150.00	46.1

This measure is appears to have a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. Condensing boilers will likely have smaller footprint. 3 at 33.3% each for sufficient redundancy or 2 at 65%. Flue will need replacement but replacement will be smaller. Intake will be ducted for completely sealed combustion or air drawn from the room. To optimize the use of condensing boilers, the loop temperature will be reset.

EEM-4b: JR/SR High School, Install Ground Source Heat Pump (GSHP)

This measure is to replace the hot water boiler with a ground source heat pump (GSHP) that generates hot and chilled water and is connected to a geothermal well field. Existing chiller is not in need of replacement at this time but the geothermal field and GSHP equipment will allow for future transition.

Baseline Assumptions:

- Cooling Efficiency 11.2 EER, 14.5 IPLV, 500 Ton Capacity
- Heating Efficiency 80% Efficiency, 12,500 MBH Capacity

Proposed Assumptions:

- Proposed GSHP efficiency 18 EER, 3.05 COP

Table 18: EEM-4b Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4b	Install Ground Source Heat Pump (GSHP)	-685,849	121.43	-$52,014.05	90,000	$42,928.45	6659.20	-$9,085.60	$4,085,000.00	-449.6

This measure does not payback. The reason to make the change would be solely to reduce carbon used in the building. The GSHP saves a substantial amount of energy, but still requires more cost to operate. At this this time, this is not recommended for this building. Hot water generated by water source units may be at a lower temperature than the existing units are currently operating. This may de-rate the units, so a calculation would need to be performed to determine if the existing coils and terminal units can operate at the lower temperatures.

EEM-4 Barry Primary School, Heating and Cooling Plant Upgrades

EEM-4a: Barry Primary School, Install High Efficiency Steam Boiler

This measure is to replace the steam boiler with a higher efficiency natural gas fired steam boiler.

Baseline Assumptions:

- Existing Boiler efficiency 75%, 4,185 MBH

Proposed Assumptions:

- Proposed Boiler efficiency 85%, 4,185 MBH

Table 19: EEM-4a Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4a	Install High Efficiency Steam Boiler	0	0.00	$0.00	5,357	$2,774.97	535.68	$2,774.97	$138,975.00	50.1

This measure is appears to have a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended.

EEM-4b: Barry Primary School, Install High Efficiency Hot Water Boiler

This measure is to convert to natural gas condensing hot water boilers and heating system. This measure requires a full piping replacement.

Baseline Assumptions:

- Existing Boiler efficiency 75%, 4,185 MBH

Proposed Assumptions:

- Proposed Boiler efficiency 95%, 4,185 MBH
- Conversion between condensate pumping and hot water pumping not included in calculation.

Table 20: EEM-4b Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4b	Convert to High Efficiency Hot Water Boilers & Distribution	0	0.00	$0.00	10,714	$5,549.94	1071.36	$5,549.94	$1,995,150.00	359.5

This measure has a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. Condensing boilers will likely have smaller footprint. 3 at 33.3% each for sufficient redundancy or 2 at 65%. Flue will need replacement but replacement will be smaller. Intake will be ducted for completely sealed combustion or air drawn from the room. To optimize the use of condensing boilers, the loop temperature will be reset.

EEM-4c: Barry Primary School, Install Central Ground Source Heat Pump (GSHP) System

This measure is to replace the steam heating system with ground source heat pump (GSHP) that generates hot water and is connected to a geothermal field. This includes the replacement of the steam piping with hot water piping, and fintube and unit ventilator replacement. This will provide the option for chilled water for future cooling if desired. The well field will need to be oversized to account for the heating only load. This measure includes the replacement of (3) AHUs.

Baseline Assumptions:

- Cooling Load 168,000 BTU/h
- Heating Load 2,511,000 BTU/h
- Existing Cooling efficiency, EER: 11.2
- Existing Heating efficiency 80%

Proposed Assumptions:

- Proposed heat pump efficiency 18 EER, 3.05 COP
- 160 geothermal wells at 2.5 tons per well, oversized 50% due unbalanced heating and cooling load.

Table 21: EEM-4c Summary

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4c	Install Central Ground Source Heat Pump (GSHP) System	-230,249	4.53	-$19,508.09	32,141	$16,649.83	2428.24	-$2,858.26	$3,690,000.00	-1291.0

This measure has a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. Hot water generated by water source units may be at a lower temperature than the existing units are currently operating. This may de-rate the units, so a calculation would need to be performed to determine if the existing coils and terminal units can operate at the lower temperatures. A test well would assist in confirming well performance. The wells may be located under a parking lot and possibly coincide with the parking lot resurface. Grassy areas are also a possibility, though care should be taken to ensure the well field does not conflict with future land use. Cabinetry changes and abatement is not included in the estimated probable cost.

EEM-4d: Barry Primary School, Install Terminal Ground Source Heat Pump (GSHP) System

This measure is to replace the steam heating system with geothermal well field coupled with water to air source heat pumps. This includes replacement of the steam piping with heat pump loop piping as well as unit ventilator replacement with heat pumps. Units will be capable of cooling. The split A/C systems would also be replaced with water to air source heat pumps. This measure includes the replacement of (3) AHUs.

Baseline Assumptions:

- Cooling Load 168,000 BTU/h
- Heating Load 2,511,000 BTU/h
- Existing Cooling efficiency, EER: 11.2
- Existing Heating efficiency 80%

Proposed Assumptions:

- Proposed heat pump efficiency is 18 EER, 3.05 COP
- 160 geothermal wells at 2.5 tons per well, oversized 50% due unbalanced heating and cooling load.

Table 22: EEM-4d Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4d	Install Terminal Ground Source Heat Pump (GSHP) System	-230,249	4.53	-$19,508.09	32,141	$16,649.83	2428.24	-$2,858.26	$3,250,000.00	-1137.1

This measure has a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended.

EEM-4 Smith Intermediate School, Heating and Cooling Plant Upgrades

EEM-4a: Smith Intermediate School - Install High Efficiency Steam Boiler

This measure is to replace the steam boiler with a higher efficiency natural gas fired steam boiler.

Baseline Assumptions:

- Existing Boiler efficiency 75%, 4,185 MBH

Proposed Assumptions:

- Proposed Boiler efficiency 85%, 4,185 MBH

Table 23: EEM-4a Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4a	Install High Efficiency Boiler	0	0.00	$0.00	5,356	$2,765.71	535.55	$2,765.71	$138,975.00	50.2

This measure is appears to have a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended.

EEM-4b: Smith Intermediate School, Install High Efficiency Steam Boiler

This measure is to convert to natural gas condensing hot water boilers and heating system. This measure requires a full piping, coils, fintube, and other terminal unit replacement.

Baseline Assumptions:

- Existing Boiler efficiency 75%, 4,185 MBH

Proposed Assumptions:

- Proposed Boiler efficiency 95%, 4,185 MBH
- Conversion between condensate pumping and hot water pumping not included in calculation.

Table 24: EEM-4b Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4b	Convert to Condensing Hot Water Boilers & Distribution	0	0.00	$0.00	10,711	$5,531.41	1071.10	$5,531.41	$1,995,150.00	360.7

This measure has a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended.

EEM-4c: Smith Intermediate School - Install Central Ground Source Heat Pump (GSHP) System

This measure is to replace the steam heating system with ground source heat pump (GSHP) that generates hot water and is connected to a geothermal field. This includes the replacement of the steam piping with hot water piping, and fintube and unit ventilator replacement. This will provide the option for chilled water for future cooling if desired. The well field will need to be oversized to account for the heating only load. This measure includes the replacement of (3) AHUs.

Baseline Assumptions:

- Cooling Load 168,000 BTU/h
- Heating Load 2,511,000 BTU/h
- Existing Cooling efficiency, EER: 11.2
- Existing Heating efficiency 80%

Proposed Assumptions:

- Proposed heat pump efficiency 18 EER, 3.05 COP
- 160 geothermal wells at 2.5 tons per well, oversized 50% due unbalanced heating and cooling load.

Table 25: EEM-4c Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4c	Install Central Ground Source Heat Pump (GSHP) System	-231,509	2.59	-$20,148.37	32,141	$16,598.20	2423.94	-$3,550.16	$3,690,000.00	-1039.4

This measure has a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. Hot water generated by water source units may be at a lower temperature than the existing units are currently operating. This may de-rate the units, so a calculation would need to be performed to determine if the existing coils and terminal units can operate at the lower temperatures. A test well would assist in confirming well performance. The wells may be located under a parking lot and possibly coincide with the parking lot resurface. Grassy areas are also a possibility, though care should be taken to ensure the well field does not conflict with future land use. Cabinetry changes and abatement is not included in the estimated probable cost.

EEM-4d: Smith Intermediate School - Install Terminal Ground Source Heat Pump (GSHP) System

This measure is to replace the steam heating system with geothermal well field coupled with water to air source heat pumps. This includes replacement of the steam piping with heat pump loop piping as well as unit ventilator replacement with heat pumps. Units will be capable of cooling. The split A/C systems would also be replaced with water to air source heat pumps. This measure includes the replacement of (3) AHUs.

Baseline Assumptions:

- Cooling Load 168,000 BTU/h
- Heating Load 2,511,000 BTU/h
- Existing Cooling efficiency, EER: 11.2
- Existing Heating efficiency 80%

Proposed Assumptions:

- Proposed heat pump efficiency is 18 EER, 3.05 COP
- 160 geothermal wells at 2.5 tons per well, oversized 50% due unbalanced heating and cooling load.

Table 26: EEM-4d Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4d	Install Terminal Ground Source Heat Pump (GSHP) System	-231,413	4.53	-$20,139.99	32,141	$16,598.20	2424.27	-$3,541.78	$3,250,000.00	-917.6

This measure has a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. A test well would assist in confirming well performance. The wells may be located under a parking lot and possibly coincide with the parking lot resurface. Grassy areas are also a possibility, though care should be taken to ensure the well field does not conflict with future land use.

EEM-4 District Offices/Bus Garage

EEM-4a: Air Source Heat Pump (VRF)

This measure is to install a air source heat pump (VRF) system for the office areas in lieu of split systems, eliminating the existing AHU.

Baseline Assumptions:

- Cooling Load 72,000 BTU/h
- Heating Load 1,004,000 BTU/h
- Existing Cooling efficiency, EER: 11.2

Proposed Assumptions:

- Proposed heat pump efficiency is 13 EER at full load and 13.9 EER seasonal efficiency.

Table 27: EEM-4a Summary - District Offices/Bus Garage

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4a	Air Source Heat Pump (VRF)	-53,919	0.71	-$4,821.33	673	$483.45	-116.77	-$4,337.88	$121,400.00	-28.0

This measure does not payback and is not recommended.

EEM-4b: Install Ground Source Heat Pump (GSHP) System

This measure is to replace the hot water heating system with geothermal well field coupled with water to water ground source heat pumps, generating hot/chilled/domestic water. Water to air heat pumps for the offices and other areas currently without hydronic heat.

Baseline Assumptions:

- Cooling Load 72,000 BTU/h
- Heating Load 1,004,000 BTU/h
- Existing Cooling efficiency, EER: 11.2
- Existing Heating efficiency 80%

Proposed Assumptions:

- Proposed heat pump efficiency is 18 EER, 3.05 COP
- 30 geothermal wells at 2.5 tons per well, oversized 50% due unbalanced heating and cooling load.

Table 28: EEM-4b Summary - District Offices/Bus Garage

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
4b	Install Ground Source Heat Pump (GSHP) System	-92,559	-391.68	-$8,276.45	12,053	$8,663.47	889.38	$387.02	$472,050.00	1219.7

This measure does not payback. The reason to make the change would be solely to reduce carbon used in the building. The GSHP saves a substantial amount of energy, but still requires more cost to operate. At this this time, this is not recommended for this building. A test well would assist in confirming well performance. The wells may be located under a parking lot and possibly coincide with the parking lot resurface. Grassy areas are also a possibility, though care should be taken to ensure the well field does not conflict with future land use.

EEM-5: SOLAR THERMAL HEAT RECOVERY OPPORTUNITIES

EEM-5: JR/SR High School, Solar Thermal Heat Recovery

The roofs are relatively unobstructed from the sun, with limited trees and adjacent structures tall enough to shade the roof. This provides potential space to roof mount solar thermal collectors. Alternatively, wall mounted systems could also be an option. The air is brought in through the perforated metal panels, which use sunlight to directly heat the air. Motorized dampers are used to bypass the panels during cooling. Because the solar energy requires no electricity input, thermal collectors reduce the load on the heating coils and reduce energy consumption.

Baseline Assumptions:

- AHUs available:
- RTU-1H, Kitchen make-up - 6,000 cfm OA
- RTU-4H, Kitchen make-up - 7,222 cfm OA

Proposed Assumptions:

- Solar thermal collectors located on nearby southwest facing gymnasium wall.
- Assumed 8 cfm/sf collector = 1,600 sf

Table 29: EEM-5 Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
5	Solar Thermal Heat Recovery Opportunities	0	0.00	$0.00	651	$310.70	65.14	$310.70	$53,716.00	172.9

This measure is appears to have a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. The reason that this measure does not perform well is due to the relatively low number of operating hours. For example a 24-hour operating facility would have significantly more savings which would lower the payback.

EEM-5 Barry Primary School - Solar Thermal Heat Recovery

The roofs are relatively unobstructed from the sun, with limited trees and adjacent structures tall enough to shade the roof. This provides potential space to roof mount solar thermal collectors. Alternatively, wall mounted systems could also be an option. The air is brought in through the perforated metal panels, which use sunlight to directly heat the air. Motorized dampers are used to bypass the panels during cooling. Because the solar energy requires no electricity input, thermal collectors reduce the load on the heating coils and reduce energy consumption.

Baseline Assumptions:

- AHUs available:
- MAU-1B, Kitchen make-up - assumed 6,000 cfm OA (nameplate capacity is 11,111 cfm max and 2,222 min)

Proposed Assumptions:

- Solar thermal collectors located on flat roof, south facing at 35°.
- Assumed 8 cfm/sf collector = 800 sf

Table 30: EEM-5 Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
5	Solar Thermal Heat Recovery Opportunities	0	0.00	$0.00	300	$155.20	29.96	$155.20	$24,792.00	159.7

This measure is appears to have a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. The reason that this measure does not perform well is due to the relatively low number of operating hours. For example a 24-hour operating facility would have significantly more savings which would lower the payback.

EEM-5 Smith Intermediate School - Solar Thermal Heat Recovery

The roofs are relatively unobstructed from the sun, with limited trees and adjacent structures tall enough to shade the roof. This provides potential space to roof mount solar thermal collectors. Alternatively, wall mounted systems could also be an option. The air is brought in through the perforated metal panels, which use sunlight to directly heat the air. Motorized dampers are used to bypass the panels during cooling. Because the solar energy requires no electricity input, thermal collectors reduce the load on the heating coils and reduce energy consumption.

Baseline Assumptions:

- AHUs available:
- MAU-1S, Kitchen make-up - assumed 6,000 cfm OA (nameplate capacity is 11,111 cfm max and 2,222 min)

Proposed Assumptions:

- Solar thermal collectors located on flat roof, south facing at 35°.
- Assumed 8 cfm/sf collector = 800 sf

Table 31: EEM-5 Summary- Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
5	Solar Thermal Heat Recovery Opportunities	0	0.00	$0.00	300	$154.72	29.96	$154.72	$24,792.00	160.2

This measure is appears to have a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. The reason that this measure does not perform well is due to the relatively low number of operating hours. For example a 24-hour operating facility would have significantly more savings which would lower the payback.

EEM-6: OUTDOOR AIR ENERGY RECOVERY OPPORTUNITIES

EEM-6 JR/SR High School - Outdoor Air Energy Recovery Opportunities

The addition of enthalpy (heating and cooling) or sensible only (heating only) energy recovery cores to precondition outdoor air. There are a number of units not utilizing this technology and could provide a potential significant energy savings.

Baseline Assumptions:

- AHU-8 Locker Room 5,000 CFM of outdoor air
- Cooling Efficiency: 11.2 EER
- Heating Efficiency: 80%

Proposed Assumptions:

- Run-around loop efficiency of 50%

Table 32: EEM-6 Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
6	Outdoor Air Energy Recovery Opportunities	400	-0.72	$30.32	9	$4.31	2.27	$34.63	$14,407.00	416.1

This measure has a long payback beyond the expected useful life of the equipment and therefore has been indicated as not recommended. The annual electric peak demand savings are negative because the increase in fan power exceeds the cooling electric power savings.

EEM-7: KITCHEN HOOD CONTROLS

EEM-7: JR/SR High School, Kitchen Hood Controls

EEM-7 JR/SR High School, Kitchen Hood Controls

The kitchen hoods currently are interlocked with the make-up air handling unit. Heat sensors may be installed along with variable speed drives and interlocked fully modulating outdoor air dampers to allow for automatic operation of the hoods and variable airflow according to sensed temperature. This will reduce both fan power and the required outdoor air. The impact of this effect on the outdoor air volume of the cafeteria to ensure that the adjacent space continues to be adequately ventilated will be included in this study.

Baseline Assumptions:
- The existing exhaust fan is (1.0) horsepower

Proposed Assumptions:
- Variable speed drive allows for 1968 kwh/hp unit savings
- Variable speed drive allows for 0.411 kW/hp unit savings
- 12,100 sqft of kitchen and cafeteria space, $ESF_{cooling}$ 296, $ESF_{heating}$ 13.7

Table 33: EEM-7 Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
7	Kitchen Hood Controls	5,550	0.33	$420.88	1,658	$790.69	184.71	$1,211.57	$14,070.00	11.6

This measure is recommended to be implemented.

EEM-7 Randall Middle School, Kitchen Hood Controls

The kitchen hoods currently are interlocked with the make-up air handling unit. Heat sensors may be installed along with variable speed drives and interlocked fully modulating outdoor air dampers to allow for automatic operation of the hoods and variable airflow according to sensed temperature. This will reduce both fan power and the required outdoor air. The impact of this effect on the outdoor air volume of the cafeteria to ensure that the adjacent space continues to be adequately ventilated will be included in this study.

Baseline Assumptions:

- The existing exhaust fan is (0.5) horsepower

Proposed Assumptions:

- Variable speed drive allows for 1968 kwh/hp unit savings
- Variable speed drive allows for 0.411 kW/hp unit savings
- 4,800 sqft of kitchen and cafeteria space, $ESF_{cooling}$ 296, $ESF_{heating}$ 13.7

Table 34: EEM-7 Summary - Randall Middle School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
7	Kitchen Hood Controls	2,405	0.16	$207.42	658	$373.96	73.97	$581.38	$13,504.00	23.2

This measure is recommended to be implemented.

EEM-7 Barry Primary School, Kitchen Hood Controls

The kitchen hoods currently are interlocked with the make-up air handling unit. Heat sensors may be installed along with variable speed drives and interlocked fully modulating outdoor air dampers to allow for automatic operation of the hoods and variable airflow according to sensed temperature. This will reduce both fan power and the required outdoor air. The impact of this effect on the outdoor air volume of the cafeteria to ensure that the adjacent space continues to be adequately ventilated will be included in this study.

Baseline Assumptions:

- The existing exhaust fan is (0.5) horsepower

Proposed Assumptions:

- Variable speed drive allows for 1968 kwh/hp unit savings
- Variable speed drive allows for 0.411 kW/hp unit savings
- 6,400 sqft of kitchen and cafeteria space, $ESF_{cooling}$ 296, $ESF_{heating}$ 13.7

Table 35: EEM-7 Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
7	Kitchen Hood Controls	2,878	0.16	$243.88	877	$454.21	97.50	$698.08	$13,504.00	19.3

This measure is recommended to be implemented.

EEM-7 Smith Intermediate School, Kitchen Hood Controls

The kitchen hoods currently are interlocked with the make-up air handling unit. Heat sensors may be installed along with variable speed drives and interlocked fully modulating outdoor air dampers to allow for automatic operation of the hoods and variable airflow according to sensed temperature. This will reduce both fan power and the required outdoor air. The impact of this effect on the outdoor air volume of the cafeteria to ensure that the adjacent space continues to be adequately ventilated will be included in this study.

Baseline Assumptions:

- The existing exhaust fan is (0.5) horsepower

Proposed Assumptions:

- Variable speed drive allows for 1968 kwh/hp unit savings
- Variable speed drive allows for 0.411 kW/hp unit savings
- 6,400 sqft of kitchen and cafeteria space, $ESF_{cooling}$ 296, $ESF_{heating}$ 13.7

Table 36: EEM-7 Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
7	Kitchen Hood Controls	2,878	0.16	$250.51	877	$452.80	97.50	$703.31	$13,504.00	19.2

This measure is recommended to be implemented.

EEM-8: STEAM TRAP REPLACEMENT

EEM-8 Barry Primary School, Steam Trap Replacement

The existing steam traps will be surveyed and units found to be non-functional, leaking, or blow-through will be repaired or replaced. When steam passes through the traps, it reduces the heating effectiveness. This has a natural gas energy benefit.

Baseline Assumptions:

- Approximately (50) steam traps based on drawings.
- Estimated 10% steam trap failure rate
- Natural gas steam boiler, 75% efficiency

Proposed Assumptions:

- (5) steam traps repaired or replaced

Table 37: EEM-8 Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
8	Steam Trap Replacement	0	0.00	$0.00	4,999	$2,589.76	499.93	$2,589.76	$2,800.00	1.1

This measure is recommended to be implemented.

EEM-8 Smith Intermediate School, Steam Trap Replacement

The existing steam traps will be surveyed and units found to be non-functional, leaking, or blow-through will be repaired or replaced. When steam passes through the traps, it reduces the heating effectiveness. This has a natural gas energy benefit.

Baseline Assumptions:
- Approximately (50) steam traps based on drawings.
- Estimated 10% steam trap failure rate
- Natural gas steam boiler, 75% efficiency

Proposed Assumptions:
- (5) steam traps repaired or replaced

Table 38: EEM-8 Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
8	Steam Trap Replacement	0	0.00	$0.00	4,999	$2,581.73	499.93	$2,581.73	$2,800.00	1.1

This measure is recommended to be implemented.

EEM-9: SOLAR PANEL ARRAY

Solar photovoltatics (PV) provide an additional opportunity to reduce the energy consumption and operation cost of the proposed facility. PV systems harvest the ambient solar energy and convert it to electricity, which can reduce the electricity required from the utility grid. When combined with a high-efficiency all-electric building, electricity purchases can even be eliminated. For cost-effectiveness, the building energy should be reduced as much as feasible before adding the PV.

A solar panel array can help a building become net-zero/carbon-neutral, in which all the energy or carbon consumption is offset with renewable energy sources. This is generally achievable with a high-performing all-electric building, such as one utilizing a high-efficiency heat pump or VRF system.

Relevant parameters:

- Roof-mounted, open rack, fixed solar array
- South-facing, 20° tilt
- Assumes premium efficiency solar panels (minimum 19% efficiency)

Solar panels generally provide a reasonable payback. Note that these calculations assume they are south facing panels; if they are oriented differently or are shaded by adjacent structures, more panels will likely be required. This analysis assumes no energy storage; in periods of low solar radiation, electricity from the grid will be required. However, during times that the PV produces more energy than is required for the building, the utility may buy back excess energy. If energy storage is utilized, it can help to soften the demand peaks. A regulatory review will be necessary to see if installation is permitted and if the grid will allow interconnection. These measures are recommended at this time, however, further study into the available roof areas and structural capacity, land, permits and grid interconnect is necessary.

<u>EEM-9 JR/SR High School, Solar Panel Array</u>

To match the existing annual consumption, a 1,725 kW array is required. The foot print would be approximately 95,000 square feet.

Table 39: EEM-9 Summary - JR/SR High School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
9	Solar PV	2,057,442	1725.00	$156,034.17	0	$0.00	7022.05	$156,034.17	$4,140,000.00	26.5

This measure is recommended to be implemented.

EEM-9 Randall Middle School, Solar Panel Array

To match the existing annual consumption, a 225 kW array is required. The foot print would be approximately 12,500 square feet.

Table 40: EEM-9 Summary - Randall Middle School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
9	Solar PV	268,909	225.00	$23,194.04	0	$0.00	917.79	$23,194.04	$540,000.00	23.3

This measure is recommended to be implemented.

EEM-9 Barry Primary School

To match the existing annual consumption, a 220 kW array is required. The foot print would be approximately 12,100 square feet.

Table 41: EEM-9 Summary - Barry Primary School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
9	Solar PV	262,398	220.00	$22,231.96	0	$0.00	895.56	$22,231.96	$528,000.00	23.7

This measure is recommended to be implemented.

EEM-9 Smith Intermediate School, Solar Panel Array

To match the existing annual consumption, a 180 kW array is required. The foot print would be approximately 9,900 square feet.

Table 42: EEM-9 Summary - Smith Intermediate School

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
9	Solar PV	215,126	180.00	$18,722.53	0	$0.00	734.23	$18,722.53	$432,000.00	23.1

This measure is recommended to be implemented.

EEM-9 District Offices/Bus Garage, Solar Panel Array

To match the existing annual consumption, a 180 kW array is required. The foot print would be approximately 9,900 square feet.

Table 43: EEM-9 Summary - District Offices/Bus Garage

EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Natural Gas Savings [therms]	Annual Natural Gas Cost Savings [$]	Total Energy Consumption Savings [mmBtu]	Total Annual Cost Savings [$]	Estimated EEM Cost [$] (total)	Simple Payback [Years]
9	Solar PV	208,727	175.00	$18,664.01	0	$0.00	712.39	$18,664.01	$420,000.00	22.5

This measure is recommended to be implemented.

CONCLUSION

Based on the findings of the study, we recommend pursing energy efficiency measures EEM-2 Kitchen Hood Controls, EEM-8 Steam Trap Replacement and EEM-9 Solar Panel Arrays. These measures will help improve the efficiency of building, reduce the carbon footprint and have a positive comfort impact on the occupants. We hope the findings of this report will assist you in making decisions about energy efficiency improvements in your facility.

ESTIMATED INCENTIVES

Estimated incentives available for geothermal systems at $80/mmBtu of annual energy savings. Available through Con Edison, National Grid and NYSEG.

Measure	Estimated Incentive
EEM-4b: JR/SR High School, Install Ground Source Heat Pump (GSHP)	$522,041
EEM-4c: Barry Primary School, Install Central Ground Source Heat Pump (GSHP) System	$191,955
EEM-4d: Barry Primary School, Install Terminal Ground Source Heat Pump (GSHP) System	$191,955
EEM-4c: Smith Intermediate School, Install Central Ground Source Heat Pump (GSHP) System	$191,680
EEM-4d: Smith Intermediate School, Install Terminal Ground Source Heat Pump (GSHP) System	$191,637
EEM-4b: District Offices/Bus Garage, Install Ground Source Heat Pump (GSHP) System	$70,224

INCENTIVE PROGRAMS

NYSERDA P-12 PROGRAM - DESIGN INCENTIVES

- High needs district 100% funded by NYSERDA, up to $250,000
- Design for high efficiency measures resulting in a 20% improvement (overall or per measure as appropriate)

NYSERDA NEW CONSTRUCTION PROGRAM

***Applicable to **<u>All-Electric</u>** Projects Only

<u>Support Level 1 – First Look:</u>

- For Carbon Neutral Ready projects of any square footage and at any design phase prior construction.
  - Projects greater than 15,000 square feet and in schematic design phase or earlier may transition to Support Level 2 upon completion of the First Look, provided the Applicant commits to a Carbon Neutral Ready or better design.
- Technical Support provided by a NYSERDA-approved Primary Energy Consultant:
  - Meet with the Applicant to review design phase plans or proposed equipment selections, and
  - Provide a summary of energy savings suggestions.
- NYSERDA contribution for Support Level 1:
  - Technical Support is provided at no cost to the Applicant.
  - Fixed fee schedule for Primary Energy Consultant:
  - Projects up to 10,000 SF - $1,500
  - Projects 10,001 to 30,000 SF - $3,000
  - Projects over 30,000 SF - $5,000

<u>Support Level 2 Carbon Neutral Ready (>15,000 SF)</u>

- Project must be all electric, including cooking, laundry, domestic hot water, etc. The only exception is an emergency generator.
- Energy Modeling, Analysis and Report:
  - Engage with the Applicant and project design team to identify, model and analyze potential energy savings and electrification opportunities. Include analysis of ventilation and related building envelope and HVAC system needs to optimize buildings to meet COVID-19 related health and safety guidance.
- Integrated Project Delivery:
  - Provide additional technical support for Applicants who incorporate and execute Integrated Project Delivery in the project design.
- Smart Buildings:
  - Provide additional technical support for Applicants who incorporate and execute a suite of Smart Building features in the project design and construction.
- Embodied Carbon:

  - Suggest, evaluate and quantify embodied carbon reduction opportunities. Prepare and submit a separate report of the embodied carbon analysis to the Applicant and NYSERDA.
- NYSERDA Contribution:
  - NYSERDA will pay 100% of the technical support costs, including energy modeling and efficiency measure analysis, up to a maximum $200,000.
  - For projects seeking to reduce embodied carbon by at least 20%, NYSERDA will pay an additional 10% of the Technical Support costs to identify and quantify strategies that reduce embodied carbon.
  - Incentive of **$2/sf** if source energy is a least 15% less than a code-compliant baseline
- For more information: Commercial New Construction Program - NYSERDA

NYS CLEAN HEAT PROGRAM

NYS Clean Heat Statewide Heat Pump Program

- Heat pump system options only. Must utilize heat pump for heating.
- Custom performance incentives per MMBtu saved, according to type and size of full load heating capacity OR per equipment if smaller sizes
- Must utilize NYSERDA-participating contractor or designer, subject to installation requirements
- For more information: clean-heat-program-guide.pdf (coned.com)

NY-SUN

NYSERDA NY-Sun Program:

- The NY-Sun program offers incentives and financing for NY businesses purchasing and installing solar panel systems.
- There are also NYS tax credits available, if eligible.
- Current incentives:
  - Non-residential (<200 kW): $0.35/W
  - Commercial (>200 kW): CLOSED 5/20/2021
  - Incentives reduce over time after a certain number of projects are awarded
- To determine eligibility, you will need to work with a participating NY-Sun contractor:
  - Find a Commercial Solar Contractor - NYSERDA
- For more information about the program: NY-Sun - NYSERDA

NYSERDA RETAIL ENERGY STORAGE

NYSERDA Retail Energy Storage Incentive Program (PON4112)

- This program provides financial incentives for new grid-connected energy storage systems up to 5 megawatts of power (5MW).
- Storage systems may be chemical, thermal or mechanical.
- Storage systems must be operated primarily for electric load management or load shifting to times more beneficial to the grid.
- Systems may be installed alone or paired with another distributed energy resource technology.
- To receive incentives, you will need to work with a participating contractor.
- For more information: Retail Energy Storage Incentive Program (PON 4112)

SOLAR TAX CREDITS

Federal Investment Tax Credit for Commercial Solar Photovoltaics

- This is a federal corporate income tax credit based on 10% of the cost of the solar PV system.
- For additional information: www.energy.gov/eere/solar

CON EDISON

Commercial and Industrial Program

- Two pathways for both gas and electric customers participating in the 2021 program year: the prescriptive path and the custom path.
- Prescriptive and custom incentives cannot exceed 70% of the customer's project cost for eligible measure(s) or 100% of each measure cost. Total incentives are capped at $1,000,000 for electric projects and $750,000 for gas projects, per account per year
- Commercial customers, over 100 kW average peak demand on a rolling 12-month basis, who pay into the EE Tracker are eligible for C&I incentives, excluding multifamily buildings. Commercial customers between 100-300 kW may also choose to participate with Con Edison through the Small Business (SMB) Program.
- For additional information : Savings for Commercial and Industrial Customers | Con Edison // Savings for Your Small or Medium Business | Con Edison

ELECTRIC VEHICLE CHARGING STATIONS

NYSERDA Charge Ready NY

- $4,000 per charging port for Level 2 charging stations
- For additional information: NYSERDA Charge Ready NY

ConEdison Electric Vehicle PowerReady - Infrastructure

- Two categories of equipment or infrastructure are eligible for incentives under the EV Make-Ready Program:
  - Utility-side Make-Ready Infrastructure: Utility electric infrastructure needed to connect and serve a new EV charger. This may include traditional distribution infrastructure such as step-down transformers, overhead service lines, and utility meters that will continue to be owned and operated by the utility.
  - Customer-side Make-Ready Infrastructure: EV equipment or infrastructure necessary to make a site ready to accept an EV charger that is owned by the charging station Developer, Equipment Owner, or Site Host. This electric infrastructure may include conductors, trenching, and panels needed for the EV charging station.
- EV Charging in Disadvantaged Communities may be eligible for higher incentive level.
- For additional information: Electric Vehicle PowerReady Program | Con Edison

NYS Electric Vehicle Recharging Property Tax Credit

- Credit the lesser of $5,000 or 50% of the cost of property less any cost paid from the proceeds of grants
- For additional information: NYS Electric Vehicle Recharging Property Tax Credit

FEDERAL ENERGY-EFFICIENCY TAX DEDUCTION

179D Commercial Buildings Energy-Efficiency Tax Deduction

- $1.80/sf deduction (adjusted annually) for property exceeding 50% energy savings utilizing the latest version of ASHRAE 90.1
- Partial deductions available for individual reductions for only envelope, HVAC/DHW, and lighting
- For additional information: 179D Commercial Buildings Energy-Efficiency Tax Deduction

PACE

The property assessed clean energy (PACE) model is an innovative mechanism for financing energy efficiency and renewable energy improvements on private property. PACE programs exist for:

- Commercial properties (commonly referred to as Commercial PACE or C-PACE)
- Residential properties (commonly referred to as Residential PACE or R-PACE).

PACE programs allow a property owner to finance the up-front cost of energy or other eligible improvements on a property and then pay the costs back over time through a voluntary assessment. PACE assessments are attached to the property rather than an individual. PACE financing for clean energy projects is generally based on an existing structure known as a "land-secured financing district," often referred to as an assessment district, a local improvement district, or other similar phrase. In a conventional assessment district, the local government issues bonds to fund projects with a public purpose such as streetlights, sewer systems, or underground utility lines.

ADDITIONAL CONSIDERATIONS

Although the main considerations in selecting an HVAC system are typically energy and cost implications, there are several other factors at play.

Existing Useful Life of Equipment

A full life cycle cost analysis has not been performed as part of this study. However, each system has a different lifespan. For example, a rooftop unit has a relatively short expected useful life of 15 years before replacement becomes necessary, while a ground source heat pump can be expected to last 25 years.

Expected Useful Lifespan			
Equipment Description	Years	Equipment Description	Years
Lighting	15	Boiler	25
Envelope	30	Ground Source Heat Pump	25
Direct Digital Control Sys	25	Air Handling Unit	15

In order to fully capture the replacement and the true cost of each system type, a full life cycle cost analysis may be warranted.

Carbon Reduction

Much of the motivation to reduce fossil fuel usage is to address climate change by reducing carbon and greenhouse gas emissions. New York State currently has one of the cleanest electric grids in the nation, and has goals of 70% renewable supply by 2030, and 100% by 2050. However, natural gas still remains less carbon intensive per unit of energy than electricity, due to the fossil fuels required to produce and distribute electricity, which is often counter-intuitive. With the New York's focus on renewable energy, that is likely to change, especially over the lifespan of equipment with long expected life.

Jr/Sr High School

Greenhouse Gas Emissions			
Tag	Carbon Consumption	Savings vs. Baseline Consumption	
	(mt CO_2e)	(mt CO_2e)	(%)
BASELINE	1577	--	--
EEM-1	4	1573	99.7%
EEM-2	33	1544	97.9%
EEM-3	4	1573	99.7%
EEM-4A	119	1458	92.4%
EEM-4B	114	1463	92.8%
EEM-5	3	1574	99.8%
EEM-6	0	1577	100.0%
EEM-7	12	1566	99.3%
EEM-9	1029	548	34.7%

Randall Middle School

Greenhouse Gas Emissions			
Tag	Carbon Consumption	Savings vs. Baseline Consumption	
	(mt CO_2e)	(mt CO_2e)	(%)
BASELINE	287	--	--
EEM-2	18	1560	98.9%
EEM-3	5	1573	99.7%
EEM-9	135	1443	91.5%

Barry Primary School

Greenhouse Gas Emissions			
Tag	Carbon Consumption	Savings vs. Baseline Consumption	
	(mt CO_2e)	(mt CO_2e)	(%)
BASELINE	393	--	--
EEM-2	23	1555	98.6%
EEM-3	4	1573	99.7%
EEM-4A	28	1549	98.2%
EEM-4B	57	1521	96.4%
EEM-4C	51	1527	96.8%
EEM-4D	51	1527	96.8%
EEM-5	2	1576	99.9%
EEM-7	6	1571	99.6%
EEM-8	26	1551	98.3%
EEM-9	131	1446	91.7%

Smith Intermediate School

Greenhouse Gas Emissions			
Tag	Carbon Consumption	Savings vs. Baseline Consumption	
	(mt CO_2e)	(mt CO_2e)	(%)
BASELINE	378	--	--
EEM-2	16	1562	99.0%
EEM-3	4	1573	99.7%
EEM-4A	28	1549	98.2%
EEM-4B	57	1521	96.4%
EEM-4C	50	1527	96.8%
EEM-4D	50	1527	96.8%
EEM-5	2	1576	99.9%
EEM-7	6	1571	99.6%
EEM-8	26	1551	98.3%
EEM-9	108	1470	93.2%

District Offices/Bus Garage

Greenhouse Gas Emissions			
Tag	Carbon Consumption	Savings vs. Baseline Consumption	
	($mt\ CO_2e$)	($mt\ CO_2e$)	(%)
BASELINE	378	--	--
EEM-2	10	1568	99.4%
EEM-4A	-23	1601	101.5%
EEM-4B	16	1562	99.0%
EEM-9	104	1473	93.4%

<u>Utility Cost Inflation</u>

New York State has aggressive carbon-reduction goals, which require the electrification of heating systems to succeed. One method of encouraging the switch from natural gas to electric heating in our climate is to provide financial incentives and penalties. Already, NYSERDA and the major utility companies have incentive programs to mitigate first costs. In the future, the economic incentives may migrate to utility rates themselves, in the form of electric rate subsidies or carbon taxes. For example, in 2018, Canada implemented a carbon tax based on consumption meant to penalize excessive fossil fuel use. While the future of energy is unknown, it is a possibility to consider.

<u>Project Stage</u>

This project is in study phase, prior to concept/schematic design, and as such, many assumptions and generalizations must be made to create the energy model. It is prudent to make conservative assumptions in order to avoid overstating energy savings or cost implications. As the design progresses, the models may be refined, and typically more energy savings are demonstrated.

APPENDIX
CALCULATIONS

All calculations generally follow NYS 8.0 Technical Resource Manual methods, unless noted.

EEM-1: Lighting and Lighting Controls

JR/SR High School

Cafeteria

Proposed :		
School LPD	0.30	W/sf
Interior hours from TRM	2,187	
$HVAC_c$	0.015	
$HVAC_d$	0.2	
$HVAC_{ff}$	-0.003	
Cafeteria wattage	3150	W
Cafeteria wattage +10% credit for OS Controls	2835	W
Existing:		
Assumed wattage/sf based on site visit observations	0.50	W/sf
SF of Cafeteria	10500	SF
baseline wattage	5250	W
CF, coincidence factor	0.54	

Cafeteria

ΔkWh	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x	hrs_{op}	x(	1	+	$HVAC_c$
ΔkWh	=	1	x(	5250.0	-	2835.0	)/	1000	x	2187	x(	1	+	0.015
ΔkWh	**=**	**5361**												
ΔkW	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x(	1	+	$HVAC_d$	)x	CF
ΔkW	=	1	x(	5250.0	-	2835.0	)/	1000	x(	1	+	0.2	)x	0.54
ΔkW	**=**	**1.565**												
ΔMMBtu	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x	hrs	x	$HVAC_{ff}$		
ΔMMBtu	=	1	x(	5250.0	-	2835.0	)/	1000	x	2187	x	-0.003		
ΔMMBtu	**=**	**-16**												
Δtherm	**=**	**-158**												

Library

Proposed :		
Library LPD	0.57	W/sf
Interior hours from TRM	2,187	
$HVAC_c$	0.015	
$HVAC_d$	0.2	
$HVAC_{ff}$	-0.003	
Library wattage	3777	W
Library wattage +10% credit for OS Controls	3399	W
Existing:		
Assumed wattage/sf based on site visit observations	0.95	W/sf
SF of Library	6627	SF
baseline wattage	6295	W
CF, coincidence factor	0.54	

Library

ΔkWh	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x	hrs_{op}	x(	1	+	$HVAC_c$
ΔkWh	=	1	x(	6295.2	-	3399.4	)/	1000	x	2187	x(	1	+	0.015
ΔkWh	**=**	**6428**												
ΔkW	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x(	1	+	$HVAC_d$	)x	CF
ΔkW	=	1	x(	6295.2	-	3399.4	)/	1000	x(	1	+	0.2	)x	0.54
ΔkW	**=**	**1.876**												
ΔMMBtu	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x	hrs	x	$HVAC_{ff}$		
ΔMMBtu	=	1	x(	6295.2	-	3399.4	)/	1000	x	2187	x	-0.003		
ΔMMBtu	**=**	**-19**												
Δtherm	**=**	**-190**												

Stairwells

Proposed :		
Stairwell LPD	0.18	W/sf
Interior hours from TRM	2,187	
$HVAC_c$	0.015	
$HVAC_d$	0.2	
$HVAC_{ff}$	-0.003	
Stairwell wattage	675	W
Stairwell wattage +10% credit for OS Controls	608	W
Existing:		
Assumed wattage/sf based on site visit observations	0.30	W/sf
SF of Stairwells	3750	SF
baseline wattage	1125	W
CF, coincidence factor	0.54	

Stairwells

ΔkWh	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x	hrs_{op}	x(	1	+	$HVAC_c$
ΔkWh	=	1	x(	1125.0	-	607.5	)/	1000	x	2187	x(	1	+	0.015
ΔkWh	**=**	**1149**												
ΔkW	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x(	1	+	$HVAC_d$	)x	CF
ΔkW	=	1	x(	1125.0	-	607.5	)/	1000	x(	1	+	0.2	)x	0.54
ΔkW	**=**	**0.335**												
ΔMMBtu	=	units	x(	W_{base}	-	W_{ee}	)/	1000	x	hrs	x	$HVAC_{ff}$		
ΔMMBtu	=	1	x(	1125.0	-	607.5	)/	1000	x	2187	x	-0.003		
ΔMMBtu	**=**	**-3**												
Δtherm	**=**	**-34**												

Total ΔkWh	**=**	**12938**
Total ΔkW	**=**	**3.777**
Δtherm	**=**	**-382**
Δ$ kWh	**=**	**$981.18**
Δ$ natural gas	**=**	**($182.40)**

EEM-2: Envelope Improvements

JR/SR High School

Room Temp Setpoint Cooling	75	°F
OA Temp Setpoint Cooling	89	°F
Room Temp Setpoint Heating	70	°F
OA Temp Setpoint Heating	0	°F
EFLH Cooling and Heating, Syracuse		
High School, Cooling	388	$EFLH_{cool}$
High School, Heating	960	$EFLH_{heat}$
Baseline NYS TRM - Code rooftop unit with chilled water 26.9 EER, 80% Efficiency		
Roof		
Roof SF Upper	140,000	SF
Existing: Built-Up roofing, 3" insulation R=5/inch	0.050	U
New: 6" Insulation, R=5/in, R-30 total	0.033	U
Cooling Efficiency	11.2	EER
Cooling Efficiency	14.5	IPLV
Heating Elec Efficiency N/A	0.0	COP
Heating Fuel Efficiency	80%	Eff
	0.446	

Roof

ΔkWh_a	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)x	$EFLH_{cool}$	/	IPLV		
ΔkWh_a	=(((	0.050	x	140000	)-(	0.033	x	140000	))x(	89	-	75	)/	1000	)x	388	/	14.5		
ΔkWh_a	=	875																		
ΔkWh_{cool}	**=**	**875**																		
ΔkWh_a	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	COPx3.412		
ΔkWh_a	=(((	0.050	x	140000	)-(	0.033	x	140000	))x(	70	-	0	)/	1000	)x	960	/	0.00		
ΔkWh_a	=	0																		
ΔkWh_{heat}	**=**	**0**																		
ΔkW_a	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)/	EER				
ΔkW_a	=(((	0.050	x	140000	)-(	0.033	x	140000	))x(	89	-	75	)/	1000	)/	11.2				
ΔkW_a	=	2.917																		
ΔkW_{cool}	**=**	**2.917**																		
$\Delta MMbtu_a$	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	$Eff_{FuelHeat}$	/	1000
$\Delta MMbtu_a$	=(((	0.050	x	140000	)-(	0.033	x	140000	))x(	70	-	0	)/	1000	)x	960	/	80%	/	1000
$\Delta MMbtu_a$	=	196																		
ΔMMBtu	**=**	**196**																		
Δtherm	**=**	**1960**																		

Total ΔkWh	**=**	**875**
Total ΔkW	**=**	**2.917**
Δtherm	**=**	**1960**
Δ$ kWh	**=**	**$66.36**
Δ$ natural gas	=	**$934.89**

Windows

double pane windows w. AC w/ fuel heat Primary School

ΔkWh/100 SF	550	
ΔkW/100 SF	0	
Δtherms/100 SF	62.3	
SF	2000	
CF	0.477	
$SEER_{part}$	14.0	
EER_{part}	11.2	
EFF_{part}	0.80	
$SEER_{baseline}$	14	
$EER_{baseline}$	11.2	
$EFF_{baseline}$	80%	

Windows

ΔkWh	=(	SF/100	)x(	ΔkWh/100 SF	)x(	$SEER_{baseline}$	/	$SEER_{part}$	)			
ΔkWh	=(	2000 / 100	)x(	550	)x(	14 / 14	)					
ΔkWh	=(	20.00	)x(	550	)x(	1.00	)					
ΔkWh	**=**	**11000.00**										
ΔkW	=(	SF/100	)x(	ΔkW/100 SF	)x(	$EER_{baseline}$	/	EER_{part}	) x	CF		
ΔkW	=(	2000 / 100	)x(	0	)x(	11.2 / 11.2	)x(	0.477	)			
ΔkW	=(	20.00	)x(	0	)x(	1	)x(	0.477	)			
ΔkW	**=**	**0.00**										
ΔMMbtu	=(	SF/100	)x((	Δtherms/100 SF	)/	10	)x(	$EER_{baseline}$	/	EER_{part}	)	
ΔMMbtu	=(	2000 / 100	)x((	62.3	)/	10	)x(	11.2 / 11.2	)			
ΔMMbtu	=(	20.00	)x((	62.3	)/	10	)x(	1.00	)			
ΔMMbtu	**=**	**124.60**										

ΔMMBtu	**=**	**320.60**
Δtherm	**=**	**3206**

TOTAL EEM-2		
Total ΔkWh	**=**	**11875**
Total ΔkW	**=**	**2.92**
Δtherm	**=**	**5166.00**
Δ$ kWh	**=**	**$900.59**
Δ$ natural gas	=	**$2,464.09**

Randall Middle School

Room Temp Setpoint Cooling	75 °F
OA Temp Setpoint Cooling	89 °F
Room Temp Setpoint Heating	70 °F
OA Temp Setpoint Heating	0 °F
EFLH Cooling and Heating, Syracuse	
High School, Cooling	388 $EFLH_{cool}$
High School, Heating	960 $EFLH_{heat}$
Baseline NYS TRM - Code rooftop unit with DX	
11 EER, 95% Efficiency	

Roof

Roof SF Upper	43000 SF
Existing: Built-Up roofing, 3" insulation R=5	0.050 U
New: 6" Insulation, R=5/in, R-30 total	0.033 U
Cooling Efficiency	11 EER
Cooling Efficiency	14.2 IPLV
Heating Elec Efficiency N/A	0.0 COP
Heating Fuel Efficiency	95% Eff

Roof

ΔkWh_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)x	$EFLH_{cool}$	/	IPLV		
ΔkWh_a	=(((	0.050	x	43000	)-(	0.033	x	43000	))x(	89	-	75	)/	1000	)x	388	/	14.2		
ΔkWh_a	=	274																		
ΔkWh_{cool}	**=**	**274**																		
ΔkWh_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	COPx3.412		
ΔkWh_a	=(((	0.050	x	43000	)-(	0.033	x	43000	))x(	70	-	0	)/	1000	)x	960	/	0.00		
ΔkWh_a	=	0																		
ΔkWh_{heat}	**=**	**0**																		
ΔkW_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)/	EER				
ΔkW_a	=(((	0.050	x	43000	)-(	0.033	x	43000	))x(	89	-	75	)/	1000	)/	11.0				
ΔkW_a	=	0.912																		
ΔkW_{cool}	**=**	**0.912**																		
$\Delta MMbtu_a$	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	$Eff_{FuelHeat}$	/	1000
$\Delta MMbtu_a$	=(((	0.050	x	43000	)-(	0.033	x	43000	))x(	70	-	0	)/	1000	)x	960	/	95%	/	1000
$\Delta MMbtu_a$	=	51																		
ΔMMBtu	**=**	**51**																		
Δtherm	**=**	**507**																		

Total ΔkWh	**=**	**274**
Total ΔkW	**=**	**0.912**
Δtherm	**=**	**507**
Δ$ kWh	**=**	**$23.60**
Δ$ natural gas	**=**	**$288.29**

Windows

double pane windows w. AC w/ fuel heat Primary School

ΔkWh/100 SF	550
ΔkW/100 SF	0
Δtherms/100 SF	62.3
SF	2000
CF	0.477
$SEER_{part}$	14
EER_{part}	11.2
EFF_{part}	95%
$SEER_{baseline}$	14
$EER_{baseline}$	11.2
$EFF_{baseline}$	95%

Windows

ΔkWh	=(	SF/100	)x(	ΔkWh/100 SF	)x(	$SEER_{baseline}$	/	$SEER_{part}$	)			
ΔkWh	=(	2000 / 100	)x(	550	)x(	14 / 14	)					
ΔkWh	=(	20.00	)x(	550	)x(	1	)					
ΔkWh	**=**	**11000.00**										
ΔkW	=(	SF/100	)x(	ΔkW/100 SF	)x(	$EER_{baseline}$	/	EER_{part}	) x	CF		
ΔkW	=(	2000 / 100	)x(	0	)x(	11.2 / 11.2	)x(	0.477	)			
ΔkW	=(	20.00	)x(	0	)x(	1	)x(	0.477	)			
ΔkW	**=**	**0.00**										
ΔMMbtu	=(	SF/100	)x((	Δtherms/100 SF	)/	10	)x(	$EER_{baseline}$	/	EER_{part}	)	
ΔMMbtu	=(	2000 / 100	)x((	62.3	)/	10	)x(	0.95 / 0.95	)			
ΔMMbtu	=(	20.00	)x((	62.3	)/	10	)x(	1.00	)			
ΔMMbtu	**=**	**124.60**										

ΔMMBtu	**=**	**175.29**
Δtherm	**=**	**1753**

TOTAL EEM-2		
Total ΔkWh	**=**	**11274**
Total ΔkW	**=**	**0.91**
Δtherm	**=**	**2259.89**
Δ$ kWh	**=**	**$972.38**
Δ$ natural gas	**=**	**$1,285.16**

Barry Primary School

Room Temp Setpoint Cooling	75	°F
OA Temp Setpoint Cooling	89	°F
Room Temp Setpoint Heating	70	°F
OA Temp Setpoint Heating	0	°F
EFLH Cooling and Heating, Syracuse		
High School, Cooling	388	EFLH$_{cool}$
High School, Heating	960	EFLH$_{heat}$
Baseline NYS TRM - Code air handling unit		
11 EER, 80% Efficiency		

Roof

ΔkWh$_a$	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	T$_{outdoor, design}$	-	T$_{indoor, setpoint}$	)/	1000	)x	EFLH$_{cool}$	/	IPLV		
ΔkWh$_a$	=(((	0.050	x	68000	)-(	0.033	x	68000	))x(	89	-	75	)/	1000	)x	388	/	14.2		
ΔkWh$_a$	=	433																		
ΔkWh$_{cool}$	**=**	**433**																		
ΔkWh$_a$	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	T$_{indoor, setpoint}$	-	T$_{outdoor, design}$	)/	1000	)x	EFLH$_{heat}$	/	COPx3.412		
ΔkWh$_a$	=(((	0.050	x	68000	)-(	0.033	x	68000	))x(	70	-	0	)/	1000	)x	960	/	0.00		
ΔkWh$_a$	=	0																		
ΔkWh$_{heat}$	**=**	**0**																		
ΔkW$_a$	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	T$_{outdoor, design}$	-	T$_{indoor, setpoint}$	)/	1000	)/	EER				
ΔkW$_a$	=(((	0.050	x	68000	)-(	0.033	x	68000	))x(	89	-	75	)/	1000	)/	11.0				
ΔkW$_a$	=	1.442																		
ΔkW$_{cool}$	**=**	**1.442**																		
ΔMMbtu$_a$	=(((	Roof Uvalue$_{base}$	x	Roof SF$_{base}$	)-(	Roof Uvalue$_{ee}$	x	Roof SF$_{ee}$	))x(	T$_{indoor, setpoint}$	-	T$_{outdoor, design}$	)/	1000	)x	EFLH$_{heat}$	/	Eff$_{FuelHeat}$	/	1000
ΔMMbtu$_a$	=(((	0.050	x	68000	)-(	0.033	x	68000	))x(	70	-	0	)/	1000	)x	960	/	80%	/	1000
ΔMMbtu$_a$	=	95																		
ΔMMBtu	**=**	**95**																		
Δtherm	**=**	**952**																		

Roof		
Roof SF Upper	68000	SF
Existing: Built-Up roofing, 3" insulation R=5	0.050	U
New: 6" Insulation, R=5/in, R-30 total	0.033	U
Cooling Efficiency	11	EER
Cooling Efficiency	14.2	IPLV
Heating Elec Efficiency N/A	0.0	COP
Heating Fuel Efficiency	80%	Eff

Total ΔkWh	**=**	**433**
Total ΔkW	**=**	**1.442**
Δtherm	**=**	**952**
Δ$ kWh	**=**	**$36.67**
Δ$ natural gas	**=**	**$493.16**

Windows

double pane windows w. AC w/ fuel heat Primary School

ΔkWh/100 SF	550
ΔkW/100 SF	0
Δtherms/100 SF	62.3
SF	2000
CF	0.477
SEER$_{part}$	14
EER$_{part}$	11.2
EFF$_{part}$	75%
SEER$_{baseline}$	14
EER$_{baseline}$	11.2
EFF$_{baseline}$	80%

Windows

ΔkWh	=(	SF/100	)x(	ΔkWh/100 SF	)x(	SEER$_{baseline}$	/	SEER$_{part}$	)			
ΔkWh	=(	2000 / 100	)x(	550	)x(	14 / 14	)					
ΔkWh	=(	20.00	)x(	550	)x(	1	)					
ΔkWh	**=**	**11000.00**										
ΔkW	=(	SF/100	)x(	ΔkW/100 SF	)x(	EER$_{baseline}$	/	EER$_{part}$	) x	CF		
ΔkW	=(	2000 / 100	)x(	0	)x(	11.2 / 11.2	)x(	0.477	)			
ΔkW	=(	20.00	)x(	0	)x(	1	)x(	0.477	)			
ΔkW	**=**	**0.00**										
ΔMMbtu	=(	SF/100	)x((	Δtherms/100 SF	)/	10	)x(	EER$_{baseline}$	/	EER$_{part}$	)	
ΔMMbtu	=(	2000 / 100	)x((	62.3	)/	10	)x(	0.8 / 0.75	)			
ΔMMbtu	=(	20.00	)x((	62.3	)/	10	)x(	1.07	)			
ΔMMbtu	**=**	**132.91**										

ΔMMBtu	**=**	**228.11**
Δtherm	**=**	**2281**

TOTAL EEM-2		
Total ΔkWh	**=**	**11433**
Total ΔkW	**=**	**1.44**
Δtherm	**=**	**3233.07**
Δ$ kWh	**=**	**$968.65**
Δ$ natural gas	**=**	**$1,674.82**

Smith Intermediate School

Room Temp Setpoint Cooling	75	°F
OA Temp Setpoint Cooling	89	°F
Room Temp Setpoint Heating	70	°F
OA Temp Setpoint Heating	0	°F
EFLH Cooling and Heating, Syracuse		
High School, Cooling	0	$EFLH_{cool}$
High School, Heating	960	$EFLH_{heat}$
Baseline NYS TRM - Code air handling unit		
11 EER, 80% Efficiency		

Roof

ΔkWh_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)x	$EFLH_{cool}$	/	IPLV
ΔkWh_a	=(((	0.050	x	60000	)-(	0.033	x	60000	))x(	89	-	75	)/	1000	)x	0	/	14.2
ΔkWh_a	=	0																
ΔkWh_{cool}	**=**	**0**																
ΔkWh_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	COPx3.412
ΔkWh_a	=(((	0.050	x	60000	)-(	0.033	x	60000	))x(	70	-	0	)/	1000	)x	960	/	0.00
ΔkWh_a	=	0																
ΔkWh_{heat}	**=**	**0**																
ΔkW_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)/	EER		
ΔkW_a	=(((	0.050	x	60000	)-(	0.033	x	60000	))x(	89	-	75	)/	1000	)/	11.0		
ΔkW_a	=	1.273																
ΔkW_{cool}	**=**	**1.273**																

Roof

Roof SF Upper	60000	SF
Existing: Built-Up roofing, 3" insulation R=5	0.050	U
New: 6" Insulation, R=5/in, R-30 total	0.033	U
Cooling Efficiency	11	EER
Cooling Efficiency	14.2	IPLV
Heating Elec Efficiency N/A	0.0	COP
Heating Fuel Efficiency	80%	Eff

$\Delta MMbtu_a$	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	$Eff_{FuelHeat}$	/	1000
$\Delta MMbtu_a$	=(((	0.050	x	60000	)-(	0.033	x	60000	))x(	70	-	0	)/	1000	)x	960	/	80%	/	1000
$\Delta MMbtu_a$	=	84																		

ΔMMBtu	**=**	**84**
Δtherm	**=**	**840**

Total ΔkWh	**=**	**0**
Total ΔkW	**=**	**1.273**
Δtherm	**=**	**840**
Δ$ kWh	**=**	**$0.00**
Δ$ natural gas	**=**	**$433.79**

Windows

double pane windows w/ fuel heat Primary School

ΔkWh/100 SF	550	
ΔkW/100 SF	0	
Δtherms/100 SF	62.3	
SF	2000	
CF	0.477	
$SEER_{part}$	0	
EER_{part}	0	
EFF_{part}	80%	
$SEER_{baseline}$	14	
$EER_{baseline}$	11.2	
$EFF_{baseline}$	80%	

Windows

ΔkWh	=(	SF/100	)x(	ΔkWh/100 SF	)x(	$SEER_{baseline}$	/	$SEER_{part}$	)			
ΔkWh	=(	2000 / 100	)x(	550	)x(	14 / 0	)					
ΔkWh	=(	20.00	)x(	550	)x(	#DIV/0!	)					
ΔkWh	**=**	**0.00**										
ΔkW	=(	SF/100	)x(	ΔkW/100 SF	)x(	$EER_{baseline}$	/	EER_{part}	) x	CF		
ΔkW	=(	2000 / 100	)x(	0	)x(	11.2 / 0	)x(	0.477	)			
ΔkW	=(	20.00	)x(	0	)x(	#DIV/0!	)x(	0.477	)			
ΔkW	**=**	**0.00**										
ΔMMbtu	=(	SF/100	)x((	Δtherms/100 SF	)/	10	)x(	$EER_{baseline}$	/	EER_{part}	)	
ΔMMbtu	=(	2000 / 100	)x((	62.3	)/	10	)x(	0.8 / 0.8	)			
ΔMMbtu	=(	20.00	)x((	62.3	)/	10	)x(	1.00	)			
ΔMMbtu	**=**	**124.60**										

ΔMMBtu	**=**	**208.60**
Δtherm	**=**	**2086**

TOTAL EEM-2		
Total ΔkWh	**=**	**0**
Total ΔkW	**=**	**1.27**
Δtherm	**=**	**2926.00**
Δ$ kWh	**=**	**$0.00**
Δ$ natural gas	**=**	**$1,511.05**

District Offices/Bus Garage

Room Temp Setpoint Cooling	75	°F
OA Temp Setpoint Cooling	89	°F
Room Temp Setpoint Heating	70	°F
OA Temp Setpoint Heating	0	°F
EFLH Cooling and Heating, Syracuse		
Auto Repair, Cooling	298	$EFLH_{cool}$
Auto Repair, Heating	3271	$EFLH_{heat}$
Baseline NYS TRM - Code air handling unit		
11 EER, 80% Efficiency		

Roof

ΔkWh_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)x	$EFLH_{cool}$	/	IPLV
ΔkWh_a	=(((	0.049	x	24000	)-(	0.037	x	24000	))x(	89	-	75	)/	1000	)x	298	/	14.2
ΔkWh_a	=	86																

ΔkWh_{cool}	=	**86**

ΔkWh_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	COPx3.412
ΔkWh_a	=(((	0.049	x	24000	)-(	0.037	x	24000	))x(	70	-	0	)/	1000	)x	3271	/	0.00
ΔkWh_a	=	0																

ΔkWh_{heat}	=	**0**

ΔkW_a	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{outdoor, design}$	-	$T_{indoor, setpoint}$	)/	1000	)/	EER
ΔkW_a	=(((	0.049	x	24000	)-(	0.037	x	24000	))x(	89	-	75	)/	1000	)/	11.0
ΔkW_a	=	0.374														

Roof

Roof SF Upper	24000	SF
Existing: Metal roofing, 6" Batt w/ Vinyl backing vapor barrier	0.049	U
New: 8" Batt Insulation	0.037	U
Cooling Efficiency	11	EER
Cooling Efficiency	14.2	IPLV
Heating Elec Efficiency N/A	0.0	COP
Heating Fuel Efficiency	80%	Eff

ΔkW_{cool}	=	**0.374**

$\Delta MMbtu_a$	=(((	Roof $Uvalue_{base}$	x	Roof SF_{base}	)-(	Roof $Uvalue_{ee}$	x	Roof SF_{ee}	))x(	$T_{indoor, setpoint}$	-	$T_{outdoor, design}$	)/	1000	)x	$EFLH_{heat}$	/	$Eff_{FuelHeat}$	/	1000
$\Delta MMbtu_a$	=(((	0.049	x	24000	)-(	0.037	x	24000	))x(	70	-	0	)/	1000	)x	3271	/	80%	/	1000
$\Delta MMbtu_a$	=	84																		

ΔMMBtu	=	**84**
Δtherm	=	**842**

Total ΔkWh	=	**86**
Total ΔkW	=	**0.374**
Δtherm	=	**842**
Δ$ kWh	=	**$7.71**
Δ$ natural gas	=	**$605.08**

Windows

double pane windows w. air source heat pump - small office

ΔkWh/100 SF	834
ΔkW/100 SF	0.156
Δtherms/100 SF	0
SF	200
CF	0.477
$SEER_{part}$	14
EER_{part}	11.2
EFF_{part}	80%
$SEER_{baseline}$	14
$EER_{baseline}$	11.2
$EFF_{baseline}$	80%

Windows

ΔkWh	=(	SF/100	)x(	ΔkWh/100 SF	)x(	$SEER_{baseline}$	/	$SEER_{part}$	)
ΔkWh	=(	200 / 100	)x(	834	)x(	14 / 14	)	
ΔkWh	=(	2.00	)x(	834	)x(	1	)	

ΔkWh	=	**1668.00**

ΔkW	=(	SF/100	)x(	ΔkW/100 SF	)x(	$EER_{baseline}$	/	EER_{part}	) x	CF
ΔkW	=(	200 / 100	)x(	0.156	)x(	11.2 / 11.2	)x(	0.477	)	
ΔkW	=(	2.00	)x(	0.156	)x(	1	)x(	0.477	)	

ΔkW	=	**0.15**

ΔMMbtu	=(	SF/100	)x((	Δtherms/100 SF	)/	10	)x(	$EER_{baseline}$	/	EER_{part})
ΔMMbtu	=(	200 / 100	)x((	0	)/	10	)x(	0.8 / 0.8	)	
ΔMMbtu	=(	2.00	)x((	0	)/	10	)x(	1.00	)	

ΔMMbtu	=	**0.00**

ΔMMBtu	=	**84.18**
Δtherm	=	**842**

TOTAL EEM-2		
Total ΔkWh	=	**1754**
Total ΔkW	=	**0.52**
Δtherm	=	**1683.60**
Δ$ kWh	=	**$156.86**
Δ$ natural gas	=	**$1,210.16**

EEM-3: Occupied / Unoccupied Controls

JR/SR High School

Temperature setback are in place
Pneumatic System to Direct Digital Control (DDC) System Upgrade

LF_{comp}	0.8
LF_{dryer}	0.8
LF_{idle}	0.254
Air_{loss}	0.1
$ACFM_r$	1
ACFM	1
kW / 100CFM	1
Cycle	0.5
Hrs	8760
$kW_{comp,Fan Motor}$	1
$kW_{comp,Comp Motor}$	1
$hp_{dryer, Fan Motor}$	1
$hp_{dryer, Comp Motor}$	1
$hp_{comp, Fan Motor}$	1
$hp_{comp, Comp Motor}$	1
$EFF_{dryer, Fan Motor}$	0.8
$EFF_{dryer,Comp Motor}$	0.8
$EFF_{comp, Fan Motor}$	1
$EFF_{comp, Comp Motor}$	1
CF	0.8

$kW / 100\ CFM = ((hp_{comp, Fan Motor} \times 0.746 / EFF_{comp,Comp Motor}))/(ACFM / 100)$

$kW / 100\ CFM = ((1 \times 0.746 / 1))/(0.01)$

$kW / 100\ CFM = 75$

Annual Electric Energy Savings

$\Delta kWh_{comp} = units \times ((LF_{comp} \times (1 + Air_{loss}) \times (ACFM_r / 100) \times (kW / 100\ CFM) \times Cycle \times hrs) + (LF_{idle} \times (kW_{comp,Fan Motor} + kW_{comp,Comp Motor}) \times (1\text{-}Cycle) \times hrs))$

$\Delta kWh_{comp} = 1 \times ((0.8 \times (1.1) \times (0.01) \times (1) \times 0.5 \times 8760) + (0.254 \times (1 + 1) \times (0.5) \times 8760))$

$\Delta kWh_{comp} = 2264$

$\Delta kWh_{dryer} = units \times LF_{comp} \times ((hp_{dryer, Fan Motor} \times 0.746 / EFF_{dryer,Fan Motor}) + (hp_{dryer,Comp Motor} \times 0.746 / EFF_{dryer,Comp Motor})) \times Cycle \times hrs$

$\Delta kWh_{dryer} = 1 \times 0.8 \times ((1 \times 0.746 / 0.8) + (1 \times 0.746 / 0.8)) \times 0.5 \times 8760$

$\Delta kWh_{dryer} = 6535$

$\Delta kWh = \Delta kWh_{comp} + \Delta kWh_{dryer}$

$\Delta kWh = 8799$

Summer Peak Coincident Demand Savings

$\Delta kW_{comp} = units \times LF_{comp} \times (ACFM/100) \times (1 + Air_{loss}) \times (kW / 100\ CFM) \times CF$

$\Delta kW_{comp} = 1 \times 0.8 \times (0.01) \times (1.1) \times (75) \times 0.8$

$\Delta kW_{comp} = 0.53$

$\Delta kW_{dryer} = units \times LF_{dryer} \times ((hp_{dryer,Fan Motor} \times 0.746 / EFF_{dryer,Fan Motor}) + (hp_{dryer,Comp Motor} \times 0.746 / EFF_{dryer,Comp Motor})) \times Cycle \times CF$

$\Delta kW_{dryer} = 1 \times 0.8 \times ((1 \times 0.746 / 0.8) + (1 \times 0.746 / 0.8)) \times 0.5 \times 0.8$

$\Delta kW_{dryer} = 0.60$

$\Delta kW = \Delta kW_{comp} + \Delta kW_{dryer}$

$\Delta kW = 1.12$

TOTAL EEM-3		
Total ΔkWh	**=**	**8799**
Total ΔkW	**=**	**1.12**
Δ$ kWh	**=**	**$667.27**

Barry Primary School

Temperature setback are in place
Pneumatic System to Direct Digital Control (DDC) System Upgrade

LF_{comp}	0.8
LF_{dryer}	0.8
LF_{idle}	0.254
Air_{loss}	0.1
$ACFM_r$	1
ACFM	1
kW / 100CFM	1
Cycle	0.5
Hrs	8760
$kW_{comp,Fan Motor}$	1
$kW_{comp,Comp Motor}$	1
$hp_{dryer, Fan Motor}$	1
$hp_{dryer, Comp Motor}$	1
$hp_{comp, Fan Motor}$	1
$hp_{comp, Comp Motor}$	1
$EFF_{dryer, Fan Motor}$	0.8
$EFF_{dryer,Comp Motor}$	0.8
$EFF_{comp, Fan Motor}$	1
$EFF_{comp, Comp Motor}$	1
CF	0.8

$kW / 100\ CFM = ((hp_{comp, Fan Motor} \times 0.746 / EFF_{comp,Comp Motor}))/(ACFM / 100)$

$kW / 100\ CFM = ((1 \times 0.746 / 1))/(0.01)$

$kW / 100\ CFM = 75$

Annual Electric Energy Savings

$\Delta kWh_{comp} = units \times ((LF_{comp} \times (1 + Air_{loss}) \times (ACFM_r / 100) \times (kW / 100\ CFM) \times Cycle \times hrs) + (LF_{idle} \times (kW_{comp,Fan Motor} + kW_{comp,Comp Motor}) \times (1\text{-}Cycle) \times hrs))$

$\Delta kWh_{comp} = 1 \times ((0.8 \times (1.1) \times (0.01) \times (1) \times 0.5 \times 8760) + (0.254 \times (1 + 1) \times (0.5) \times 8760))$

$\Delta kWh_{comp} = 2264$

$\Delta kWh_{dryer} = units \times LF_{comp} \times ((hp_{dryer, Fan Motor} \times 0.746 / EFF_{dryer,Fan Motor}) + (hp_{dryer,Comp Motor} \times 0.746 / EFF_{dryer,Comp Motor})) \times Cycle \times hrs$

$\Delta kWh_{dryer} = 1 \times 0.8 \times ((1 \times 0.746 / 0.8) + (1 \times 0.746 / 0.8)) \times 0.5 \times 8760$

$\Delta kWh_{dryer} = 6535$

$\Delta kWh = \Delta kWh_{comp} + \Delta kWh_{dryer}$

$\Delta kWh = 8799$

Summer Peak Coincident Demand Savings

$\Delta kW_{comp} = units \times LF_{comp} \times (ACFM/100) \times (1 + Air_{loss}) \times (kW / 100\ CFM) \times CF$

$\Delta kW_{comp} = 1 \times 0.8 \times (0.01) \times (1.1) \times (75) \times 0.8$

$\Delta kW_{comp} = 0.53$

$\Delta kW_{dryer} = units \times LF_{dryer} \times ((hp_{dryer,Fan Motor} \times 0.746 / EFF_{dryer,Fan Motor}) + (hp_{dryer,Comp Motor} \times 0.746 / EFF_{dryer,Comp Motor})) \times Cycle \times CF$

$\Delta kW_{dryer} = 1 \times 0.8 \times ((1 \times 0.746 / 0.8) + (1 \times 0.746 / 0.8)) \times 0.5 \times 0.8$

$\Delta kW_{dryer} = 0.60$

$\Delta kW = \Delta kW_{comp} + \Delta kW_{dryer}$

$\Delta kW = 1.12$

TOTAL EEM-3		
Total ΔkWh	**=**	**8799**
Total ΔkW	**=**	**1.12**
Δ$ kWh	**=**	**$745.47**

Smith Intermediate School

Temperature setback are in place

Pneumatic System to Direct Digital Control (DDC) System Upgrade

LF_{comp}	0.8
LF_{dryer}	0.8
LF_{idle}	0.254
Air_{loss}	0.1
$ACFM_r$	1
ACFM	1
kW / 100CFM	1
Cycle	0.5
Hrs	8760
$kW_{comp,Fan\ Motor}$	1
$kW_{comp,Comp\ Motor}$	1
$hp_{dryer,\ Fan\ Motor}$	1
$hp_{dryer,\ Comp\ Motor}$	1
$hp_{comp,\ Fan\ Motor}$	1
$hp_{comp,\ Comp\ Motor}$	1
$EFF_{dryer,\ Fan\ Motor}$	0.8
$EFF_{dryer,Comp\ Motor}$	0.8
$EFF_{comp,\ Fan\ Motor}$	1
$EFF_{comp,\ Comp\ Motor}$	1
CF	0.8

kW / 100 CFM =(($hp_{comp,\ Fan\ Motor}$ x 0.746 / $EFF_{comp,Comp\ Motor}$))/(ACFM / 100)

kW / 100 CFM =((1 x 0.746 / 1))/(0.01)

kW / 100 CFM = 75

Annual Electric Energy Savings

ΔkWh_{comp} = units x((LF_{comp} x(1 + Air_{loss})x($ACFM_r$ /100)x(kW / 100 CFM)x Cycle x hrs)+(LF_{idle} x($kW_{comp,Fan\ Motor}$ + $kW_{comp,Comp\ Motor}$)x(1-Cycle)x hrs))

ΔkWh_{comp} = 1 x((0.8 x(1.1)x(0.01)x(1)x 0.5 x 8760)+(0.254 x(1 + 1)x(0.5)x 8760))

ΔkWh_{comp} = 2264

ΔkWh_{dryer} = units x LF_{comp} x(($hp_{dryer,\ Fan\ Motor}$ x 0.746 / $EFF_{dryer,Fan\ Motor}$)+($hp_{dryer,Comp\ Motor}$ x 0.746 / $EFF_{dryer,Comp\ Motor}$))x Cycle x hrs

ΔkWh_{dryer} = 1 x 0.8 x((1 x 0.746 / 0.8)+(1 x 0.746 / 0.8))x 0.5 x 8760

ΔkWh_{dryer} = 6535

ΔkWh = ΔkWh_{comp} + ΔkWh_{dryer}

ΔkWh = 8799

Summer Peak Coincident Demand Savings

ΔkW_{comp} = units x LF_{comp} x(ACFM/100)x(1 + Air_{loss})x(kW / 100 CFM)x CF

ΔkW_{comp} = 1 x 0.8 x(0.01)x(1.1)x(75)x 0.8

ΔkW_{comp} = 0.53

ΔkW_{dryer} = units x LF_{dryer} x(($hp_{dryer,Fan\ Motor}$ x 0.746 / $EFF_{dryer,Fan\ Motor}$)+($hp_{dryer,Comp\ Motor}$ x 0.746 / $EFF_{dryer,Comp\ Motor}$))x Cycle x CF

ΔkW_{dryer} = 1 x 0.8 x((1 x 0.746 / 0.8)+(1 x 0.746 / 0.8))x 0.5 x 0.8

ΔkW_{dryer} = 0.60

ΔkW = ΔkW_{comp} + ΔkW_{dryer}

ΔkW = 1.12

TOTAL EEM-3		
Total ΔkWh	**=**	**8799**
Total ΔkW	**=**	**1.12**
Δ$ kWh	**=**	**$765.74**

EEM-4: Heating and Cooling Plant Upgrades

JR/SR High School

EEM-4a: Install High Efficiency Boiler

units	1
$kBTU/h_{in}$	12500
Eff_{ee}	95%
$Eff_{baseline}$	80%
$EFLH_{heating}$	960

Annual Fuel Energy Savings

ΔMMBtu	=	units	x	$kBTU/h_{in}$	/	unit	x(	Eff_{ee}	/	$Eff_{baseline}$	-	1	)x	$EFLH_{heating}$	/	1,000
ΔMMBtu	=	1	x	12500	/	1	x(	95%	/	80%	-	1	)x	960	/	1,000

ΔMMBtu	=	**2250**
Δtherm	=	**22500**

TOTAL EEM-4a		
Total ΔkWh	=	**0**
Total ΔkW	=	**0.00**
Δtherm	=	**22500**
Δ$ kWh	=	**$0.00**
Δ$ natural gas	=	**$10,732**

EEM-4b: Install Ground Source Heat Pump (GSHP) System

BCL	4,500,000	BTU/h
BHL	7,500,000	BTU/h
$F_{ElecHeat}$	0	
$F_{FuelHeat}$	1	
$EER_{season,baseline}$	14.0	BTU/W-hr
$EER_{peak,baseline}$	11.2	BTU/W-hı
$EER_{season,ee}$	14.71	BTU/W-hı
$EER_{GSHP,full,ee}$	18	BTU/W-hı
$COP_{season,baseline}$	4.10	
$COP_{season,ee}$	3.05	
$Eff_{baseline}$	80%	
$EFLH_{cooling}$	388	
$EFLH_{heating}$	960	
CF	0.8	

Annual Electric Energy Savings

ΔkWh	=(	BCL / 1,000	x(	$1/EER_{season,baseline}$	-	$1/EER_{season,ee}$	)x	$EFLH_{cooling}$	)+(	BHL / 3,412	x(	$F_{ElecHeat}$	/	$COP_{season,baseline}$	-	$1 / COP_{season,ee}$	)x	$EFLH_{heating}$)
ΔkWh	=(	4500	x(	0.071	-	0.068	)x	388	)+(	2198	x(	0	/	4.10	-	0.33	)x	960)

ΔkWh	=	**(685849)**

Summer Peak Coincident Demand Savings

ΔkW	=	BCL / 1,000	x(	$1/EER_{peak,baseline}$	-	$1/EER_{GSHP,full,ee}$	)x	CF
ΔkW	=	4500	x(	0.089285714	-	0.055555556	)x	0.8

ΔkW	=	**121**

Annual Fuel Energy Savings

ΔMMBtu	=	BHL / 1,000,000	x	$F_{FuelHeat}$	/	$Eff_{baseline}$	x	$EFLH_{heating}$
ΔMMBtu	=	7.50	x	1	/	80%	x	960

ΔMMBtu	=	**9000**
Δtherm	=	**90000**

TOTAL EEM-4b		
Total ΔkWh	=	**-685849**
Total ΔkW	=	**121.43**
Δtherm	=	**90000**
Δ$ kWh	=	**($52,014.05)**
Δ$ natural gas	=	**$42,928.45**

Barry Primary School

EEM-4: Heating and Cooling Plant Upgrades

EEM-4a: Install High Efficiency Steam Boiler

units	1
$kBTU/h_{in}$	4185
Eff_{ee}	85%
$Eff_{baseline}$	75%
$EFLH_{heating}$	960

Annual Fuel Energy Savings

ΔMMBtu	=	units	x	$kBTU/h_{in}$	/	unit	x(	Eff_{ee}	/	$Eff_{baseline}$	-	1	)x	$EFLH_{heating}$	/	1,000
ΔMMBtu	=	1	x	4185	/	1	x(	85%	/	75%	-	1	)x	960	/	1,000
ΔMMBtu	**=**	**536**														
Δtherm	**=**	**5357**														

TOTAL EEM-4a		
Total ΔkWh	=	0
Total ΔkW	=	0.00
Δtherm	=	5357
Δ$ kWh	=	$0.00
Δ$ natural gas	=	$2,775

EEM-4b: Convert to High Efficiency Hot Water Boilers & Distribution

units	1
$kBTU/h_{in}$	4185
Eff_{ee}	95%
$Eff_{baseline}$	75%
$EFLH_{heating}$	960

Annual Fuel Energy Savings

ΔMMBtu	=	units	x	$kBTU/h_{in}$	/	unit	x(	Eff_{ee}	/	$Eff_{baseline}$	-	1	)x	$EFLH_{heating}$	/	1,000
ΔMMBtu	=	1	x	4185	/	1	x(	95%	/	75%	-	1	)x	960	/	1,000
ΔMMBtu	**=**	**1071**														
Δtherm	**=**	**10714**														

TOTAL EEM-4a		
Total ΔkWh	=	0
Total ΔkW	=	0.00
Δtherm	=	10714
Δ$ kWh	=	$0.00
Δ$ natural gas	=	$5,550

EEM-4c: Install Central Ground Source Heat Pump (GSHP) System

BCL	168,000	BTU/h
BHL	2,511,000	BTU/h
$F_{ElecHeat}$	0	
$F_{FuelHeat}$	1	
$EER_{season,baseline}$	11.2	BTU/W-hr
$EER_{peak,baseline}$	11.2	BTU/W-hr
$EER_{season,ee}$	14.71	BTU/W-hr
$EER_{GSHP,full,ee}$	18	BTU/W-hr
$COP_{season,baseline}$	3.28	
$COP_{season,ee}$	3.05	
$Eff_{baseline}$	75%	
$EFLH_{cooling}$	388	
$EFLH_{heating}$	960	
CF	0.8	

Annual Electric Energy Savings

ΔkWh	=(	BCL / 1,000	x(	$1/EER_{season,baseline}$	-	$1/EER_{season,ee}$	)x	$EFLH_{cooling}$	)+(	BHL / 3,412	x(	$F_{ElecHeat}$	/	$COP_{season,baseline}$	-	$1 / COP_{season,ee}$	)x	$EFLH_{heating}$	)
ΔkWh	=(	168	x(	0.089	-	0.068	)x	388	)+(	736	x(	0	/	3.28	-	0.33	)x	960	)
ΔkWh	**=**	**(230249)**																	

Summer Peak Coincident Demand Savings

ΔkW	=	BCL / 1,000	x(	$1/EER_{peak,baseline}$	-	$1/EER_{GSHP,full,ee}$	)x	CF
ΔkW	=	168	x(	0.089	-	0.056	)x	0.8
ΔkW	**=**	**5**						

Annual Fuel Energy Savings

ΔMMBtu	=	BHL / 1,000,000	x	$F_{FuelHeat}$	/	$Eff_{baseline}$	x	$EFLH_{heating}$
ΔMMBtu	=	2.51	x	1	/	75%	x	960
ΔMMBtu	**=**	**3214**						
Δtherm	**=**	**32141**						

TOTAL EEM-4c		
Total ΔkWh	=	-230249
Total ΔkW	=	4.53
Δtherm	=	32141
Δ$ kWh	=	($19,508.09)
Δ$ natural gas	=	$16,649.83

EEM-4d: Install Terminal Ground Source Heat Pump (GSHP) System

BCL	168,000	BTU/h
BHL	2,511,000	BTU/h
$F_{ElecHeat}$	0	
$F_{FuelHeat}$	1	
$EER_{season,baseline}$	11.2	BTU/W-hr
$EER_{peak,baseline}$	11.2	BTU/W-hr
$EER_{season,ee}$	14.71	BTU/W-hr
$EER_{GSHP,full,ee}$	18	BTU/W-hr
$COP_{season,baseline}$	3.28	
$COP_{season,ee}$	3.05	
$Eff_{baseline}$	75%	
$EFLH_{cooling}$	388	
$EFLH_{heating}$	960	
CF	0.8	

Annual Electric Energy Savings

$$\Delta kWh = \left(BCL / 1{,}000 \times \left(1/EER_{season,baseline} - 1/EER_{season,ee}\right) \times EFLH_{cooling}\right) + \left(BHL / 3{,}412 \times \left(F_{ElecHeat} / COP_{season,baseline} - 1 / COP_{season,ee}\right) \times EFLH_{heating}\right)$$

$$\Delta kWh = \left(168 \times \left(0.089 - 0.068\right) \times 388\right) + \left(736 \times \left(0 / 3.28 - 0.33\right) \times 960\right)$$

ΔkWh	**=**	**(230249)**

Summer Peak Coincident Demand Savings

$$\Delta kW = BCL / 1{,}000 \times \left(1/EER_{peak,baseline} - 1/EER_{GSHP,full,ee}\right) \times CF$$

$$\Delta kW = 168 \times \left(0.089 - 0.056\right) \times 0.8$$

ΔkW	**=**	**5**

Annual Fuel Energy Savings

$$\Delta MMBtu = BHL / 1{,}000{,}000 \times F_{FuelHeat} / Eff_{baseline} \times EFLH_{heating}$$

$$\Delta MMBtu = 2.51 \times 1 / 75\% \times 960$$

ΔMMBtu	**=**	**3214**
Δtherm	**=**	**32141**

TOTAL EEM-4c		
Total ΔkWh	**=**	**-230249**
Total ΔkW	**=**	**4.53**
Δtherm	**=**	**32141**
Δ$ kWh	**=**	**($19,508.09)**
Δ$ natural gas	**=**	**$16,649.83**

Smith Intermediate School

EEM-4: Heating and Cooling Plant Upgrades

EEM-4a: Install High Efficiency Steam Boiler

units	1
kBTU/h_{in}	4,184
Eff_{ee}	85%
$Eff_{baseline}$	75%
$EFLH_{heating}$	960

Annual Fuel Energy Savings

ΔMMBtu	=	units	x	kBTU/h_{in}	/	unit	x(	Eff_{ee}	/	$Eff_{baseline}$	-	1	)x	$EFLH_{heating}$	/ 1,000
ΔMMBtu	=	1	x	4184	/	1	x(	85%	/	75%	-	1	)x	960	/ 1,000

ΔMMBtu	=	**536**
Δtherm	=	**5356**

TOTAL EEM-4a		
Total ΔkWh	=	**0**
Total ΔkW	=	**0.00**
Δtherm	=	**5356**
Δ$ kWh	=	**$0.00**
Δ$ natural gas	=	**$2,766**

EEM-4b: Convert to High Efficiency Hot Water Boilers & Distribution

units	1
kBTU/h_{in}	4,184
Eff_{ee}	95%
$Eff_{baseline}$	75%
$EFLH_{heating}$	960

Annual Fuel Energy Savings

ΔMMBtu	=	units	x	kBTU/h_{in}	/	unit	x(	Eff_{ee}	/	$Eff_{baseline}$	-	1	)x	$EFLH_{heating}$	/ 1,000
ΔMMBtu	=	1	x	4184	/	1	x(	95%	/	75%	-	1	)x	960	/ 1,000

ΔMMBtu	=	**1071**
Δtherm	=	**10711**

TOTAL EEM-4a		
Total ΔkWh	=	**0**
Total ΔkW	=	**0.00**
Δtherm	=	**10711**
Δ$ kWh	=	**$0.00**
Δ$ natural gas	=	**$5,531**

EEM-4c: Install Central Ground Source Heat Pump (GSHP) System

BCL	96,000	BTU/h
BHL	2,511,000	BTU/h
$F_{ElecHeat}$	0	
$F_{FuelHeat}$	1	
$EER_{season,baseline}$	14	BTU/W-hr
$EER_{peak,baseline}$	11.2	BTU/W-hr
$EER_{season,ee}$	14.71	BTU/W-hr
$EER_{GSHP,full,ee}$	18	BTU/W-hr
$COP_{season,baseline}$	4.10	
$COP_{season,ee}$	3.05	
$Eff_{baseline}$	75%	
$EFLH_{cooling}$	388	
$EFLH_{heating}$	960	
CF	0.8	

Annual Electric Energy Savings

ΔkWh	=(	BCL / 1,000	x(	1/$EER_{season,baseline}$	-	1/$EER_{season,ee}$	)x	$EFLH_{cooling}$	)+(	BHL / 3,412	x(	$F_{ElecHeat}$	/	$COP_{season,baseline}$	-	1 / $COP_{season,ee}$	)x	$EFLH_{heating}$)
ΔkWh	=(	96	x(	0.071	-	0.068	)x	388	)+(	736	x(	0	/	4.10	-	0.33	)x	960)

ΔkWh	=	**(231509)**

Summer Peak Coincident Demand Savings

ΔkW	=	BCL / 1,000	x(	1/$EER_{peak,baseline}$	-	1/$EER_{GSHP,full,ee}$	)x	CF
ΔkW	=	96	x(	0.089	-	0.056	)x	0.8

ΔkW	=	**3**

Annual Fuel Energy Savings

ΔMMBtu	=	BHL / 1,000,000	x	$F_{FuelHeat}$	/	$Eff_{baseline}$	x	$EFLH_{heating}$
ΔMMBtu	=	2.51	x	1	/	75%	x	960

ΔMMBtu	=	**3214**
Δtherm	=	**32141**

TOTAL EEM-4c		
Total ΔkWh	=	**-231509**
Total ΔkW	=	**2.59**
Δtherm	=	**32141**
Δ$ kWh	=	**($20,148.37)**
Δ$ natural gas	=	**$16,598.20**

EEM-4d: Install Terminal Ground Source Heat Pump (GSHP) System

Input	Value	Unit
BCL	168,000	BTU/h
BHL	2,511,000	BTU/h
$F_{ElecHeat}$	0	
$F_{FuelHeat}$	1	
$EER_{season,baseline}$	14	BTU/W-hr
$EER_{peak,baseline}$	11.2	BTU/W-hr
$EER_{season,ee}$	14.71	BTU/W-hr
$EER_{GSHP,full,ee}$	18	BTU/W-hr
$COP_{season,baseline}$	4.10	
$COP_{season,ee}$	3.05	
$Eff_{baseline}$	75%	
$EFLH_{cooling}$	388	
$EFLH_{heating}$	960	
CF	0.8	

Annual Electric Energy Savings

$$\Delta kWh = (BCL / 1{,}000 \times (1/EER_{season,baseline} - 1/EER_{season,ee}) \times EFLH_{cooling}) + (BHL / 3{,}412 \times (F_{ElecHeat} / COP_{season,baseline} - 1 / COP_{season,ee}) \times EFLH_{heating})$$

$$\Delta kWh = (168 \times (0.071 - 0.068) \times 388) + (736 \times (0 / 4.10 - 0.33) \times 960)$$

ΔkWh = (231413)

Summer Peak Coincident Demand Savings

$$\Delta kW = BCL / 1{,}000 \times (1/EER_{peak,baseline} - 1/EER_{GSHP,full,ee}) \times CF$$

$$\Delta kW = 168 \times (0.089 - 0.056) \times 0.8$$

ΔkW = 5

Annual Fuel Energy Savings

$$\Delta MMBtu = BHL / 1{,}000{,}000 \times F_{FuelHeat} / Eff_{baseline} \times EFLH_{heating}$$

$$\Delta MMBtu = 2.51 \times 1 / 75\% \times 960$$

$\Delta MMBtu$ = 3214

$\Delta therm$ = 32141

TOTAL EEM-4c		
Total ΔkWh	=	**-231413**
Total ΔkW	=	**4.53**
Δtherm	=	**32141**
Δ$ kWh	=	**($20,139.99)**
Δ$ natural gas	=	**$16,598.20**

District Offices/Bus Garage

EEM-4: Heating and Cooling Plant Upgrades

EEM-4a: Air Source Heat Pump (VRF)

BCL	72,000	BTU/h
BHL	1,004,400	BTU/h
$EFLH_{cooling}$	768	
$EFLH_{heating}$	750	
$SEER_{baseline}$	13	
$EER_{baseline}$	11.2	
EER_{ee}	13	
$EER_{season,ee}$	13.9	
$COP_{season,baseline}$	3.8	
$COP_{season,ee}$	4.1	
$F_{ElecHeat}$	0	
$F_{ElecHeat,new}$	0	
$F_{FuelHeat}$	1	
$F_{load,cooling}$	1	
$F_{load,heating}$	1	
$F_{load,heating,ElecHeat}$	1	
$F_{load,heating,FuelHeat}$	1	
CF	0.8	

ΔkWh	=((	BCL x 1/1,000	x(	$1/SEER_{baseline}$	-	$1/EER_{season,ee}$	)x	$EFLH_{cooling}$	x	$F_{load,cooling}$	)+(	BHL x 1/1,000	x(	$F_{ElecHeat}$	/	$COP_{season,baseline}$	-	$1/COP_{season,ee}$	)x
		1/3.412	x	$EFLH_{heating}$	x	$F_{load,heating,ElecHeat}$	)-(	BHL x 1/1,000	x	$F_{ElecHeat,new}$	x	1/3.412	x	$EFLH_{heating}$	x(	$1-F_{load,heating}$	)))		
ΔkWh	=((	72	x(	0.077	-	0.072	)x	768	x	1	)+(	1004.4	x(	0	/	3.810	-	0.245	)x
		0.293	x	750	x	1	)-(	1004	x	0	x	0.293	x	750	x(	0	)))		
ΔkWh	**=**	**(53,918.84)**																	

ΔkW	=	BCL	x	1/1,000	x(	$1/EER_{baseline}$	-	$1/EER_{ee}$	)x	$F_{load,cooling}$	x	CF
ΔkW	=	72,000	x	0.001	x(	0.089	-	0.077	)x	1	x	0.8
ΔkW	**=**	**0.71**										

ΔMMBtu	=	BHL	x	1/1,000,000	x	$F_{FuelHeat}$	/	$EFF_{baseline}$	x	$EFLH_{heating}$	x	$F_{load,heating,ElecHeat}$
ΔMMBtu	=	1,004,400	x	0.000001	x	1	/	11.2	x	750	x	1
ΔMMBtu	**=**	**67.26**										
Δtherm	**=**	**673**										

Total ΔkWh	**=**	**-53919**
Total ΔkW	**=**	**0.71**
Δtherm	**=**	**673**
Δ$ kWh	**=**	**($4,821.33)**
Δ$ natural gas	**=**	**$483.45**

EEM-4b: Install Ground Source Heat Pump (GSHP) System

BCL	72,000	BTU/h
BHL	1,004,400	BTU/h
$F_{ElecHeat}$	0	
$F_{FuelHeat}$	1	
$EER_{season,baseline}$	14	BTU/W-hr
$EER_{peak,baseline}$	11.2	BTU/W-h
$EER_{season,ee}$	14.71	BTU/W-h
$EER_{GSHP,full,ee}$	18	BTU/W-h
$COP_{season,baseline}$	4.10	
$COP_{season,ee}$	3.05	
$Eff_{baseline}$	80%	
$EFLH_{cooling}$	388	
$EFLH_{heating}$	960	
CF	0.8	

Annual Electric Energy Savings

ΔkWh	=(	BCL / 1,000	x(	$1/EER_{season,baseline}$	-	$1/EER_{season,ee}$	)x	$EFLH_{cooling}$	)+(	BHL / 3,412	x(	$F_{ElecHeat}$	/	$COP_{season,baseline}$	- 1 / $COP_{season,ee}$	)x	$EFLH_{heating}$	)
ΔkWh	=(	72	x(	0.071	-	0.068	)x	388	)+(	294	x(	0	/	4.10	- 0.33	)x	960	)
ΔkWh	**=**	**(92559)**															

Summer Peak Coincident Demand Savings

ΔkW	=	BCL / 1,000	x(	$1/EER_{peak,baseline}$	-	$1/EER_{GSHP,full,ee}$	)x	CF
ΔkW	=	72	x(	11.2	-	18	)x	0.8
ΔkW	**=**	**(392)**						

Annual Fuel Energy Savings

ΔMMBtu	=	BHL / 1,000,000	x	$F_{FuelHeat}$	/	$Eff_{baseline}$	x	$EFLH_{heating}$
ΔMMBtu	=	1.00	x	1	/	80%	x	960
ΔMMBtu	**=**	**1205**						
Δtherm	**=**	**12053**						

TOTAL EEM-4b		
Total ΔkWh	**=**	**-92559**
Total ΔkW	**=**	**-391.68**
Δtherm	**=**	**12053**
Δ$ kWh	**=**	**($8,276.45)**
Δ$ natural gas	**=**	**$8,663.47**

EEM-5: Solar Thermal Heat Recovery Opportunities

Jr/Sr High School

Month	Day Of Month	n Day Of Year	CT Clock Time [hr] (Local standard time)	l Latitude [degrees]	L_{loc} Longitude of Actual Location [deg west]	L_{std} Standard Meridian for local time zone [deg west]	Date 2006 used to match bin data (January starts on a Sunday and Feburary has 28 days)	Week Of Month	DOW Day Of Week [Sunday=1 to Saturday=7]	Day Of Week Adjusted [Sunday=1 to Saturday=7, Holiday = 8]	1st, 2nd, 3rd, etc. Sunday of month (CAREFUL! Formula changes after 1 wk!)	Daylight Savings Starts (2nd Sunday of March 2am becomes 3am, spring ahead to daylight time)	Daylight Savings Ends (1st Sunday of November 2am becomes 1am, fall back to standard time)	DT Corrected Time For Daylight Savings [hr]
1.00	1.00	1.00	1.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	1.00
1.00	1.00	1.00	2.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	2.00
1.00	1.00	1.00	3.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	3.00

Y Fractional Year [Radians]	EOT Equation Of Time [Min]	E Equation Of Time [hr]	AST Apparent Solar Time [hr]	h hour angle [degrees]	δ declination [degrees]	Σ Tilt Angle [degrees]	θ_H Solar Zenith Angle [degrees]	β solar altitude angle [degrees]	Check β solar altitude angle [degrees]	φ solar azimuth angle [degrees]	east/ west	ψ surface azimuth angle (off south) [degrees]	γ surface-solar azimuth angle [degrees]
-0.0079	-2.70	-0.04	0.88	-166.77	-23.01	90.00	157.11	-67.11	-67.11	-147.22	EAST	-45.00	102.22
-0.0072	-2.72	-0.05	1.88	-151.78	-23.01	90.00	149.23	-59.23	-59.23	-121.71	EAST	-45.00	76.71
-0.0065	-2.74	-0.05	2.88	-136.78	-23.01	90.00	139.19	-49.19	-49.19	-105.36	EAST	-45.00	60.36

θ Incidence Angle [degrees]	I_{DN} Direct Normal Radiation [BTUh/ft^2]	I_D Direct Solar Radiation [BTUh/ft^2]	I_{dh} Diffuse Horizontal Radiation [BTUh/ft^2]	I_d Diffuse Solar Raditiaon [BTUh/ft^2]	I_{GH} Global Horizontal Raditiaon [BTUh/ft^2]	I_H Horizontal Solar Radiaiton [BTUh/ft^2]	DB Dry Bulb Temperature [°F]	ρ_g Ground Solar Reflectance	I_R Reflected Solar Radiation [BTUh/ft^2]	I Total Solar Radiation On Surface [BTUh/ft2]	I Total Solar Irradiance on Surface [Wh/m^2]		HEAT On =1 Off = 0 DB ° F < Heat limit	COOL On =1 Off = 0 DB ° F > Cool limit
94.72	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.31	0.00	0.00	0.00		1	0
83.25	0.00	0.00	0.00	0.00	0.00	0.00	30.40	0.29	0.00	0.00	0.00		1	0
71.14	0.00	0.00	0.00	0.00	0.00	0.00	30.60	0.28	0.00	0.00	0.00		1	0

Full ECON On=1 Off=0 DB °F > Heat limit and DB °F < Cool limit	Partial ECON On=1 Off=0 DB °F > Cool and DB °F < Max limit	heat/cool/econ	Ventilation OA Needed Total [Cfm]	Ventilation OA Needed Duct Total [Cfm]	Ventilation Through Duct Collectors [Cfm]	Ventilation Bypass Duct Collectors [Cfm]	Ventilation EA Req'd Cfm		G_{max} Global solar radiation incident in the plane of the collector [BTUh/ft2]	G_{max} Global solar radiation incident in the plane of the collector [Wh/m2]	A Collector Area [ft^2]	A Collector Area [m^2]	G_{coll} solar energy usable by the collector [BTUh]	G_{coll} solar energy usable by the collector [Wh]
0	0	HEAT	0	0	0	0	0		0.00	0.00	1,600.00	148.64	0.00	0.00
0	0	HEAT	0	0	0	0	0		0.00	0.00	1,600.00	148.64	0.00	0.00
0	0	HEAT	0	0	0	0	0		0.00	0.00	1,600.00	148.64	0.00	0.00

α Shortwave absorptivity of the collector	v wind speed mph	v wind speed ft/min	v wind speed m/s	Qcoll Ventilation through Collectors cfm	Qcoll Ventilation through Collectors m^3/hr	η collector efficiency	ΔTavl available temperature rise °F	ΔTavl available temperature rise °C	DB outdoor air temp °F	DB outdoor air temp °C	$T_{delivered\ avl}$ Avaliable delivered air temperature °F (ΔT_{avl}+DB)	$T_{delivered\ avl}$ Avaliable delivered air temperature °C (ΔT_{avl}+DB)	RA ° F (If sensible energy recovery device is present)	RA ° C (If sensible energy recovery device is present)
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	30.000	-1.111	30.000	-1.111	65.000	18.333
0.95	1.57	138.16	0.70	0.00	0.00	0.00	0.00	0.000	30.400	-0.889	30.400	-0.889	65.000	18.333
0.95	3.13	275.44	1.40	0.00	0.00	0.00	0.00	0.000	30.600	-0.778	30.600	-0.778	65.000	18.333

$T_{delivered\ max}$ Maximum delivered air temperature °F	$T_{delivered\ max}$ Maximum delivered air temperature °C	$T_{delivered\ actual}$ Actual delivered air temperature °F	$T_{delivered\ actual}$ Actual delivered air temperature °C	ΔTact actual temperature rise through collector °F	ΔTact actual temperature rise through collector °C	Qsolar Solar energy Btuh	Qsolar Solar energy Wh	Qsolar Solar energy Check Btuh	Qsolar Solar energy Check Wh		Total Annual Ventilation Heating Energy Required Btuh	Total Annual Ventilation Heating Energy Required Wh
47.759	8.755	30.000	-1.111	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
47.759	8.755	30.400	-0.889	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
47.759	8.755	30.600	-0.778	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00

SOLAR PANEL ENERGY MODELING RESULTS DUCT COLLECTOR ANTICIPATED VENTILATION COSTS W/O SOLAR THERMAL				
MONTH	**BTUS REQUIRED**	**BTUS REQUIRED WITH 80% EFFICIENT HEATING PLANT**	**THERMS**	**COST AT $0.477 PER THERM**
JANUARY	50,231,994	62,789,993	608	$371.93
FEBRUARY	46,833,370	58,541,712	567	$346.77
MARCH	29,801,945	37,252,431	361	$220.66
APRIL	11,740,288	14,675,360	142	$86.93
MAY	746,050	932,563	9	$5.52
JUNE	29,352	36,690	0	$0.22
JULY	0	0	0	$0.00
AUGUST	0	0	0	$0.00
SEPTEMBER	1,148,330	1,435,412	14	$8.50
OCTOBER	2,510,484	3,138,105	30	$18.59
NOVEMBER	10,347,209	12,934,011	125	$76.61
DECEMBER	47,609,018	59,511,273	577	$352.51
TOTAL	***200,998,040***	***251,247,549***	***2,435***	***$1,488.25***

SOLAR PANEL ENERGY MODELING RESULTS DUCT COLLECTOR FINAL ADJUSTED VENTILATION COSTS USING SOLAR THERMAL				
MONTH	**BTUS REQUIRED**	**BTUS REQUIRED WITH 80% EFFICIENT HEATING PLANT**	**THERMS**	**COST AT $0.477 PER THERM**
JANUARY	39,866,076	49,832,595	483	$295.18
FEBRUARY	32,698,310	40,872,887	396	$242.11
MARCH	17,124,956	21,406,195	207	$126.80
APRIL	7,581,063	9,476,329	92	$56.13
MAY	301,997	377,496	4	$2.24
JUNE	0	0	0	$0.00
JULY	0	0	0	$0.00
AUGUST	0	0	0	$0.00
SEPTEMBER	989,056	1,236,320	12	$7.32
OCTOBER	2,078,761	2,598,451	25	$15.39
NOVEMBER	7,686,768	9,608,460	93	$56.92
DECEMBER	38,893,107	48,616,384	471	$287.98
TOTAL	***147,220,094***	***184,025,118***	***1,783***	***$1,090.06***

Barry Primary School

Month	Day Of Month	n Day Of Year	CT Clock Time [hr] (Local standard time)	l Latitude [degrees]	L_{loc} Longitude of Actual Location [deg west]	L_{std} Standard Meridian for local time zone [deg west]	Date 2006 used to match bin data (January starts on a Sunday and Feburary has 28 days)	Week Of Month	DOW Day Of Week [Sunday=1 to Saturday=7]	Day Of Week Adjusted [Sunday=1 to Saturday=7, Holiday = 8]	1st, 2nd, 3rd, etc. Sunday of month (CAREFUL! Formula changes after 1 wk!)	Daylight Savings Starts (2nd Sunday of March 2am becomes 3am, spring ahead to daylight time)	Daylight Savings Ends (1st Sunday of November 2am becomes 1am, fall back to standard time)	DT Corrected Time For Daylight Savings [hr]
1.00	1.00	1.00	1.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	1.00
1.00	1.00	1.00	2.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	2.00
1.00	1.00	1.00	3.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	3.00

Y Fractional Year [Radians]	EOT Equation Of Time [Min]	E Equation Of Time [hr]	AST Apparent Solar Time [hr]	h hour angle [degrees]	δ declination [degrees]	Σ Tilt Angle [degrees]	$θ_H$ Solar Zenith Angle [degrees]	β solar altitude angle [degrees]	Check β solar altitude angle [degrees]	φ solar azimuth angle [degrees]	east/ west	ψ surface azimuth angle (off south) [degrees]	γ surface-solar azimuth angle [degrees]
-0.0079	-2.70	-0.04	0.88	-166.77	-23.01	35.00	157.11	-67.11	-67.11	-147.22	EAST	0.00	147.22
-0.0072	-2.72	-0.05	1.88	-151.78	-23.01	35.00	149.23	-59.23	-59.23	-121.71	EAST	0.00	121.71
-0.0065	-2.74	-0.05	2.88	-136.78	-23.01	35.00	139.19	-49.19	-49.19	-105.36	EAST	0.00	105.36

θ Incidence Angle [degrees]	I_{DN} Direct Normal Radiation [BTUh/ft^2]	I_D Direct Solar Radiation [BTUh/ft^2]	I_{dh} Diffuse Horizontal Radiation [BTUh/ft^2]	I_d Diffuse Solar Raditiaon [BTUh/ft^2]	I_{GH} Global Horizontal Raditiaon [BTUh/ft^2]	I_H Horizontal Solar Radiaiton [BTUh/ft^2]	DB Dry Bulb Temperature [°F]	$ρ_g$ Ground Solar Reflectance	I_R Reflected Solar Radiation [BTUh/ft^2]	I Total Solar Radiation On Surface [BTUh/ft2]	I Total Solar Irradiance on Surface [Wh/m^2]		HEAT On =1 Off = 0 DB ° F < Heat limit	COOL On =1 Off = 0 DB ° F > Cool limit
160.43	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.31	0.00	0.00	0.00		1	0
149.10	0.00	0.00	0.00	0.00	0.00	0.00	30.40	0.29	0.00	0.00	0.00		1	0
135.99	0.00	0.00	0.00	0.00	0.00	0.00	30.60	0.28	0.00	0.00	0.00		1	0

Full ECON On=1 Off=0 DB °F > Heat limit and DB °F < Cool limit	Partial ECON On=1 Off=0 DB °F > Cool and DB °F < Max limit	heat/cool/econ	Ventilation OA Needed Total [Cfm]	Ventilation OA Needed Duct Total [Cfm]	Ventilation Through Duct Collectors [Cfm]	Ventilation Bypass Duct Collectors [Cfm]	Ventilation EA Req'd Cfm		G_{max} Global solar radiation incident in the plane of the collector [BTUh/ft2]	G_{max} Global solar radiation incident in the plane of the collector [Wh/m2]	A Collector Area [ft^2]	A Collector Area [m^2]	G_{coll} solar energy usable by the collector [BTUh]	G_{coll} solar energy usable by the collector [Wh]
0	0	HEAT	0	0	0	0	0		0.00	0.00	800.00	74.32	0.00	0.00
0	0	HEAT	0	0	0	0	0		0.00	0.00	800.00	74.32	0.00	0.00
0	0	HEAT	0	0	0	0	0		0.00	0.00	800.00	74.32	0.00	0.00

α Shortwave absorptivity of the collector	v wind speed mph	v wind speed ft/min	v wind speed m/s	Qcoll Ventilation through Collectors cfm	Qcoll Ventilation through Collectors m^3/hr	η collector efficiency	ΔTavl available temperature rise °F	ΔTavl available temperature rise °C	DB outdoor air temp °F	DB outdoor air temp °C	$T_{delivered\ avl}$ Avaliable delivered air temperature °F (ΔT_{avl}+DB)	$T_{delivered\ avl}$ Avaliable delivered air temperature °C (ΔT_{avl}+DB)	RA ° F (If sensible energy recovery device is present)	RA ° C (If sensible energy recovery device is present)
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	30.000	-1.111	30.000	-1.111	65.000	18.333
0.95	1.57	138.16	0.70	0.00	0.00	0.00	0.00	0.000	30.400	-0.889	30.400	-0.889	65.000	18.333
0.95	3.13	275.44	1.40	0.00	0.00	0.00	0.00	0.000	30.600	-0.778	30.600	-0.778	65.000	18.333

$T_{delivered\ max}$ Maximum delivered air temperature °F	$T_{delivered\ max}$ Maximum delivered air temperature °C	$T_{delivered\ actual}$ Actual delivered air temperature °F	$T_{delivered\ actual}$ Actual delivered air temperature °C	ΔTact actual temperature rise through collector °F	ΔTact actual temperature rise through collector °C	Qsolar Solar energy Btuh	Qsolar Solar energy Wh	Qsolar Solar energy Check Btuh	Qsolar Solar energy Check Wh		Total Annual Ventilation Heating Energy Required Btuh	Total Annual Ventilation Heating Energy Required Wh
47.759	8.755	30.000	-1.111	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
47.759	8.755	30.400	-0.889	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
47.759	8.755	30.600	-0.778	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00

SOLAR PANEL ENERGY MODELING RESULTS DUCT COLLECTOR ANTICIPATED VENTILATION COSTS W/O SOLAR THERMAL				
MONTH	**BTUS REQUIRED**	**BTUS REQUIRED WITH 80% EFFICIENT HEATING PLANT**	**THERMS**	**COST AT $0.518 PER THERM**
JANUARY	22,794,733	28,493,417	276	$168.78
FEBRUARY	21,252,474	26,565,593	257	$157.36
MARCH	13,523,799	16,904,749	164	$100.13
APRIL	5,327,615	6,659,519	65	$39.45
MAY	338,550	423,187	4	$2.51
JUNE	13,320	16,650	0	$0.10
JULY	0	0	0	$0.00
AUGUST	0	0	0	$0.00
SEPTEMBER	521,099	651,374	6	$3.86
OCTOBER	1,139,230	1,424,038	14	$8.44
NOVEMBER	4,695,451	5,869,314	57	$34.77
DECEMBER	21,604,455	27,005,569	262	$159.97
TOTAL	***91,210,727***	***114,013,409***	***1,105***	***$675.35***

SOLAR PANEL ENERGY MODELING RESULTS DUCT COLLECTOR FINAL ADJUSTED VENTILATION COSTS USING SOLAR THERMAL				
MONTH	**BTUS REQUIRED**	**BTUS REQUIRED WITH 80% EFFICIENT HEATING PLANT**	**THERMS**	**COST AT $0.518 PER THERM**
JANUARY	17,787,018	22,233,773	215	$131.70
FEBRUARY	14,614,668	18,268,334	177	$108.21
MARCH	7,784,758	9,730,947	94	$57.64
APRIL	3,433,311	4,291,639	42	$25.42
MAY	182,958	228,698	2	$1.35
JUNE	3,397	4,246	0	$0.03
JULY	0	0	0	$0.00
AUGUST	0	0	0	$0.00
SEPTEMBER	449,052	561,315	5	$3.32
OCTOBER	976,815	1,221,019	12	$7.23
NOVEMBER	3,574,437	4,468,046	43	$26.47
DECEMBER	17,670,087	22,087,609	214	$130.83
TOTAL	***66,476,500***	***83,095,625***	***805***	***$492.21***

Smith Intermediate School

Month	Day Of Month	n Day Of Year	CT Clock Time [hr] (Local standard time)	l Latitude [degrees]	L_{loc} Longitude of Actual Location [deg west]	L_{std} Standard Meridian for local time zone [deg west]	Date 2006 used to match bin data (January starts on a Sunday and Feburary has 28 days)	Week Of Month	DOW Day Of Week [Sunday=1 to Saturday=7]	Day Of Week Adjusted [Sunday=1 to Saturday=7, Holiday = 8]	1st, 2nd, 3rd, etc. Sunday of month (CAREFUL! Formula changes after 1 wk!)	Daylight Savings Starts (2nd Sunday of March 2am becomes 3am, spring ahead to daylight time)	Daylight Savings Ends (1st Sunday of November 2am becomes 1am, fall back to standard time)	DT Corrected Time For Daylight Savings [hr]
1.00	1.00	1.00	1.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	1.00
1.00	1.00	1.00	2.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	2.00
1.00	1.00	1.00	3.00	43.12	76.10	75.00	1/1/2006	1	3	3	0	0	0	3.00

Y Fractional Year [Radians]	EOT Equation Of Time [Min]	E Equation Of Time [hr]	AST Apparent Solar Time [hr]	h hour angle [degrees]	δ declination [degrees]	Σ Tilt Angle [degrees]	θ_H Solar Zenith Angle [degrees]	β solar altitude angle [degrees]	Check β solar altitude angle [degrees]	φ solar azimuth angle [degrees]	east/ west	ψ surface azimuth angle (off south) [degrees]	γ surface-solar azimuth angle [degrees]
-0.0079	-2.70	-0.04	0.88	-166.77	-23.01	35.00	157.11	-67.11	-67.11	-147.22	EAST	0.00	147.22
-0.0072	-2.72	-0.05	1.88	-151.78	-23.01	35.00	149.23	-59.23	-59.23	-121.71	EAST	0.00	121.71
-0.0065	-2.74	-0.05	2.88	-136.78	-23.01	35.00	139.19	-49.19	-49.19	-105.36	EAST	0.00	105.36

θ Incidence Angle [degrees]	I_{DN} Direct Normal Radiation [BTUh/ft^2]	I_D Direct Solar Radiation [BTUh/ft^2]	I_{dh} Diffuse Horizontal Radiation [BTUh/ft^2]	I_d Diffuse Solar Raditiaon [BTUh/ft^2]	I_{GH} Global Horizontal Raditiaon [BTUh/ft^2]	I_H Horizontal Solar Radiaiton [BTUh/ft^2]	DB Dry Bulb Temperature [°F]	ρ_g Ground Solar Reflectance	I_R Reflected Solar Radiation [BTUh/ft^2]	I Total Solar Radiation On Surface [BTUh/ft2]	I Total Solar Irradiance on Surface [Wh/m^2]		HEAT On =1 Off = 0 DB ° F < Heat limit	COOL On =1 Off = 0 DB ° F > Cool limit
160.43	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.31	0.00	0.00	0.00		1	0
149.10	0.00	0.00	0.00	0.00	0.00	0.00	30.40	0.29	0.00	0.00	0.00		1	0
135.99	0.00	0.00	0.00	0.00	0.00	0.00	30.60	0.28	0.00	0.00	0.00		1	0

Full ECON On=1 Off=0 DB °F > Heat limit and DB °F < Cool limit	Partial ECON On=1 Off=0 DB °F > Cool and DB °F < Max limit	heat/cool/econ	Ventilation OA Needed Total [Cfm]	Ventilation OA Needed Duct Total [Cfm]	Ventilation Through Duct Collectors [Cfm]	Ventilation Bypass Duct Collectors [Cfm]	Ventilation EA Req'd Cfm		G_{max} Global solar radiation incident in the plane of the collector [BTUh/ft2]	G_{max} Global solar radiation incident in the plane of the collector [Wh/m2]	A Collector Area [ft^2]	A Collector Area [m^2]	G_{coll} solar energy usable by the collector [BTUh]	G_{coll} solar energy usable by the collector [Wh]
0	0	HEAT	0	0	0	0	0		0.00	0.00	800.00	74.32	0.00	0.00
0	0	HEAT	0	0	0	0	0		0.00	0.00	800.00	74.32	0.00	0.00
0	0	HEAT	0	0	0	0	0		0.00	0.00	800.00	74.32	0.00	0.00

α Shortwave absorptivity of the collector	v wind speed mph	v wind speed ft/min	v wind speed m/s	Qcoll Ventilation through Collectors cfm	Qcoll Ventilation through Collectors m^3/hr	η collector efficiency	ΔTavl available temperature rise °F	ΔTavl available temperature rise °C	DB outdoor air temp °F	DB outdoor air temp °C	$T_{delivered\ avl}$ Avaliable delivered air temperature °F (ΔT_{avl}+DB)	$T_{delivered\ avl}$ Avaliable delivered air temperature °C (ΔT_{avl}+DB)	RA ° F (If sensible energy recovery device is present)	RA ° C (If sensible energy recovery device is present)
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	30.000	-1.111	30.000	-1.111	65.000	18.333
0.95	1.57	138.16	0.70	0.00	0.00	0.00	0.00	0.000	30.400	-0.889	30.400	-0.889	65.000	18.333
0.95	3.13	275.44	1.40	0.00	0.00	0.00	0.00	0.000	30.600	-0.778	30.600	-0.778	65.000	18.333

$T_{delivered\ max}$ Maximum delivered air temperature °F	$T_{delivered\ max}$ Maximum delivered air temperature °C	$T_{delivered\ actual}$ Actual delivered air temperature °F	$T_{delivered\ actual}$ Actual delivered air temperature °C	ΔTact actual temperature rise through collector °F	ΔTact actual temperature rise through collector °C	Qsolar Solar energy Btuh	Qsolar Solar energy Wh	Qsolar Solar energy Check Btuh	Qsolar Solar energy Check Wh		Total Annual Ventilation Heating Energy Required Btuh	Total Annual Ventilation Heating Energy Required Wh
47.759	8.755	30.000	-1.111	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
47.759	8.755	30.400	-0.889	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
47.759	8.755	30.600	-0.778	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00

SOLAR PANEL ENERGY MODELING RESULTS DUCT COLLECTOR ANTICIPATED VENTILATION COSTS W/O SOLAR THERMAL				
MONTH	**BTUS REQUIRED**	**BTUS REQUIRED WITH 80% EFFICIENT HEATING PLANT**	**THERMS**	**COST AT $0.5164 PER THERM**
JANUARY	22,794,733	28,493,417	276	$168.78
FEBRUARY	21,252,474	26,565,593	257	$157.36
MARCH	13,523,799	16,904,749	164	$100.13
APRIL	5,327,615	6,659,519	65	$39.45
MAY	338,550	423,187	4	$2.51
JUNE	13,320	16,650	0	$0.10
JULY	0	0	0	$0.00
AUGUST	0	0	0	$0.00
SEPTEMBER	521,099	651,374	6	$3.86
OCTOBER	1,139,230	1,424,038	14	$8.44
NOVEMBER	4,695,451	5,869,314	57	$34.77
DECEMBER	21,604,455	27,005,569	262	$159.97
TOTAL	***91,210,727***	***114,013,409***	***1,105***	***$675.35***

SOLAR PANEL ENERGY MODELING RESULTS DUCT COLLECTOR FINAL ADJUSTED VENTILATION COSTS USING SOLAR THERMAL				
MONTH	**BTUS REQUIRED**	**BTUS REQUIRED WITH 80% EFFICIENT HEATING PLANT**	**THERMS**	**COST AT $0.5164 PER THERM**
JANUARY	17,787,018	22,233,773	215	$131.70
FEBRUARY	14,614,668	18,268,334	177	$108.21
MARCH	7,784,758	9,730,947	94	$57.64
APRIL	3,433,311	4,291,639	42	$25.42
MAY	182,958	228,698	2	$1.35
JUNE	3,397	4,246	0	$0.03
JULY	0	0	0	$0.00
AUGUST	0	0	0	$0.00
SEPTEMBER	449,052	561,315	5	$3.32
OCTOBER	976,815	1,221,019	12	$7.23
NOVEMBER	3,574,437	4,468,046	43	$26.47
DECEMBER	17,670,087	22,087,609	214	$130.83
TOTAL	***66,476,500***	***83,095,625***	***805***	***$492.21***

EEM-6: Outdoor Air Energy Recovery Opportunities

JR/SR High School - AHU- 8 - Locker Rooms

EFLH Cooling and Heating, Syracuse

High School, Cooling	388	$EFLH_{cool}$
High School, Heating	960	$EFLH_{heat}$
Ventilation, 100% OA	5000	cfm OA
	70	$T_{indoor, heating}$
	42.11	$T_{outdoor, heating}$
	75	$T_{indoor, cooling}$
	71.94	$T_{outdoor, cooling}$
	0	$Eff_{hx, sens base}$
	0.5	$Eff_{hx, sens ee}$
Cooling Efficiency	11.2	EER
	80	$Eff_{ElecHeat}$
Additional fan power due to ER PD only	0.16	kW_{fan}

ΔkWh_{ERU1}	=[((	1.08	x	cfm OA	x(	$Eff_{hx, sens ee}$	-	$Eff_{hx, sens base}$	)x(	$T_{indoor, heating}$	-	$T_{outdoor, heating}$	))/(	1000	x	$Eff_{ElecHeat}$	))x	$F_{ElecHeat}$	)-	kW_{fan}	]x	$EFLH_{heat}$
ΔkWh_{ERU1}	=[((	1.08	x	5000	x(	0.50	-	0.00	)x(	70.00	-	42.11	))/(	1000	x	80.00	))x	1	)-	0.16	]x	960
ΔkWh_{ERU1}	=	749																				

ΔkWh$_{heat}$	**=**	**749**

ΔkWh_{ERU1}	=[((	1.08	x	cfm OA	x(	$Eff_{hx, sens ee}$	-	$Eff_{hx, sens base}$	)x(	$T_{outdoor, cooling}$	-	$T_{indoor, cooling}$	))/(	1000	x	$Eff_{ElecCool}$	))-	kW_{fan}	]x	$EFLH_{cool}$
ΔkWh_{ERU1}	=[((	1.08	x	5000	x(	0.50	-	0.00	)x(	71.94	-	75.00	))/(	1000	x	11.2	))-	0.16	]x	388
ΔkWh_{ERU1}	=	-349																		

ΔkWh$_{cool}$	**=**	**-349**

ΔkW_{ERU1}	=[((	1.08	x	cfm OA	x(	$Eff_{hx, sens ee}$	-	$Eff_{hx, sens base}$	)x(	$T_{outdoor, cooling}$	-	$T_{indoor, cooling}$	))/(	1000	x	$Eff_{ElecCool}$	))-	kW_{fan}	]x	CF
ΔkW_{ERU1}	=[((	1.08	x	5000	x(	0.50	-	0.00	)x(	71.94	-	75.00	))/(	1000	x	11.2	))-	0.16	]x	0.8
ΔkW_{ERU1}	=	-0.719																		

ΔkW	**=**	**-0.719**

$\Delta MMbtu_{ERU1}$	=[(	1.08	x	cfm OA	x(	$Eff_{hx, sens ee}$	-	$Eff_{hx, sens base}$	)x(	$T_{indoor, heating}$	-	$T_{outdoor, heating}$	))/(	1000000	x	$Eff_{FuelHeat}$	)]x	$F_{FuelHeat}$	x	$EFLH_{heat}$
$\Delta MMbtu_{ERU1}$	=[(	1.08	x	5000	x(	0.50	-	0.00	)x(	70.00	-	42.11	))/(	1000000	x	80.00	)]x	1	x	960
$\Delta MMbtu_{ERU1}$	=	0.904																		

ΔMMbtu	**=**	**0.904**
Δtherm	**=**	**9**

Total ΔkWh	**=**	**400**
Total ΔkW	**=**	**-0.719**
Δtherm	**=**	**9.036**
Δ$ kWh	**=**	**$30.32**
Δ$ natural gas	=	**$4.31**

EEM-7: Kitchen Hood Controls

JR/SR High School

units	1
hp	1.0
ΔkWh/hp	1968
ΔkW/hp	0.411
CF	0.8
ft^2 / 1,000	12.1
$ESF_{cooling}$	296
$ESF_{heating}$	13.7

Annual Electric Energy Savings

ΔkWh_{exh}	=	units	x	hp	x(	ΔkWh/hp	)			
ΔkWh_{exh}	=	1	x	1	x(	1968	)			
ΔkWh_{exh}	**=**	**1968**								
ΔkWh_{sup}	=	ft^2 / 1,000	x	$ESF_{cooling}$						
ΔkWh_{sup}	=	12	x	296						
ΔkWh_{sup}	**=**	**3582**								

Summer Peak Coincident Demand Savings

ΔkW_{exh}	=	units	x	hp	x(	ΔkW/hp	)x	CF
ΔkW_{exh}	=	1	x	1	x(	0.411	)x	0.8
ΔkW_{exh}	**=**	**0.33**						

Annual Fuel Energy Savings

$\Delta MMBtu_{sup}$	=	ft^2 / 1,000	x	$ESF_{heating}$
$\Delta MMBtu_{sup}$	=	12	x	13.7
$\Delta MMBtu_{sup}$	**=**	**166**		
$\Delta therm_{sup}$	**=**	**1658**		

TOTAL EEM-7		
Total ΔkWh	**=**	**5550**
Total ΔkW	**=**	**0.33**
Δtherm	**=**	**1658**
Δ$ kWh	**=**	**$420.88**
Δ$ natural gas	=	**$790.69**

Randall Middle School

units	1
hp	0.5
ΔkWh/hp	1968
ΔkW/hp	0.411
CF	0.8
ft^2 / 1,000	4.8
$ESF_{cooling}$	296
$ESF_{heating}$	13.7

Annual Electric Energy Savings

ΔkWh_{exh} = units x hp x(ΔkWh/hp)

ΔkWh_{exh} = 1 x 0.5 x(1968)

ΔkWh_{exh} = 984

ΔkWh_{sup} = ft^2 / 1,000 x $ESF_{cooling}$

ΔkWh_{sup} = 5 x 296

ΔkWh_{sup} = 1421

Summer Peak Coincident Demand Savings

ΔkW_{exh} = units x hp x(ΔkW/hp)x CF

ΔkW_{exh} = 1 x 0.5 x(0.411)x 0.8

ΔkW_{exh} = 0.16

Annual Fuel Energy Savings

$\Delta MMBtu_{sup}$ = ft^2 / 1,000 x $ESF_{heating}$

$\Delta MMBtu_{sup}$ = 5 x 13.7

$\Delta MMBtu_{sup}$ = 66

$\Delta therm_{sup}$ = 658

TOTAL EEM-7		
Total ΔkWh	=	2405
Total ΔkW	=	0.16
Δtherm	=	658
Δ$ kWh	=	$207.42
Δ$ natural gas	=	$373.96

Barry Primary School

units	1
hp	0.5
ΔkWh/hp	1968
ΔkW/hp	0.411
CF	0.8
ft^2 / 1,000	6.4
$ESF_{cooling}$	296
$ESF_{heating}$	13.7

Annual Electric Energy Savings

ΔkWh_{exh}	=	units	x	hp	x(	ΔkWh/hp	)
ΔkWh_{exh}	=	1	x	0.5	x(	1968	)
ΔkWh_{exh}	**=**	**984**					

ΔkWh_{sup}	=	ft^2 / 1,000	x	$ESF_{cooling}$
ΔkWh_{sup}	=	6	x	296
ΔkWh_{sup}	**=**	**1894**		

Summer Peak Coincident Demand Savings

ΔkW_{exh}	=	units	x	hp	x(	ΔkW/hp	)x	CF
ΔkW_{exh}	=	1	x	0.5	x(	0.411	)x	0.8
ΔkW_{exh}	**=**	**0.16**						

Annual Fuel Energy Savings

$\Delta MMBtu_{sup}$	=	ft^2 / 1,000	x	$ESF_{heating}$
$\Delta MMBtu_{sup}$	=	6	x	13.7
$\Delta MMBtu_{sup}$	**=**	**88**		
$\Delta therm_{sup}$	**=**	**877**		

TOTAL EEM-7		
Total ΔkWh	=	**2878**
Total ΔkW	=	**0.16**
Δtherm	=	**877**
Δ$ kWh	=	**$243.88**
Δ$ natural gas	=	**$454.21**

Smith Intermediate School

units	1
hp	0.5
ΔkWh/hp	1968
ΔkW/hp	0.411
CF	0.8
ft^2 / 1,000	6.4
$ESF_{cooling}$	296
$ESF_{heating}$	13.7

Annual Electric Energy Savings

ΔkWh_{exh} = units x hp x(ΔkWh/hp)

ΔkWh_{exh} = 1 x 0.5 x(1968)

ΔkWh_{exh} = 984

ΔkWh_{sup} = ft^2 / 1,000 x $ESF_{cooling}$

ΔkWh_{sup} = 6 x 296

ΔkWh_{sup} = 1894

Summer Peak Coincident Demand Savings

ΔkW_{exh} = units x hp x(ΔkW/hp)x CF

ΔkW_{exh} = 1 x 0.5 x(0.411)x 0.8

ΔkW_{exh} = 0.16

Annual Fuel Energy Savings

$\Delta MMBtu_{sup}$ = ft^2 / 1,000 x $ESF_{heating}$

$\Delta MMBtu_{sup}$ = 6 x 13.7

$\Delta MMBtu_{sup}$ = 88

$\Delta therm_{sup}$ = 877

TOTAL EEM-7		
Total ΔkWh	=	2878
Total ΔkW	=	0.16
Δtherm	=	877
Δ$ kWh	=	$250.51
Δ$ natural gas	=	$452.80

EEM-8: Steam Trap Replacement

Barry Primary School

units	5
ΔH_{vap}	966
Eff	0.75
$EFLH_{heating}$	960
F_{CR}	0.45
Dia	1.0
psig	2
p_{atm}	14
$F_{Discharge}$	0.7
F_{Loss}	0.37

Annual Fuel Energy Savings

$\Delta MMBtu = units \times Loss_{steam} \times \Delta H_{vap} / Eff \times EFLH_{heating} / 1{,}000{,}000 \times F_{CR}$

$\Delta MMBtu = 5 \times 180 \times 966 / 0.75 \times 960 / 1{,}000{,}000 \times 0.45$

ΔMMBtu = 500

Δtherm = 4999

$Loss_{steam} = 60 \times \pi/4 \times Dia^2 \times psia^{0.97} \times F_{Discharge} \times F_{Loss}$

$Loss_{steam} = 60 \times 0.79 \times 1 \times 14.72 \times 1 \times 0$

$Loss_{steam} = 180$

$psia = psig + p_{atm}$

$psia = 2 + 14$

$psia = 16$

TOTAL EEM-8		
Total ΔkWh	=	**0**
Total ΔkW	=	**0.00**
Δtherm	=	**4999**
Δ$ kWh	=	**$0.00**
Δ$ natural gas	=	**$2,589.76**

Smith Intermediate School

units	5
ΔH_{vap}	966
Eff	0.75
$EFLH_{heating}$	960
F_{CR}	0.45
Dia	1.0
psig	2
p_{atm}	14
$F_{Discharge}$	0.7
F_{Loss}	0.37

Annual Fuel Energy Savings

$\Delta MMBtu = units \times Loss_{steam} \times \Delta H_{vap} / Eff \times EFLH_{heating} / 1{,}000{,}000 \times F_{CR}$

$\Delta MMBtu = 5 \times 180 \times 966 / 0.75 \times 960 / 1{,}000{,}000 \times 0.45$

ΔMMBtu = 500

Δtherm = 4999

$Loss_{steam} = 60 \times \pi/4 \times Dia^2 \times psia^{0.97} \times F_{Discharge} \times F_{Loss}$

$Loss_{steam} = 60 \times 0.79 \times 1 \times 14.72 \times 1 \times 0$

$Loss_{steam} = 180$

$psia = psig + p_{atm}$

$psia = 2 + 14$

$psia = 16$

TOTAL EEM-8		
Total ΔkWh	=	**0**
Total ΔkW	=	**0.00**
Δtherm	=	**4999**
Δ$ kWh	=	**$0.00**
Δ$ natural gas	=	**$2,581.73**

EEM-9 - Solar PV - Jr/Sr High School

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Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

2,057,442 kWh/Year*

System output may range from 1,980,700 to 2,121,017 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	2.15	97,292	7,375
February	3.03	122,300	9,270
March	4.18	179,163	13,581
April	5.18	208,311	15,790
May	5.84	240,194	18,207
June	6.02	232,529	17,626
July	6.05	240,159	18,204
August	5.71	225,539	17,096
September	4.88	189,765	14,384
October	3.36	138,225	10,477
November	2.37	99,704	7,558
December	1.90	84,261	6,387
Annual	**4.22**	**2,057,442**	**$ 155,955**

Location and Station Identification

Requested Location	8 Valley View Drive Cortland, New York
Weather Data Source	Lat, Lon: 42.57, -76.18 1.3 mi
Latitude	42.57° N
Longitude	76.18° W

PV System Specifications

DC System Size	1725 kW
Module Type	Premium
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.076 $/kWh

Performance Metrics

Capacity Factor	13.6%

EEM-9 - Solar PV - Randall Middle School

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NATIONAL RENEWABLE ENERGY LABORATORY

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The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

268,909 kWh/Year*

System output may range from 258,878 to 277,218 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	2.16	12,664	1,093
February	3.05	16,077	1,387
March	4.27	23,843	2,058
April	5.18	27,176	2,345
May	5.84	31,017	2,677
June	5.84	29,697	2,563
July	6.24	32,082	2,769
August	5.70	29,535	2,549
September	4.87	24,655	2,128
October	3.39	18,210	1,572
November	2.46	13,326	1,150
December	1.81	10,627	917
Annual	**4.23**	**268,909**	**$ 23,208**

Location and Station Identification

Requested Location	31 Randall Street Cortland, New York
Weather Data Source	Lat, Lon: 42.61, -76.18 1.1 mi
Latitude	42.61° N
Longitude	76.18° W

PV System Specifications

DC System Size	225 kW
Module Type	Premium
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.086 $/kWh

Performance Metrics

Capacity Factor	13.6%

EEM-9 - Solar PV - Barry Primary School

NREL

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

262,398 kWh/Year*

System output may range from 252,611 to 270,507 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	2.15	12,408	1,051
February	3.03	15,598	1,321
March	4.18	22,850	1,935
April	5.18	26,567	2,250
May	5.84	30,633	2,595
June	6.02	29,656	2,512
July	6.05	30,629	2,594
August	5.71	28,764	2,436
September	4.88	24,202	2,050
October	3.36	17,629	1,493
November	2.37	12,716	1,077
December	1.90	10,746	910
Annual	**4.22**	**262,398**	**$ 22,224**

Location and Station Identification

Requested Location	20 Raymond Ave Cortland, New York
Weather Data Source	Lat, Lon: 42.57, -76.18 1.4 mi
Latitude	42.57° N
Longitude	76.18° W

PV System Specifications

DC System Size	220 kW
Module Type	Premium
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.085 $/kWh

Performance Metrics

Capacity Factor	13.6%

EEM-9 - Solar PV - Smith Intermediate School

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The energy output range is based on analysis of 30 years of historical weather data for nearby, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

215,127 kWh/Year*

System output may range from 207,103 to 221,774 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	2.16	10,131	881
February	3.05	12,861	1,119
March	4.27	19,075	1,659
April	5.18	21,741	1,891
May	5.84	24,814	2,159
June	5.84	23,757	2,067
July	6.24	25,665	2,233
August	5.70	23,628	2,056
September	4.87	19,724	1,716
October	3.39	14,568	1,267
November	2.46	10,661	928
December	1.81	8,501	740
Annual	**4.23**	**215,126**	**$ 18,716**

Location and Station Identification

Requested Location	33 Wheeler Avenue Cortland, New York
Weather Data Source	Lat, Lon: 42.61, -76.18 0.5 mi
Latitude	42.61° N
Longitude	76.18° W

PV System Specifications

DC System Size	180 kW
Module Type	Premium
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.087 $/kWh

Performance Metrics

Capacity Factor	13.6%

EEM-9 - Solar PV - District Offices/Bus Garage

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The energy output range is based on analysis of 30 years of historical weather data for nearby, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

208,726 kWh/Year*

System output may range from 200,941 to 215,176 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	2.15	9,870	882
February	3.03	12,407	1,109
March	4.18	18,176	1,625
April	5.18	21,133	1,889
May	5.84	24,368	2,178
June	6.02	23,590	2,109
July	6.05	24,364	2,178
August	5.71	22,881	2,046
September	4.88	19,252	1,721
October	3.36	14,023	1,254
November	2.37	10,115	904
December	1.90	8,548	764
Annual	**4.22**	**208,727**	**$ 18,659**

Location and Station Identification

Requested Location	1 Valley View Drive Cortland, New York
Weather Data Source	Lat, Lon: 42.57, -76.18 1.3 mi
Latitude	42.57° N
Longitude	76.18° W

PV System Specifications *(Residential)*

DC System Size	175 kW
Module Type	Premium
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.089 $/kWh

Performance Metrics

Capacity Factor	13.6%

BUDGET PRICING (from RS means data)

Mechanical/Electrical
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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	**ENERGY**	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-1: Lighting and Lighting Controls						
	Existing Fixtures - Cafeteria	10500	SF	$0.00	$0.00	$0
	Existing Fixtures - Library	6627	SF	$0.00	$0.00	$0
	Existing Fixtures - Stairwells	3750	SF	$0.00	$0.00	$0
	TOTAL BASECASE					$0
	LED Lighting & Controls - Cafeteria	10500	SF	$0.80	$1.73	$26,600
	LED Lighting & Controls - Library	6627	SF	$0.80	$1.73	$16,787
	LED Lighting & Controls - Stairwells	3750	SF	$0.40	$0.87	$4,750
	TOTAL PROPOSED					$48,137
	EEM-1 TOTAL INCREMENTAL COST					**$48,137**

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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	**ENERGY**	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-2: Envelope Improvements - JR/SR High School						
	Existing Roof To Remain	140,000	SF	$0.00	$0	$0
	Existing Windows to Remain	167	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Replace Roof, 6" insulation R-30	140,000	SF	$18.00	$7	$3,556,361
	Replace Single Pane Windows	167	EA	$180.00	$300	$80,160
	TOTAL PROPOSED					$3,636,521
	EEM-2 TOTAL INCREMENTAL COST					**$3,636,521**
EEM-2: Envelope Improvements - Randall Middle School						
	Existing Roof To Remain	43000	SF	$0.00	$0	$0
	Existing Windows to Remain	167	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Replace Roof, 6" insulation R-30	43,000	SF	$18.00	$7	$1,092,311
	Replace Single Pane Windows	167	EA	$180.00	$300	$80,160
	TOTAL PROPOSED					$1,172,471
	EEM-2 TOTAL INCREMENTAL COST					**$1,172,471**
EEM-2: Envelope Improvements - Barry Primary School						
	Existing Roof To Remain	68000	SF	$0.00	$0	$0
	Existing Windows to Remain	167	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Replace Roof, 6" insulation R-30	68,000	SF	$18.00	$7	$1,727,375
	Replace Single Pane Windows	167	EA	$180.00	$300	$80,160
	TOTAL PROPOSED					$1,807,535
	EEM-2 TOTAL INCREMENTAL COST					**$1,807,535**
EEM-2: Envelope Improvements - Smith Intermediate						
	Existing Roof To Remain	60000	SF	$0.00	$0	$0
	Existing Windows to Remain	167	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Replace Roof, 6" insulation R-30	60,000	SF	$18.00	$7	$1,524,155
	Replace Single Pane Windows	167	EA	$180.00	$300	$80,160
	TOTAL PROPOSED					$1,604,315
	EEM-2 TOTAL INCREMENTAL COST					**$1,604,315**

EEM-2: Envelope Improvements - District Offices/Bus Garage						
	Existing Roof To Remain	24000	SF	$0.00	$0	$0
	Existing Windows to Remain	25	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Replace Roof, 6" insulation R-30	24,000	SF	$18.00	$7	$609,662
	Replace Single Pane Windows	25	EA	$180.00	$300	$12,000
	TOTAL PROPOSED					$621,662
	EEM-2 TOTAL INCREMENTAL COST					**$621,662**

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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	**ENERGY**	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-3: Occupied / Unoccupied Controls - JR/SR High School						
	Existing Pneumatic Controls	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Direct Digital Control Point Upgrade	90	EA			$90,000
	TOTAL PROPOSED					$90,000
	EEM-3 TOTAL INCREMENTAL COST					**$90,000**
EEM-3: Occupied / Unoccupied Controls - Barry Primary School						
	Existing Pneumatic Controls	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Direct Digital Control Point Upgrade	50	EA			$50,000
	TOTAL PROPOSED					$50,000
	EEM-3 TOTAL INCREMENTAL COST					**$50,000**
EEM-3: Occupied / Unoccupied Controls - Smith Intermediate						
	Existing Pneumatic Controls	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Direct Digital Control Point Upgrade	50	EA			$50,000
	TOTAL PROPOSED					$50,000
	EEM-3 TOTAL INCREMENTAL COST					**$50,000**

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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	**ENERGY**	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-4: Heating and Cooling Plant Upgrades - JR/SR High School						
EEM-4a: Heating and Cooling Plant Upgrades - Install High Efficiency Boiler						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install Condensing Boilers (3x 6MMBTU units)	3	EA	$16,300.00	$148,750	$495,150
	TOTAL PROPOSED					$495,150
	EEM-4a TOTAL INCREMENTAL COST					**$495,150**
EEM-4b: Heating and Cooling Plant Upgrades - Install Ground Source Heat Pump (GSHP)						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install Ground Source Heat Pumps (4.4 MMBTU)	3	EA			$885,000
	Install Geothermal Wells	320	EA		$10,000	$3,200,000
	TOTAL PROPOSED					$4,085,000
	EEM-4b TOTAL INCREMENTAL COST					**$4,085,000**

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Budget Pricing Cost Estimate

PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	**ENERGY**	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-4: Heating and Cooling Plant Upgrades - Barry Primary School						
EEM-4a: Heating and Cooling Plant Upgrades - Install High Efficiency Boiler						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install High Efficiency Boilers (3x 2MMBTU units)	3	EA	$7,950.00	$38,375	$138,975
	TOTAL PROPOSED					$138,975
	EEM-4a TOTAL INCREMENTAL COST					**$138,975**
EEM-4b: Heating and Cooling Plant Upgrades - Conversion to natural gas condensing hot wtaer boilers and heating system						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install High Efficiency Boilers (3x 2MMBTU units)	3	EA	$16,300.00	$148,750	$495,150
	Piping Conversion - Steam to Hot Water	1	EA			$750,000
	Unit Ventilator Replacement	40	EA		$15,000	$600,000
	AHU replacement	3	EA		$50,000	$150,000
	TOTAL PROPOSED					$1,995,150
	EEM-4b TOTAL INCREMENTAL COST					**$1,995,150**
EEM-4c: Heating and Cooling Plant Upgrades - Install Ground Source Heat Pump (GSHP)						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install Ground Source Heat Pump	2	EA			$590,000
	Install Geothermal Wells	160	EA		$10,000	$1,600,000
	Piping Conversion - Steam to Hot Water	1	EA			$750,000
	Unit Ventilator Replacement	40	EA		$15,000	$600,000
	AHU replacement	3	EA		$50,000	$150,000
	TOTAL PROPOSED					$3,690,000
	EEM-4c TOTAL INCREMENTAL COST					**$3,690,000**
EEM-4d: Heating and Cooling Plant Upgrades - Geothermal Well Field With Water to Air Source Heat Pumps						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install Geothermal Wells	160	EA		$10,000	$1,600,000
	Piping Conversion - Steam to Hot Water	1	EA			$750,000
	Terminal Heat Pumps	50	EA		$15,000	$750,000
	AHU replacement	3	EA		$50,000	$150,000
	TOTAL PROPOSED					$3,250,000
	EEM-4c TOTAL INCREMENTAL COST					**$3,250,000**

Mechanical/Electrical
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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE: 211078		DATE:	11/19/2021
DIVISION:	ENERGY	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-4: Heating and Cooling Plant Upgrades - Smith Intermediate School						
EEM-4a: Heating and Cooling Plant Upgrades - Install High Efficiency Boiler						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install High Efficiency Boilers (3x 2MMBTU units)	3	EA	$7,950.00	$38,375	$138,975
	TOTAL PROPOSED					$138,975
	EEM-4a TOTAL INCREMENTAL COST					**$138,975**
EEM-4b: Heating and Cooling Plant Upgrades - Conversion to natural gas condensing hot wtaer boilers and heating system						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install High Efficiency Boilers (3x 2MMBTU units)	3	EA	$16,300.00	$148,750	$495,150
	Piping Conversion - Steam to Hot Water	1	EA			$750,000
	Unit Ventilator Replacement	40	EA		$15,000	$600,000
	AHU replacement	3	EA		$50,000	$150,000
	TOTAL PROPOSED					$1,995,150
	EEM-4b TOTAL INCREMENTAL COST					**$1,995,150**
EEM-4c: Heating and Cooling Plant Upgrades - Install Ground Source Heat Pump (GSHP)						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install Ground Source Heat Pump	2	EA			$590,000
	Install Geothermal Wells	160	EA		$10,000	$1,600,000
	Piping Conversion - Steam to Hot Water	1	EA			$750,000
	Unit Ventilator Replacement	40	EA		$15,000	$600,000
	AHU replacement	3	EA		$50,000	$150,000
	TOTAL PROPOSED					$3,690,000
	EEM-4c TOTAL INCREMENTAL COST					**$3,690,000**
EEM-4d: Heating and Cooling Plant Upgrades - Geothermal Well Field With Water to Air Source Heat Pumps						
	Existing Heating and Cooling Plant	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install Geothermal Wells	160	EA		$10,000	$1,600,000
	Piping Conversion - Steam to Hot Water	1	EA			$750,000
	Terminal Heat Pumps	50	EA		$15,000	$750,000
	AHU replacement	3	EA		$50,000	$150,000
	TOTAL PROPOSED					$3,250,000
	EEM-4c TOTAL INCREMENTAL COST					**$3,250,000**

Mechanical/Electrical
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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	ENERGY	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-4: Heating and Cooling Plant Upgrades - District Offices/Bus Garage						
EEM-4a: Heating and Cooling Plant Upgrades - Air Source Heat Pumps (VRF)						
	Existing Heating and Cooling	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Air Source Heat Pumps (VRF) for offices (20ton)	1	EA	$15,900.00	$105,500	$121,400
	TOTAL PROPOSED					$121,400
	EEM-4a TOTAL INCREMENTAL COST					**$121,400**
EEM-4b: Heating and Cooling Plant Upgrades - Geothermal Well Field with Water to Water Ground Source Heat Pumps						
	Existing Heating and Cooling	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Install Geothermal Wells	30	EA		$10,000	$300,000
	Install Ground Source Heat Pump	2	EA		$86,025	$172,050
	TOTAL PROPOSED					$472,050
	EEM-4b TOTAL INCREMENTAL COST					**$472,050**

Mechanical/Electrical
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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	ENERGY	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-5: Solar Thermal Heat Recovery - JR/SR High School						
	Existing Outdoor Air Intake	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Solar Thermal Heat Recovery (4' x 10') Collector	40	EA			$53,716
	TOTAL PROPOSED					$53,716
	EEM-6 TOTAL INCREMENTAL COST					**$53,716**
EEM-5: Solar Thermal Heat Recovery - Barry Primary School						
	Existing Outdoor Air Intake	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Solar Thermal Heat Recovery (4' x 10') Collector	20	EA			$24,792
	TOTAL PROPOSED					$24,792
	EEM-6 TOTAL INCREMENTAL COST					**$24,792**
EEM-5: Solar Thermal Heat Recovery - Smith Intermediate						
	Existing Outdoor Air Intake	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Solar Thermal Heat Recovery (4' x 10') Collector	20	EA			$24,792
	TOTAL PROPOSED					$24,792
	EEM-6 TOTAL INCREMENTAL COST					**$24,792**

Mechanical/Electrical
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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	**ENERGY**	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-6: Outdoor Air Energy Recovery Opportunities - JR/SR High School						
	Existing Supply and Exhaust System To Remain	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Run-around loop, glycol, 50% efficient	1	EA	$3,510.00	$10,897	$14,407
	TOTAL PROPOSED					$14,407
	EEM-6 TOTAL INCREMENTAL COST					**$14,407**

Mechanical/Electrical
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Budget Pricing Cost Estimate			
PROJECT NAME: Cortland Enlarged City School District			
M/E REFERENCE:	211078	DATE:	11/19/2021
DIVISION:	**ENERGY**	BY:	RMR

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-7: Kitchen Hood Controls - JR/SR High School						
	Existing Exhaust Fan and Supply Fan To Remain	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	1 HP Motor and VFD	1	EA	$748	$6,004.00	$6,752
	5 HP Motor and VFD	1	EA	$748	$6,570.00	$7,318
	TOTAL PROPOSED					$14,070
	EEM-7 TOTAL INCREMENTAL COST					**$14,070**
EEM-7: Kitchen Hood Controls - Randall Middle School						
	Existing Exhaust Fan and Supply Fan To Remain	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	1-3 HP Motor and VFD	2	EA	$748	$6,004.00	$13,504
	TOTAL PROPOSED					$13,504
	EEM-7 TOTAL INCREMENTAL COST					**$13,504**
EEM-7: Kitchen Hood Controls - Barry Primary School						
	Existing Exhaust Fan and Supply Fan To Remain	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	1-3 HP Motor and VFD	2	EA	$748	$6,004.00	$13,504
	TOTAL PROPOSED					$13,504
	EEM-7 TOTAL INCREMENTAL COST					**$13,504**
EEM-7: Kitchen Hood Controls - Smith Intermediate						
	Existing Exhaust Fan and Supply Fan To Remain	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	1-3 HP Motor and VFD	2	EA	$748	$6,004.00	$13,504
	TOTAL PROPOSED					$13,504
	EEM-7 TOTAL INCREMENTAL COST					**$13,504**

Mechanical/Electrical
Engineering Consultants
60 LAKEFRONT BLVD, SUITE 320
BUFFALO, NY 14202

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ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-8: Steam Trap Replacement - Barry Primary School						
	Existing Steam Traps To Remain	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Study Existing Steam Traps	1	EA	$1,000	$0.00	$1,000
	Repair/Replace Failed Steam Traps	3	EA	$100	$500.00	$1,800
	TOTAL PROPOSED					$2,800
	EEM-2 TOTAL INCREMENTAL COST					**$2,800**
EEM-8: Steam Trap Replacement - Smith Intermediate						
	Existing Steam Traps To Remain	0	EA	$0.00	$0	$0
	TOTAL BASECASE					$0
	Study Existing Steam Traps	1	EA	$1,000	$0.00	$1,000
	Replace Failed Steam Traps	3	EA	$100	$500.00	$1,800
	TOTAL PROPOSED					$2,800
	EEM-2 TOTAL INCREMENTAL COST					**$2,800**

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ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-9: Solar PV Arry - JR/SR High School						
	Solar PV (1725 kW array)	1725	EA	$1,800.00	$600	$4,140,000
	TOTAL EEM-6 INCREMENTAL COST					**$4,140,000**
EEM-9: Solar PV Arry - Randall Middle School						
	Solar PV (225 kW array)	225	EA	$1,800.00	$600	$540,000
	TOTAL EEM-6 INCREMENTAL COST					**$540,000**
EEM-9: Solar PV Arry - Barry Primary School						
	Solar PV (220 kW array)	220	EA	$1,800.00	$600	$528,000
	TOTAL EEM-6 INCREMENTAL COST					**$528,000**
EEM-9: Solar PV Arry - Smith Intermediate						
	Solar PV (180 kW array)	180	EA	$1,800.00	$600	$432,000
	TOTAL EEM-6 INCREMENTAL COST					**$432,000**
EEM-9: Solar PV Arry - District Offices/Bus Garage						
	Solar PV (175 kW array)	175	EA	$1,800.00	$600	$420,000
	TOTAL EEM-6 INCREMENTAL COST					**$420,000**

PHOTOGRAPHS AND EQUIPMENT LIST

Available upon request