Kenilworth Public Schools

Harding Elementary School
David Brearley High/Middle School

Energy Savings Plan for Kenilworth Public Schools

WILLDAN

Summary of Revisions

04/15/2020:	Draft Report Submission
05/28/2020:	Draft Report Review Submission
11/25/2020:	Final Report Option -2
03/05/2021:	BPU Comments

Table of Contents

List of Tables

List of Figures

1. Contacts

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2. Executive Summary

Site: Kenilworth Public Schools

Dates of Audit: January - March 2020

Auditors: Tejas Desai, PE, Ning Yang - Willdan Energy Solutions

Kenilworth Board of Education contracted with Willdan Energy Solutions (Willdan) to develop an energy saving plan (ESP) to be used in a Do – It – Yourself (DIY) Energy Savings Improvement Program (ESIP) for Kenilworth Public Schools in Kenilworth, NJ, including Harding Elementary School (ES) and David Brearley Middle/High School (MSHS).

This report summarizes the Energy Conservation Measures (ECMs) that Willdan identified, along with the associated energy and cost savings for each measure. Section 2 summarizes the estimated savings, describes the site, and discusses the building occupancy and use, the local climate conditions, the existing building systems, the facility's utility use, the facility's energy end use, and peer benchmarking of the facility. Section 3 describes each ECM in detail.

The main requirement of NJ ESIP is to justify cost estimate and energy saving calculations for all the proposed ECMs that will pay for itself through energy savings over fifteen (15) years. Pursuant to the NJ ESIP Law, N.J.S.A. 18A:18A-4.6(d)(2), the ESP shall:

- Contain the results of an Energy Audit.
- Describe the ECMs that will comprise the program.
- Estimate greenhouse-gas reductions resulting from those energy savings.
- Include an assessment of risks involved in the successful implementation of the plan.
- Identify the eligibility for and the costs and revenues associated with the PJM Independent System Operator for demand response and curtailable service activities.
- Include schedules showing calculations of all costs of implementing the proposed energy conservation measures and the projected energy savings.
- Identify maintenance requirements necessary to ensure continued energy savings and describe how they will be fulfilled.

The purpose of this ESP report is to provide a District-wide NJ Do It yourself (DIY) ESIP project with all the ECMs. There were many energy conservation measures evaluated during development of this ESP, and after careful consideration the list of ECMs were included in this report. Willdan will work closely with Kenilworth BOE to determine ECMs included under ESIP project. This ESP is structured to comply with the ESIP Law with all the necessary information to make a firm decision. The possible areas of energy savings for Kenilworth BOE, as described initially, are as follows:

- Boiler
- Chiller
- Rooftop units and Air Handling Units
- Unit Ventilators
- Lighting
- Vending Machines
- Walk-in Cooler and Freezer
- Building Management System
- Transformer
- Voltage Management
- DHW Devices
- Solar PV Panel

The energy cost savings for both schools have been derived through detailed energy analysis using both spreadsheet analysis and eQuest energy modelling to model the building systems.

Table 1 and Table 2 shows the energy and energy cost savings for Harding Elementary School and David Brearley Middle/High School, respectively.

Table 1: ES – Estimated Total Utility & Cost Savings

Savings			% Reduction
Annual Electric Energy	136,954	kWh	22%
Annual Electric Demand	53.4	kW	9%
Annual Natural Gas	5,182	therms	10%
Annual Utility Cost Savings	23,312	$	18%

Table 2: MSHS - Estimated Total Utility & Cost Savings

Savings			% Reduction
Annual Electric Energy	269,915	kWh	23%
Annual Electric Demand	86.8	kW	10%
Annual Natural Gas	8,197	therms	12%
Annual Utility Cost Savings	42,436	$	20%

Note: Electric savings presented in Table 1 and Table 2 does not include onsite electric generation potential from installation of solar PV panels.

2.1 Overall Opportunity Summary

Harding Elementary School

The table below presents the projected savings for Harding Elementary School.

Table 3: ES - Projected Overall Savings

Measure		Annual Estimated Savings				CO_2 Emission Savings (tCO_2e)	Estimated Implementation Cost ($)	Estimated Simple Payback Period (Years)
Meas. No.	Description	Electricity (kWh)	Annual Demand (kW)	Natural Gas (Therms)	Cost Savings ($)			
ECM - 1	Replace Existing Boilers with Condensing Boilers & Install DHW Heat Exchanger	-2,394	-0.3	6,673	$5,568	34.7	$417,910	75.1
ECM - 2	Replace Existing Chiller with High Efficiency Chiller	3,619	7.5	0	$495	1.0	$296,120	598.1
ECM - 3	Replace Existing DX Units with High Efficiency DX Units	3,118	0.4	708	$1,052	1.4	$40,912	38.9
ECM – 4	LED Lighting Upgrades - Interior	97,945	44.3	-2,209	$11,447	16.6	$95,035	8.3
ECM – 5	LED Lighting Upgrades - Exterior	21,813	0.0	0	$2,984	6.3	$5,800	1.9
ECM – 6	Implement Vending Machine Miser Controls	680	0.1	-9	$85	0.0	$575	6.8
ECM – 7	Install Energy Efficient Transformers	12,173	1.4	0	$1,665	3.5	$21,644	13.0
ECM – 8	Install Low-Flow DHW Devices	0	0.0	19	$17	0.1	$426	25.4
ECM - 9	Install Solar PV Panel	345,274	293.6	0	$16,442	99.8	-	-
Total		**136,954**	**53.4**	**5,182**	**$23,312**	**64**	**$878,421**	**37.7**

[1] All energy savings accounts for interactive effects of each measure.

[2] Potential for onsite electricity generation solar PV panel (ECM-9) are not included in the “Total” row.

David Brearley Middle/High School

The table below presents the projected savings for David Brearley Middle/High School.

Table 4: MSHS - Projected Overall Savings

Measure		Annual Estimated Savings				CO_2 Emission Savings (tCO_2e)	Estimated Implementation Cost ($)	Estimated Simple Payback Period (Years)
Meas. No.	Description	Electricity (kWh)	Annual Demand (kW)	Natural Gas (Therms)	Cost Savings ($)			
ECM – 1	Replace Existing Chiller with High Efficiency Chiller	3,486	0.3	0	$458	1	$322,520	703.9
ECM – 2	LED Lighting Upgrades - Interior	132,038	55.5	-1,636	$15,966	29	$167,510	10.5
ECM – 3	LED Lighting Upgrades - Exterior	1,515	0.0	0	$199	0	$2,645	13.3
ECM – 4	Implement Vending Machine Miser Controls	1,209	0.1	-10	$150	0	$1,045	7.0
ECM – 5	Install Controls on Walk-in Coolers and Freezers	1,640	0.2	-11	$206	0	$1,817	8.8
ECM – 6	Install Energy Efficient Transformers	37,898	4.3	0	$4,981	11	$59,475	11.9
ECM – 7	Install Low-Flow DHW Devices	0	0.0	26	$22	0	$619	28.1
ECM - 8	Install Solar PV Panels	518,735	438.0	0	$32,392	150	-	-
Total		**177,786**	**60.5**	**-1,632**	**$21,983**	**43**	**$555,631**	**25.3**

[1] All energy savings accounts for interactive effects of each measure.

[2] Potential for onsite electricity generation solar PV panel (ECM-8) are not included in the “Total” row.

Harding Elementary School- Considered but Not Recommended

The table below presents the projected savings for Harding Elementary School.

Table 5: ES - Projected Overall Savings

Measure		Annual Estimated Savings				CO_2 Emission Savings (tCO_2e)	Estimated Implementation Cost ($)	Estimated Simple Payback Period (Years)
Meas. No.	Description	Electricity (kWh)	Annual Demand (kW)	Natural Gas (Therms)	Cost Savings ($)			
ECM – 1R	Replace Existing UVs with New Uvs	35,331	8.5	-859	$4,074	5.7	$1,134,458	278.4
ECM – 2R	Install VFDs on Heating Hot Water Pumps	15,988	2.2	-735	$1,538	0.7	$41,544	27.0
ECM – 3R	Install VFDs on Chilled Water Pumps	2,229	1.9	0	$305	0.6	$35,298	115.8
ECM – 4R	Implement Demand Controlled Ventilation for Auditorium Unit	-82	0.0	335	$285	1.8	$40,348	141.7
ECM – 5R	Upgrade BMS	3,525	0.3	439	$870	3.4	$469,370	539.4
Total		**56,990**	**12.8**	**-819**	**$7,072**	**12.1**	**$1,721,017**	**243.4**

David Brearley Middle/High School- Considered but Not Recommended

The table below presents the projected savings for David Brearley Middle/High School.

Table 6: MSHS - Projected Overall Savings

Measure		Annual Estimated Savings				CO_2 Emission Savings (tCO_2e)	Estimated Implementation Cost ($)	Estimated Simple Payback Period (Years)
Meas. No.	Description	Electricity (kWh)	Annual Demand (kW)	Natural Gas (Therms)	Cost Savings ($)			
ECM - 1R	Replace Existing Boilers with Condensing Boilers	964	0.2	8,973	$7,744	48	$573,547	74.1
ECM - 2R	Replace Existing RTU with New RTU	10,183	2.4	-22	$1,320	3	$611,366	463.3
ECM - 3R	Replace Existing UV with New UV	14,039	4.3	-324	$1,570	2	$1,185,019	754.7
ECM - 4R	Install VFDs on CHW/HHW Pumps	3,066	0.3	-126	$296	0	$47,515	160.5
ECM - 5R	Upgrade BMS	36,554	3.7	884	$5,555	15	$712,993	128.3
ECM - 6R	Implement Kitchen Hood Exhaust Control System	56	0.0	443	$384	2	$49,645	129.4
ECM - 7R	Implement Voltage Management	27,267	15.3	0	$3,584	8	$64,000	17.9
Total		**92,129**	**26.3**	**9,828**	**$20,453**	**79**	**$3,244,084**	**158.6**

[1] All energy savings accounts for interactive effects of each measure.

As part of the major Budget Referendum, Willdan is supporting Kenilworth Public Schools with a percentage of implementation costs through ESIP. From a list of improvements and additions, the chosen ECMs under this ESP have yield the following savings and cash flow.

Table 7: Kenilworth BOE Form II

FORM II

ESCO's PRELIMINARY ENERGY SAVINGS PLAN (ESP):

ENERGY CONSERVATION MEASUREs (ECMs) SUMMARY FORM

Kenilworth BOE

ENERGY SAVING IMPROVEMENT PROGRAM

ESCO Name: Willdan Energy Solutions

Proposed Preliminary Energy Savings Plan: Base Project 15 years @ 2%

Energy Conservation Measures	Estimated Installed Hard Costs (1) ($)	Estimated Annual Savings ($)	Estimated Simple Payback (Yrs)
ECM#1 - Replace Existing Boilers with Condensing Boilers	$417,910	$5,568	75.1
ECM#2 - Replace Existing Chiller with High Efficiency Chiller	$618,640	$953	649.0
ECM#3 - Replace Existing DX Units with High Efficiency DX Units	$40,912	$1,052	21.9
ECM#4 - Replace Existing UVs with New Uvs	$0	$0	-
ECM#5 - LED Lighting Upgrades - Interior	$262,545	$27,413	7.1
ECM#6 - LED Lighting Upgrades - Exterior	$8,445	$3,183	2.7
ECM#7 - Install VFDs on Heating Hot Water Pumps	$0	$0	-
ECM#8 - Install VFDs on Chilled Water Pumps	$0	$0	-
ECM#9 - Install VFDs on CHW/HHW Pumps	$0	$0	-
ECM#10 - Implement Demand Controlled Ventilation for Auditorium Unit	$0	$0	-
ECM#11 - Implement Vending Machine Miser Controls	$1,620	$235	6.9
ECM#12 - Upgrade BMS	$0	$0	-
ECM#13 - Install Controls on Walk-in Coolers and Freezers	$1,817	$206	8.8
ECM#14 - Implement Kitchen Hood Exhaust Control System	$0	$0	-
ECM#15 - Install Energy Efficient Transformers	$81,119	$6,647	12.2
ECM#16 - Implement Voltage Management	$0	$0	-
ECM#17 - Install Low-Flow DHW Devices	$1,045	$39	26.9
ECM#18 - Wire Emergency Lighting to Generator	$0	$0	-
ECM#19 - Install Onsite Power Generation	$0	$0	-
ECM#20 - Install Solar PV Panel	$0	$48,834	0.0
Project Summary:	**$1,434,052**	**$94,129**	**15.2**

Table 8: Kenilworth BOE Form III

FORM III

ESCO's PRELIMINARY ENERGY SAVINGS PLAN (ESP):
PROJECTED ANNUAL ENERGY SAVINGS DATA FORM

Kenilworth BOE

ENERGY SAVING IMPROVEMENT PROGRAM

ESCO Name: Willdan Energy Solutions

Proposed Preliminary Energy Savings Plan: Base Project 15 years @ 2%

Energy/Water	ESCO Developed Baseline (Units) (2)	ESCO Developed Baseline (Costs $) (2)	Proposed Annual Savings (Units) (3)	Proposed Annual Savings (Costs $) (3)
Electric Demand (kW)	1,428		113.8	
Electric Energy (kWh)	1,782,133	$237,548	314,740	$42,102
Natural Gas (ccf)	111,137	$99,545	3,424	$3,193
AVOIDED EMISSIONS (1)	**Provide in Pounds (Lbs)**			
NOX	914	Lbs		
SO_2	2,046	Lbs		
CO_2	519,946	Lbs		

(1) ESCOs are to use the rates provided as part of this RFP to calculate Avoided Emissions. Calculation for all project energy savings and greenhouse gas reductions will be conducted in accordance with adopted NJBPU protocols

(2) "ESCOs Developed Baseline": Board's current annual usages and costs as determined by the proposing ESCO; based off Board's utility information as provided to proposing ESCO.

(3) "Proposed Annual Savings": ESCOs proposed annual savings resulting from the Board's implementation of the proposed ESP, as based upon "ESCOs Developed Baseline".

Table 9: Kenilworth BOE Form IV

FORM IV

ESCO's PRELIMINARY ENERGY SAVINGS PLAN (ESP):

PROJECTED ANNUAL ENERGY SAVINGS DATA FORM IN MMBTUs

ESCO's PRELIMINARY ENERGY SAVINGS PLAN (ESP):
PROJECTED ANNUAL ENERGY SAVINGS DATA FORM

Kenilworth BOE

ENERGY SAVING IMPROVEMENT PROGRAM

ESCO Name: Willdan Energy Solutions

Proposed Preliminary Energy Savings Plan: Base Project 15 years @ 2%

The projected annual energy savings for each fuel type MUST be completed using the following format. Data should be given in equivalent MMBTUs.

ENERGY	ESCO Developed Baseline	ESCO Proposed Savings Annual	Comments
Electric Energy (MMBTUs)	608,064	107,389	
Natural Gas (MMBTUs)	11,525	355	
Fuel Oil (MMBTUs)	0	0	
Steam (MMBTUs)	0	0	
Other (Specify) (MMBTUs)	0	0	

NOTE: MMBTU Defined: A standard unit of measurement used to denote both the amount of heat energy in fuels and the ability of appliances and air conditioning systems to produce heating or cooling.

Table 10: Kenilworth BOE Form V

FORM V

ESCO's PRELIMINARY ENERGY SAVINGS PLAN (ESP):

ESCOs PROPOSED FINAL PROJECT COST FORM FOR BASE CASE PROJECT

Kenilworth BOE

ENERGY SAVING IMPROVEMENT PROGRAM

ESCO Name: Willdan Energy Solutions

Proposed Preliminary Energy Savings Plan: Base Project 15 years @ 2%

PROPOSED CONSTRUCTION FEES

Fee Category	Fees [1] Dollar ($) Value	Percentage of Hard Cost
Estimated Value of Hard Costs [2]:	$1,434,052	
Project Service Fees		
Investment Grade Energy Audit	$60,941	3.0%
Design Engineering Fees	$43,022	3.0%
Construction Management & Project Administration	$63,098	4.4%
System Commissioning	$18,643	1.3%
Equipment Initial Training Fees	$10,038	0.7%
ESCO Overhead	$53,060	3.7%
ESCO Profit	$50,192	3.5%
Project Service Fees Sub Total	$298,994	20.8%
TOTAL FINANCED PROJECT COSTS:	$1,733,046	120.8%

PROPOSED ANNUAL SERVICE FEES

Fee Category	Fees [1] Dollar ($) Value	Percentage of Hard Cost
SAVINGS GUARANTEE (*OPTION*)		
Measurement and Verification (Associated w/ Savings Guarantee Option)	$17,926	1.25%
ENERGY STAR™ Services (*optiona l*)	Included Above	0.00%
Post Construction Services *(If applicable)*	Included Above	0.00%
Performance Monitoring	Included Above	0.00%
On-going Training Services	Included Above	0.00%
Verification Reports	Included Above	0.00%
TOTAL FIRST YEAR ANNUAL SERVICES	$17,926	1.25%

NOTES:

(1) Fees should include all mark-ups, overhead, and profit. Figures stated as a range will NOT be accepted.

(2) The total value of Hard Costs is defined in accordance with standard AIA definitions that include:

Labor Costs, Subcontractor Costs, Cost of Materials and Equipment, Temporary Facilities and Related Items, and Miscellaneous Costs such as Permits, Bonds Taxes, Insurance, Mark-ups, Overhead and Profit, etc.

ESCO's proposed interest rate at the time of submission: 2.5 % TO BE USED BY ALL RESPONDING ESCOs FOR PROPOSAL PURPOSES

Table 11:Kenilworth BOE Form VI

FORM VI

ESCO's PRELIMINARY ENERGY SAVINGS PLAN (ESP):
ESCO's PRELIMINARY ANNUAL CASH FLOW ANALYSIS FORM

Kenilworth BOE

ENERGY SAVINGS IMPROVEMENT PROGRAM

ESCO Name: Willdan Energy Solutions

Proposed Preliminary Energy Savings Plan: Base Project 15 years @ 2%

Note: Respondents must use the following assumptions in all financial calculations:

(a) The cost of all types of energy should be assumed to inflate at 2.4 % gas, 2.2 % electric per year; and

1. Term of Agreement: 15 years (____ Months)	180
2. Construction Period (2) (months):	12
3. Cash Flow Analysis Format:	
Estimated Installed Hard Costs	$1,434,052
ESCO's Fee (From Form V)	$298,994
Legal & Bond Fees	$40,000
Third Party Fees	$15,000
AE Fees	$161,894
Direct Install Incentive	$0
Project Cost [(1)]:	$1,849,941

Interest Rate to Be Used for Proposal Purposes: 2.0%

Year	Annual Energy Savings	Annual Operational Savings	Energy Rebates/ Incentives	Solar PPA	Total Annual Savings	Annual Project Costs	Board Cost	Annual Service Costs (3)	Net Cash-Flow to Client	Cummulative Cash Flow
Installation	$38,736	$ -		$43,951	$ 82,686		$ -		$7,644	$7,644
1	$46,298	$35,670	$121,344	$51,153	$254,465	-$142,854	-$160,780	-$17,926	$7,644	$15,288
2	$47,323	$35,670	$1,446	$53,581	$138,021	-$142,854	-$142,854	$0	$7,644	$22,932
3	$48,371	$27,170	$1,446	$56,125	$133,112	-$142,854	-$142,854	$0	$7,644	$30,576
4	$49,442	$27,170	$1,446	$58,790	$136,848	-$142,854	-$142,854	$0	$7,644	$38,220
5	$50,537	$27,170		$61,582	$139,288	-$142,854	-$142,854	$0	$7,644	$45,864
6	$51,656			$64,505	$116,161	-$142,854	-$142,854	$0	$7,644	$53,508
7	$52,800			$67,568	$120,368	-$142,854	-$142,854	$0	$7,644	$61,152
8	$53,969			$70,776	$124,745	-$142,854	-$142,854	$0	$7,644	$68,796
9	$55,164			$74,137	$129,301	-$142,854	-$142,854	$0	$7,644	$76,440
10	$56,385			$77,657	$134,042	-$142,854	-$142,854	$0	$7,644	$84,084
11	$57,634			$81,344	$138,978	-$142,854	-$142,854	$0	$7,644	$91,728
12	$58,910			$85,206	$144,116	-$142,854	-$142,854	$0	$7,644	$99,372
13	$60,215			$89,252	$149,466	-$142,854	-$142,854	$0	$7,644	$107,016
14	$61,548			$93,489	$155,037	-$142,854	-$142,854	$0	$7,644	$114,660
15	$62,911			$97,928	$160,839	-$142,854	-$142,854	$0	$7,644	$122,304
Totals	**$851,898**	**$152,850**	**$125,682**	**$1,127,045**	**$2,257,475**	**-$2,142,815**	**-$2,160,741**	**-$17,926**	**$122,304**	

NOTES:

(1) Includes: Hard costs and project service fees defined in ESCO's PROPOSED "FORM V"

(2) No payments are made by Board during the construction period.

(3) This figure should equal the value indicated on the ESCO's PROPOSED "FORM V". DO NOT include in the Financed Project Cost

2.2 Site Background Information

Harding Elementary School

Project Name:	Harding Elementary School
Location:	426 Boulevard, Kenilworth, NJ 07033
Building Type:	Primary School
Occupancy Type:	Educational
Conditioned Building Area:	Approximately 98,921 sq. ft. (Estimated based on eQuest model)
Owner:	Kenilworth Public Schools
Year Built:	1923
Hours of Operation:	8:35 am – 3:05 pm, 5 days per week, two school sessions, summer camp: 9:00 am – 3:00 pm, winter break (See Section 2.6)

David Brearley Middle/High School

Project Name:	David Brearley Middle/High School
Location:	401 Monroe Ave, Kenilworth, NJ 07033
Building Type:	Secondary School
Occupancy Type:	Educational
Conditioned Building Area:	Approximately 153,072 sq. ft. (Calculated based on eQuest model)
Owner:	Kenilworth Public Schools
Year Built:	1966
Hours of Operation:	7:35 am – 3:08 pm, 5 days per week, two school sessions, summer school: 8:00 am – 2:00 pm, winter break (See Section 2.6)

2.3 Site Description

Harding Elementary School

Harding Elementary School is located at 426 Boulevard, Kenilworth, NJ 07033. The facility consists of two floors. The building includes classrooms, offices, computer rooms, a gymnasium, an auditorium, a cafeteria, a library, a kitchen, locker rooms, and storages. The exterior area mainly comprises of parking lot, and softball fields.

David Brearley Middle/High School

David Brearley Middle/High School is located at 401 Monroe Ave, Kenilworth, NJ 07033. The facility consists of two floors. The building includes classrooms, offices, computer rooms, two gymnasiums, a wrestling room, a weight room, an auditorium, a cafeteria, a library, a kitchen, locker rooms, and storages.

The exterior area mainly comprises of parking lot, soccer field, softball fields, baseball field, and football field.

2.4 Local Climate Conditions

Local climate is an important factor in a building's energy use. Outdoor temperatures affect the building envelope and drive heat transfer through the "skin" of the building. Outdoor temperatures also dictate the energy required to condition fresh air that is drawn into the building for occupant ventilation, which is typically a large portion of the overall heating and cooling load for a school type of buildings. Outdoor weather conditions also determine the types of technologies and systems that will be effective in an HVAC system. The following design conditions apply.

Location: Kenilworth, New Jersey

Cooling Season Design Condition: 90.4° F Dry Bulb / 73.3° F Wet Bulb

Heating Season Design Condition: 14.8° F Dry Bulb

In Kenilworth, the summers are warm and humid, the winters are very cold, and it is wet and partly cloudy year-round. Over the course of the year, the temperature typically varies from 26 °F to 87 °F and is very rarely below 12°F or above 95°F.

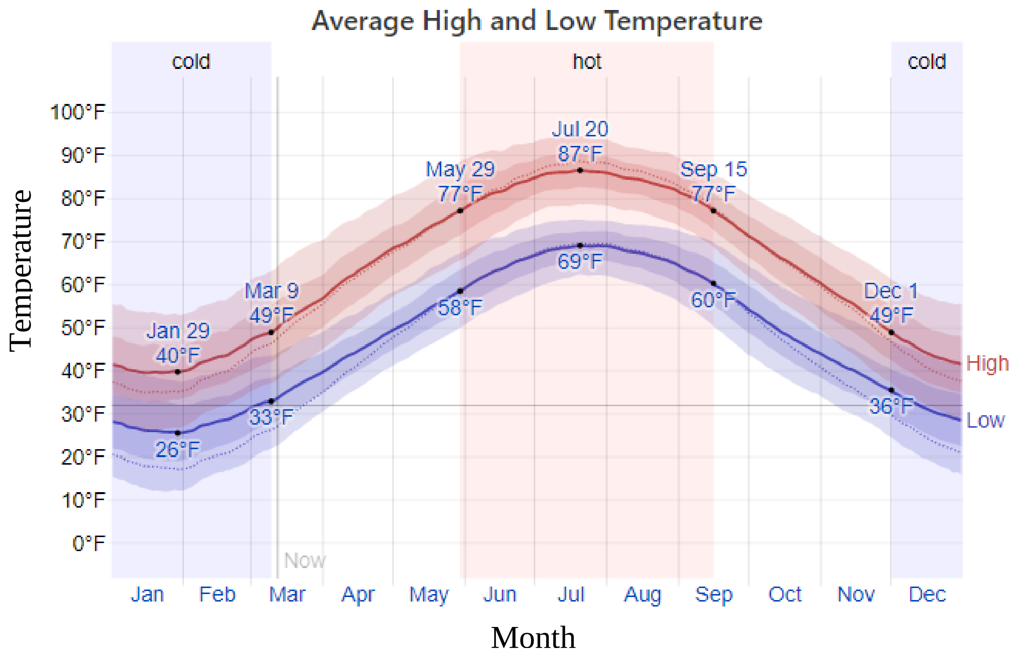


Figure 1: Historical Weather Conditions for Kenilworth, NJ

2.5 Envelope

Harding Elementary School

Building walls are made of concrete masonry units (CMUs) with a brick facade. The roof is flat, covered with stones, and in fair condition. Most of the windows are double pane and operable with metal frames. The glass-to-frame seals and operable and window weather seals are in good condition. Exterior doors are metal with metal frames and have adequate door seals.

David Brearley Middle/High School

Building walls are made of concrete masonry units (CMUs) with a brick facade. The roof is flat, covered with stones, and in fair condition. Most of the windows are double pane and operable with metal frames. The glass-to-frame seals and operable window weather seals are in good condition. Exterior doors are metal with metal frames and have und adequate door seals.

2.6 Building Occupancy & Usage

Harding Elementary School

Harding Elementary School is occupied year-round. The main school year is from September through June with a summer camp program from July to August. Typical weekday occupancy consists of approximately 100 staff members and 657 students. The building is occupied after hours for continuing custodial and maintenance activities. There are no regular weekend activities.

Table 12: ES - Building Schedule

Occupancy	Weekday/Weekend	Operating Schedule
Student School Day	Weekday	8:35 am – 3:05 pm
	Weekend	No Use
Before School Care	Weekday	7:15 pm – 8:15 am
	Weekend	No Use
After school Care	Weekday	3:30 pm – 6:30 pm
	Weekend	No Use
Summer Camp	Weekday	9:00 am - 3:00 pm
	Weekend	No Use

David Brearley Middle/High School

David Brearley Middle/High School is occupied year-round. The main school year is from September through June with a summer camp program from July to August. Typical weekday occupancy consists of approximately 100 staff members and 735 students. The building is occupied after hours for continuing custodial and maintenance activities. There are sports team practices on Saturdays throughout the year. There are a few times a year where the auditorium is rented out to community dance companies which utilize the space on Saturday evenings.

Table 13: MSHS - Building Schedule

Occupancy	Weekday/Weekend	Operating Schedule
Student School Day	Weekday	7:35am – 3:08pm
	Weekend	No Use
Sports Team Practice	Weekday	No Use
	Weekend	8:00 AM - 3:00 PM
Summer School	Weekday	8:00 AM - 2:00 PM
	Weekend	No Use

2.7 Building Systems Description

Heating, ventilating and air-conditioning (HVAC) is provided for conditioned spaces in both buildings. The HVAC systems maintain a comfortable environment in the building and provide required ventilation to meet occupancy. This section describes the main systems in the facility, which include HVAC systems, domestic hot water system, building management system, lighting, food service equipment, and refrigeration.

2.7.1 Heating Hot Water System

Harding Elementary School

The hot water system consists of two (2) 4,663 MBH input capacity, gas-fired, hot water boilers. The hot water supply temperature is manually adjusted between 160 ºF to 195ºF depending on the weather conditions. According to the site personnel, during peak heating season, hot water is typically generated using two boilers. Based on the visual inspection and information obtained from the site personnel, the boilers, in general, are in good operating condition and appeared to be well maintained. However, these units were installed in 2000 and are past their useful service life.

The burners on the boilers are controlled with a high fire/low fire sequence. Based on the set-points, burners switch between the low-fire and high-fire stages to meet the needs of the facility. A piston operated mechanical lever controls the air intake opening of the burner based on the mode of operation. According to building operators, the boilers have no outside air heating hot water reset control.

Table 14: ES - Boiler Schedule

Tag	Manufacturer	Year Installed	Natural Gas Input (MBH)	Output (MBH)	Description
Boiler No. 1	Peerless	2000	4,663	3,777	Gas-fired boiler
Boiler No. 2	Peerless	2000	4,663	3,777	Gas-fired boiler

Figure 2: ES - Two (2) 4,663 MBH Gas-Fired Boilers

David Brearley Middle/High School

The hot water system consists of two (2) 6,894 MBH input each, gas-fired, hot water boilers. These units were installed in 1999 and past their useful equipment life. The hot water supply temperature is manually adjusted between 160 ºF to 195ºF depending on the weather conditions. According to the site personnel, during peak heating season, hot water is typically generated using one boiler.

The burners on the boilers are controlled with a high fire / low fire sequence. Based on the set-points, burners switch between the low-fire and high-fire stages to meet the needs of the facility. A piston operated mechanical lever controls the air intake opening of the burner based on the mode of operation. According to building operators, the boilers have no automated outside air heating hot water reset control.

Table 15: MSHS - Boiler Schedule

Tag	Manufacturer	Year Installed	Natural Gas Input (MBH)	Output (MBH)	Description
Boiler No. 1	Universal Boiler Works	1999	6,894	5,860	Gas-fired Boilers
Boiler No. 2	Universal Boiler Works	1999	6,894	5,860	Gas-fired Boilers


Figure 3: MSHS - Two (2) 5,860 MBH Gas-Fired Boilers

In addition to boilers, there are a series of electric baseboard heaters located throughout the MSHS corridors, office areas and vestibules used for meeting the space heating load in the building. Zone controls for the electric heaters are done at the control panel located by the boiler room and thermostats located throughout the building.

2.7.2 Chilled Water System

Harding Elementary School

One (1) 150-ton Carrier air-cooled chiller serves most of the building cooling load. The chiller was installed in 2000 and is past its useful service life. This system is controlled by the building energy management system (EMS).

Table 16: ES - Chiller Schedule

Tag	Manufacturer	Year Installed	Capacity (tons)	Description
Chiller	Carrier	2000	150	Air-Cooled Chiller

Figure 4: ES - 150-ton Air-cooled Chiller

David Brearley Middle/High School

One (1) 170-ton McQuay air-cooled chiller serves most of the building cooling load. The chiller was installed in 1999 and is in fair condition and standard efficiency. This system is controlled by the building energy management system (EMS).

Table 17: MSHS - Chiller Schedule

Tag	Manufacturer	Year Installed	Capacity (tons)	Description
Chiller	McQuay	1999	170	Air-Cooled Chiller

Figure 5: MSHS - 170-ton Air-cooled Chiller

2.7.3 Hydronic Distribution System

Harding Elementary School

The hydronic distribution system for the ES consists of a four-pipe, heating and cooling system. Pipe insulation appeared to be in good condition. The chilled water system is configured as a constant flow distribution with two (2) 15 hp constant speed chilled water pumps operating in a lead-lag control sequence. The chilled water is supplied to unit ventilators. The hot water system is configured in a constant flow primary distribution with two (2) 20 hp constant speed hot water pumps operating in a lead-lag control sequence. The boilers provide hot water to radiators, unit ventilators, and air handling units throughout the building. Table 18 below summarizes the inventory of the pumps at the facility.

Table 18: ES HW/CHW Pump Schedule

Tag	Location	Service	Make	Motor HP	Speed Control
HWP-1	Boiler Room	Hot Water Loop	Baldor Industrial Motor	20	Constant
HWP-2	Boiler Room	Hot Water Loop	Baldor Industrial Motor	20	Constant
CHWP-1	Boiler Room	Chilled Water Loop	Baldor Industrial Motor	15	Constant
CHWP-2	Boiler Room	Chilled Water Loop	Baldor Industrial Motor	15	Constant

David Brearley Middle/High School

The hydronic distribution system for the MSHS consists of a two-pipe, heating and cooling system. The constant flow primary distribution is operated as a lead-lag system and is served by three (3) 10 hp constant speed pumps. According to the site personnel, the operating pump is rotated every season. Pipe insulation appeared to be in good condition. The hot water/chilled water produced by the boiler/chiller is supplied to unit ventilators throughout the building. Table 19 below summarizes the inventory of the pumps at the facility.

Table 19: MSHS HW/CHW Pump Schedule

Tag	Location	Service	Make	Motor HP	Speed Control
CHW/HWP-1	Boiler Room	Chilled/Hot Water Loop	Marathon Electric	10	Constant
CHW/HWP-2	Boiler Room	Chilled/Hot Water Loop	Marathon Electric	10	Constant
CHW/HWP-3	Boiler Room	Chilled/Hot Water Loop	Marathon Electric	10	Constant

2.7.4 HVAC Units

Harding Elementary School

Unit Ventilators

Most classrooms and offices are conditioned by unit ventilators that supply heating and cooling to the zones. There is a total of fifty-three (53) unit ventilators in the building. These unit ventilators have supply fan motors and outside air dampers that operate with the building energy management system (BMS). However, facility staff reported that the controls tend to fail, and the control system components are in poor condition and not upgradable. Unit ventilators have three-way control valves that according to the site personnel no longer function. Facility staff reported that these valves are now manually controlled; and teachers have been complaining about the malfunction of UVs which subsequently often causes overheating and undercooling in some classrooms. The outside air dampers are manually closed by the operators to prevent water coil freezing in the winter and therefore, required ventilation rates are not being met under current operation.

Heating and Ventilation Units

The gymnasium is conditioned by heating-ventilation units. They have supply fan motors and hot water coils. They are controlled by a manual dial thermostat in the gym. No cooling is provided to the gym.

Table 20: ES – Heating and Ventilation Units Schedule

Tag	Manufacturer	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
HV-1L (Gym1)	-	-	Gym	Gym	N/A	HW	N/A	*	Heating and Ventilation Unit	Unknown
HV-1R (Gym2)	-	-	Gym	Gym	N/A	HW	N/A	*	Heating and Ventilation Unit	Unknown

[*] Nameplate could not be located on units HV-1L & HV-1R.

Air Handling Units

The auditorium is conditioned by an air handling unit. This unit has a 5-HP supply fan motor and a hot water coil and is configured as a split air-conditioning (AC) system with an outdoor condensing unit. This unit is in poor condition and beyond its useful service life. Facility staff reported that in the summer unit runs continuously, and the space does not reach the cooling set point when space is occupied.

Table 21: ES – AHU Units Schedule

Tag	Manufacturer	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
AHU-Aud	Carrier	3BAK8024	Roof Penthouse	Auditorium	DX	HW	18	*	Air Handling Units	2000

[*] Unit heating capacity data could not be extracted from the unit nameplate.

Packaged Units

The main office is conditioned by a 5.1-ton roof top unit and the band room is also conditioned by a roof to unit. Each packaged roof top unit (RTU) has a supply fan motor, a gas fired furnace for heating and a direct expansion (DX) coil for cooling. The RTU-1 serving the main office was installed in 2009 and in fair condition. The library is conditioned by a 3-ton, cooling only roof top unit. According to facility personnel, the band room and library units have been in use over 18 years.

Table 22: ES – Packaged DX Units Schedule

Tag	Manufacturer	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
RTU-1	Trane	YHC060E3 RMAOOR2 00A180000	Roof	Main Office	DX	Furnace	5.1	80	Packaged DX	2009
RTU-Band Room	Carrier	48TJE-004-511GA	Roof	Band Room	DX	Furnace	3	*	Packaged DX	Unknown
RTU-Library	Carrier	48TJE-004-511GA	Roof	Library 252	DX	N/A	3	N/A	Packaged DX	Unknown

[*] Unit heating capacity data could not be extracted from the unit nameplate.

Make-Up-Air Units

The hallways are conditioned by make-up-air units that are equipped with a supply fan, DX cooling coil and a gas-fired furnace. These units have a cooling capacity of 8 tons and a heating capacity of 145.8 MBH. They were installed in 2009 and are in fair condition. There are also exhaust fans throughout the building.

Table 23: ES – Make-Up-Air Units Schedule

Tag	Manufacturer	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
MAU-1	Reznor	RDCA-090-H150	Roof	1st Floor West Corridor	DX	Furnace	8	145.8	Make-up Air Unit	2009
MAU-2	Reznor	RDCA-090-H150	Roof	1st Floor East Corridor	DX	Furnace	8	145.8	Make-up Air Unit	2009
MAU-3	Reznor	RDCA-090-H150	Roof	2nd Floor West Corridor	DX	Furnace	8	145.8	Make-up Air Unit	2009
MAU-4	Reznor	RDCA-090-H150	Roof	2nd Floor East Corridor	DX	Furnace	8	145.8	Make-up Air Unit	2009

Air Conditioners

There are several split AC systems throughout the building. These serve classrooms (#167, #169, #246, #248), the locker rooms (102 & #103), the teachers' lounge (#108), and offices (#127, #106). The older units are beyond their useful service life, in poor condition, and of standard efficiency. The newer units are in good condition and typically have higher efficiencies.

These units vary in capacity ranges between 1 and 5 tons, and in fair condition and efficiency. There is also a new split direct expansion system serving office #127 that was installed which is in good condition and of high efficiency.

Table 24: ES – Air Conditioner Units Schedule

Tag	Manufacturer	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
FCU-1	Trane	4TTB3024A 1000BA	Roof	Locker Room #102	DX	HW	2	*	Split DX	2009
FCU-2	Trane	4TTB3024A 1000BA	Roof	Locker Room #103	DX	HW	2	*	Split DX	2009
AC - # 246	Unknown	Unknown	Roof	Computer Lab #246	DX	N/A	*	N/A	Split DX	Unknown
AC - # 248	Unknown	Unknown	Roof	Computer Lab #248	DX	N/A	*	N/A	Split DX	Unknown
AC -# 127	Trane	4TTA3060D 3000DA	Roof	BOE Office #127	DX	HW	5	*	Split DX	2018
AC - #106-1	Trane	4TTB3048A 3000BA	Roof	Office #106	DX	N/A	4	*	Split DX	2010
AC - #106-2	Carrier	38CKC042 510	Roof	Office #106	DX	HW	3.5	*	Split DX	2000
AC - #108	Carrier	38CKC042 510	Roof	Teachers' Lounge #108	DX	HW	3.5	*	Split DX	unclear
AC - #167	Unknown	Unknown	Ground	Classroom #167 UV	DX	HW	*	*	Split DX	unclear
AC - #169	Unknown	Unknown	Ground	Classroom #169 UV	DX	HW	*	*	Split DX	unclear

[*] Unit capacity data could not be extracted from the unit nameplate.

David Brearley Middle/High School

Unit Ventilators

Most classrooms and offices are conditioned by unit ventilators that supply heating and cooling to the zones. There is a total of fifty-nine (59) unit ventilators in the building. While a handful of these units were replaced due to failures in 2009, majority of the unit ventilators are approximately 20 years old. These unit ventilators have supply fan motors, outside air dampers, and three-way valves on the heating hot water and chilled water coils. Facility staff reported that the control board on unit ventilators are out of date and no longer upgradeable.

Heating-Ventilation Units

The gymnasium, auxiliary gym, and kitchen area are conditioned by heating-ventilation units. These are gas fired standard efficiency units. No cooling is provided to the gym.

Table 25: MSHS – Heating and Ventilation Units Schedule

Tag	Manufacturer	Model	Location	Area served	Cooling System Type	Heating System Type	Heating Capacity (MBH)	System Type	Year Installed
H&V-3	Unknown	Unknown	Gym	Gym SE Area	N/A	HW	*	Heating and Ventilation Unit	Unknown
H&V-4	Unknown	Unknown	Gym	Gym NE Area	N/A	HW	*	Heating and Ventilation Unit	Unknown
H&V-5	Unknown	Unknown	Gym	Gym SW Area	N/A	HW	*	Heating and Ventilation Unit	Unknown
H&V-6	Unknown	Unknown	Gym	Gym NW Area	N/A	HW	*	Heating and Ventilation Unit	Unknown
H&V-7	Unknown	Unknown	Kitchen	Kitchen Area	N/A	HW	*	Heating and Ventilation Unit	Unknown

[*] Unit nameplate could not be located.

Air Handling Units

The guidance area, corridors, auditorium, library, cafeteria, and few classroom and offices are conditioned by air handling units. These are direct expansion (DX) units with hot water heating coils. These AHUs are summarized in the table that follows. The units serving teacher's lounge unit is installed in 2010 and in fair condition. The other units serving auditorium, library, cafeteria and teachers' lounge are installed between 2005 and 2007. The rest of the AHU are at the end of their service life.

Table 26: MSHS – AHU Units Schedule

Tag	Manufacturer	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
AHU-1	Carrier	39AC6077UBF	Roof	Guidance	DX	HW	5.4	*	Air Handling Unit	Unknown
AHU-2	Trane	TTA090A400FA	Roof	Corridor-D Drama Area	DX	HW	7.5	*	Air Handling Unit	2005
AHU-3	Trane	TTA120A400FA	Roof	Vocal Music Offices	DX	HW	10.0	*	Air Handling Unit	2005
AHU-4	Carrier	38AKS009---601--	Roof	Band Room	DX	HW	8.4	*	Air Handling Unit	2000
AHU-5	McQuay	CAH017GDAC	Roof	Auditorium	DX	HW	35	*	Air Handling Unit	2007
AHU-6	McQuay	CAH017GDAC	Roof	Auditorium	DX	HW	35	*	Air Handling Unit	2007
AHU-7	McQuay	CAH012GDAC	Roof	Library	DX	HW	20	*	Air Handling Unit	2007
AHU-8	McQuay	CAH010GDAC	Roof	Cafeteria	DX	HW	20	*	Air Handling Unit	2007
AHU-9	McQuay	CAH010GDAC	Roof	Cafeteria	DX	HW	20	*	Air Handling Unit	2007
AHU-10	McQuay	RCS06F078D	Roof	Teachers' Lounge	DX	HW	6	*	Air Handling Unit	2010

[*] Unit capacity data could not be extracted from the unit nameplate.

Air Conditioners

There are several split AC systems throughout the building. These serve offices, the board room, classrooms, and a server room. These units have various cooling efficiency, ranging from 2.75 tons to 4 tons. The older units are beyond their useful life, in poor condition, and of standard efficiency. The newer units are in good condition and typically have higher efficiencies.

Table 27: MSHS – Air Conditioner Units Schedule

Tag	Manufacture	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
AC - #212	Carrier	FB4ANF036	Roof	Room #212	Heat Pump	Heat Pump	3	*	Heat Pump	2000
AC - #190	Trane	2TTB0048A10 00AA	Roof	190 Board Room	DX	HW	4	*	Split DX	2005
AC - #184	Mitsubishi	MS09NW	Roof	184 Custodial Office	DX	No Heating	0.75	N/A	Split DX	Unknown
AC-Copy Room	Carrier	50EE018310	Roof	2nd Floor copy room	DX	HW	1.5	*	Split DX	1986
AC-Frame Room 1	Fujitsu	AOU36RLXB	Roof	Frame room	Heat Pump	Heat Pump	2.75	34	Heat Pump	Unknown
AC-Frame Room 2	Luxaire	HABA-T048SG	Roof	Frame room	DX	HW	*	*	Split DX	Unknown
AC-Conference Room	Unknown	Unknown	Roof	Conference Room	DX	HW	*	*	Split DX	Unknown
FCU-1	EMI	S1CG2000A0 0	Roof	Trainer Office	DX	HW	2	*	Split DX	Unknown
FCU-1	EMI	S1CG2000A0 0	Roof	Female Coach Office	DX	HW	2	*	Split DX	Unknown
FCU-1	EMI	S1CG2000A0 0	Roof	Male Coach Office	DX	HW	2	*	Split DX	Unknown

[*] Unit capacity data could not be extracted from the unit nameplate.

Make-Up-Air Units

The hallways are conditioned by make-up-air units that are equipped with a supply fan, DX cooling coil and a gas-fired furnace. These units have a cooling capacity of 6.4 tons to 8.8 tons and a heating capacity of 145.8 MBH. The rest of the units are heating only units and serves various areas of the school. They were installed between 2009 and 2010 and are in fair condition. There are also exhaust fans throughout the building.

Table 28: MSHS – Make-Up-Air Units Schedule

Tag	Manufacture	Model	Location	Area served	Cooling System Type	Heating System Type	Cooling Capacity (tons)	Heating Capacity (MBH)	System Type	Year Installed
MUA-1	Reznor	RDCA-102-H200	Roof	1st Floor West Corridor	DX	Furnace	8.8	145.8	Make-Up-Air Unit	2009
MUA-2	Reznor	RDCA-102-H200	Roof	1st Floor North Corridor	DX	Furnace	8.0	145.8	Make-Up-Air Unit	2009
MUA-3	Reznor	RDCA-078-H150	Roof	1st Floor South Corridor	DX	Furnace	6.5	145.8	Make-Up-Air Unit	2009
MUA-4	Reznor	RDCA-078-H150	Roof	2nd Floor High Corridor & Janitor	DX	Furnace	6.4	145.8	Make-Up-Air Unit	2009
MUA-5	Reznor	RDH300	Roof	Weight Room	N/A	Furnace	N/A	243	Make-Up-Air Unit	2009
MUA-6	Reznor	RDH300	Roof	Wrestling Room	N/A	Furnace	N/A	243	Make-Up-Air Unit	2009
MUA-7	Reznor	RDH125	Roof	Girls Team Room	N/A	Furnace	N/A	101.25	Make-Up-Air Unit	2010

MUA-8	Reznor	RDH350	Roof	Girls Locker Room	N/A	Furnace	N/A	283.5	Make-Up-Air Unit	2010
MUA-9	Reznor	RDH300	Roof	Trainers' Room	N/A	Furnace	N/A	243	Make-Up-Air Unit	2010
MUA-10	Reznor	RDH150	Roof	Boys Team Room	N/A	Furnace	N/A	121.5	Make-Up-Air Unit	2010
MUA-11	Reznor	RDH350	Roof	Boys Locker Room	N/A	Furnace	N/A	283.5	Make-Up-Air Unit	2010
MUA-12	Reznor	RDH225	Roof	Boys Locker	N/A	Furnace	N/A	182.25	Make-Up-Air Unit	2010

2.7.5 Building Management System

Harding Elementary School

There are two energy management systems, TBS control system and Johnson control Metasys control system. The TBS system controls the boilers and heating system, the chiller and chilled water system, gymnasium heating-ventilation units, auditorium air handling unit, and most of the units. The boilers are enabled when the outdoor air temperature is below ~55°F. The chiller is enabled when the outdoor air temperature is above ~60°F.

This BMS is capable of controlling equipment scheduling and monitoring space temperatures, supply air temperatures, humidity, heating water loop temperatures, and chilled water loop temperatures and trending the unit operation performance. However, some unit' trending functions is not operational. And the unit ventilators have a lot of supply fan failure alarms. Per discussion with the facility personnel, teachers seldom complain about overheating and undercooling in some classrooms.

A Johnson Controls Metasys controls the make-up air units, exhaust fans, roof top units, fan coil units, and newer unit ventilators. Facility staff reported that there are no effective temperature setbacks for HVAC equipment. However, the teachers manually turn off the unit when the school is off. The site staff expressed a great interest in replacing both EMS systems with a new EMS.

The following summarize the temperature set points as read from the TBS user interface:

Table 29. ES - HVACs Temperature Setpoint Schedule - TBS

Cooling Occupied	Heating Occupied
66°F - 77°F	50°F - 90°F

The following summarize the temperature set points as read from the Metasys user interface:

Table 30. ES - HVACs Temperature Setpoint Schedule - Metasys

Cooling Occupied	Heating Occupied
61°F - 76°F	70°F - 80°F

There are several sensors which were currently off-line or mis-calibrated. Per discussions with facility personnel, there has never been a retro-commissioning of the control system and the system is over 20 years old.

The following summarize the occupied schedules from the TBS user interface:

- Classrooms 5:30 AM – 6:00 PM
- Cafeteria 6:00 AM – 6:00 PM
- Auditorium 6:00 AM – 8:30 PM

The following summarize the occupied schedules from the Metasys user interface:

- Make Up Air Units 6:00 AM – 8:00 PM
- Unit Ventilators 6:00 AM – 5:00 PM

David Brearley Middle/High School

A Johnson Controls Metasys EMS controls the HVAC systems and other equipment including the boilers, the chiller, the air handlers, exhaust fans, and most of the unit ventilators. The EMS provides equipment scheduling control and monitors space temperatures, supply air temperatures, humidity, and hydronic water temperatures. The following summarize the temperature set points as read from the Metasys user interface:

Table 31. MSHS - HVACs Temperature Setpoint Schedule

Heating Occupied	Cooling Occupied	Heating Unoccupied	Cooling Unoccupied
68°F - 72°F	71°F - 73°F	60°F - 65°F	80°F - 85°F

There are several sensors which were currently off-line or mis-calibrated. Per discussions with facility personnel, there has never been a retro-commissioning of the control system and the system is over 20 years old. The gym area has Saturday team training session from 6am to 6pm. Apart from the gym area, most of the school area operates during Monday to Friday. The following summarizes the occupied schedules:

- Gym Area 6:00 AM – 8:00 PM (Monday-Friday)
  6:00 AM – 6:00 PM (Saturday)
- Classroom Area 6:00 AM – 4:00 PM
- Auditorium 6:00 AM – 11:30PM
- Cafeteria 5:00 AM – 3:00 PM

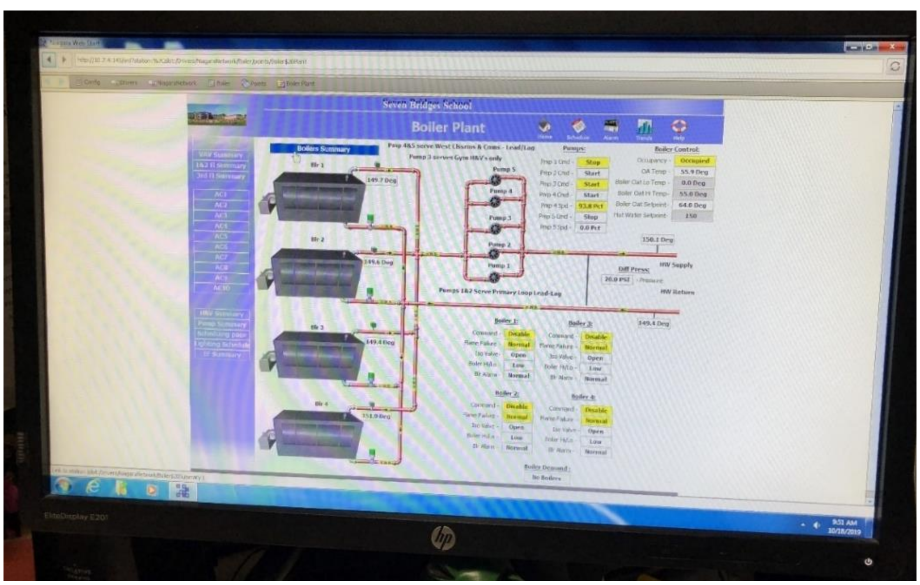


Figure 6. Niagara Building Energy Management System (BMS)

2.7.6 Domestic Hot Water

Harding Elementary School

Hot water is produced with a 199 MBH gas-fired AO Smith BTR 199 with 104-gallon storage tank water heater. This serves the majority of the building's domestic hot water needs. This water heater is beyond its useful service life. There is also a 50-gallon, electric AO Smith DRE 52 100 24 kW storage tank water heater that serves the kitchen. The domestic hot water pipes are insulated, and the insulation is in good condition.

Table 32. ES - Existing Domestic Hot Water Heater

Tag	Manufacture	Model Number	Location	Storage Capacity (Gallons)	Input
DHW-1	AO Smith	BTR 199	Boiler Room	104	199 MBH
DHW-2	AO Smith	DRE 52 100	Kitchen	50	24 kW

David Brearley Middle/High School

Hot water is produced with a 999 MBH Raypak hot water boiler WH7-1003 and stored in a 115-gallon storage tank. The system has an efficiency of about 87%. This system was installed in 2010 and is in good condition. There are two 200-gallon storage tanks which are also supplied by this boiler. They are located in the gym storage rooms and serve the locker rooms. The facility personnel stated that the showers are only used a few times a year. Hot water for the kitchen dishwasher is produced with a 36 kW Hatco C-36 electric booster water heater. Per discussions with facility personnel, the dishwasher is also rarely used.

Table 33. MSHS - Existing Domestic Hot Water Heater

Tag	Manufacture	Model Number	Location	Storage Capacity (Gallons)	Input
DHW-1	MVB	WH7-1003	Boiler Room	115	999 MBH
Storage Tanks	AO Smith	TJV 200A 000000000	Gym Storage Room	200	N/A
DHW-2	Hatco	C-36	Kitchen	N/A	36kW

2.7.7 Lighting Systems

Harding Elementary School

Warren Harding Elementary School uses a variety of interior fixtures throughout the building. The most prevalent lamp type used in the school is 4-feet 32-watt linear fluorescent T8 lamps in fixtures equipped with 2, 3 or 4 lamps per fixture. Additionally, the range of lamps used in interior lighting varies from 4-feet T5 & T12 linear fluorescent lamps, 2-feet T8 linear fluorescent lamps and T8 U-bend fluorescent tubes. Fixtures using T5 and T8 lamps are equipped with electronic ballasts while T12 lamps are used with magnetic ballasts. There are also compact fluorescent and incandescent lamps used for interior lighting. Occupancy sensors are installed in classrooms and offices.

Majority of the high energy consuming exterior lighting consists of metal halide HID lamps of 50, 100 or 250-watts. Fixtures equipped with incandescent, compact fluorescent, 4-feet T8 and T12 lamps are also found in exterior areas.

David Brearley Middle/High School

Similar to the elementary school the most prevalent lamp type used in the David Brearley Middle/High School is 4-feet 32-watt linear fluorescent T8 lamps in fixtures equipped with 1 and up to 4 lamps per fixture. 4-feet T5 & T12 linear fluorescent lamps, compact fluorescent & incandescent lamps, 2-feet T8 linear fluorescent lamps and T8 U-bend fluorescent tubes are also commonly used in interior lighting fixtures. In some areas such as gym, auditorium, restrooms and storage spaces fixtures are already upgraded with LED screw-in, LED linear tubes and LED high-bay lamps. However, vast majority of the existing interior lighting inventory still comprise of non-LED lighting. Occupancy sensors are installed on some of the fixtures throughout the school mainly in areas such as classrooms, library, gym, corridors and storage spaces.

Majority of the exterior lighting has already been upgraded to LED lighting. There are only a handful of fixtures remaining that are equipped with metal halide HID and compact fluorescent lamps serving the exterior spaces.

2.8 Utility Bill Energy Use Summary

Harding Elementary School

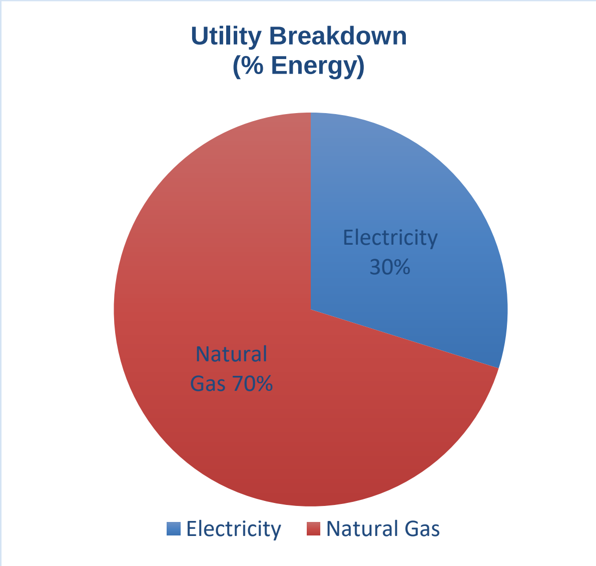
A summary of monthly utility consumption and costs for the Warren Harding Elementary School was analyzed for the 12-month period between January 2019 and December 2019. This summary is useful for understanding the various uses of energy and the annual variation in energy usage. The total electricity consumed by the facility in the analyzed period was 617,431 kWh. Additionally, the facility also consumed 49,564 therms of natural gas based on the utility bills provided by the facility.

The utility cost data was used to determine a blended rate. The blended rate is the overall annual rate per unit of consumption that the facility pays for electricity and natural gas. The blended rate is determined by dividing the total electric/natural gas cost for a time period by the total electric/natural gas consumption in kWh/therms for the same time period.

The blended rate for electricity was determined to be $0.137 per kilowatt-hour. The blended rate for natural gas was determined to be $0.883 per therm.

Table 34: ES - Base Building Energy Consumption and Costs (1/2019 – 12/2019)

Energy Type	Total Annual Use	Units	kBTU	% Energy	Total Annual Cost ($)	% Cost	kBTU/SF	$/SF
Electricity	617,431	kWh	2,106,675	30%	$84,460	66%	21.30	$0.85
Natural Gas	49,564	Therms	4,955,238	70%	$43,785	34%	50.09	$0.44
Total			**7,061,913**	**100%**	**$128,245**	**100%**	**71.39**	**$1.30**



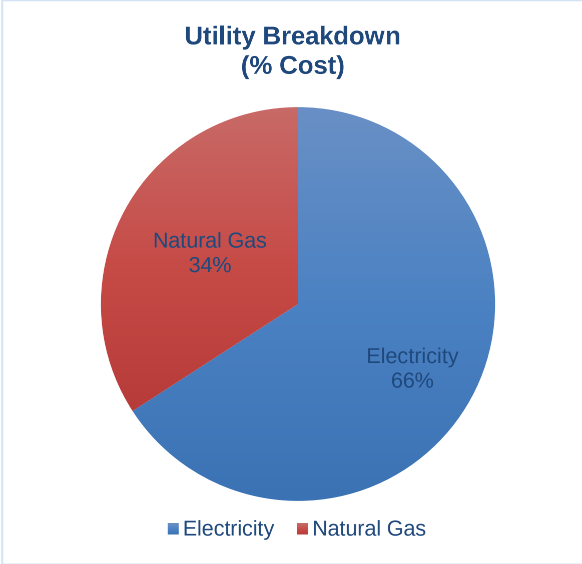


Figure 7: ES - Utility Breakdown (1/2019 – 12/2019)

Table 35: ES - Unit Energy Cost Summary (1/2019 – 12/2019)

Utility	Blended Rate	Rate Units
Electric	$0.137	$/kWh
Natural Gas	$0.883	$/Therms

David Brearley Middle/High School

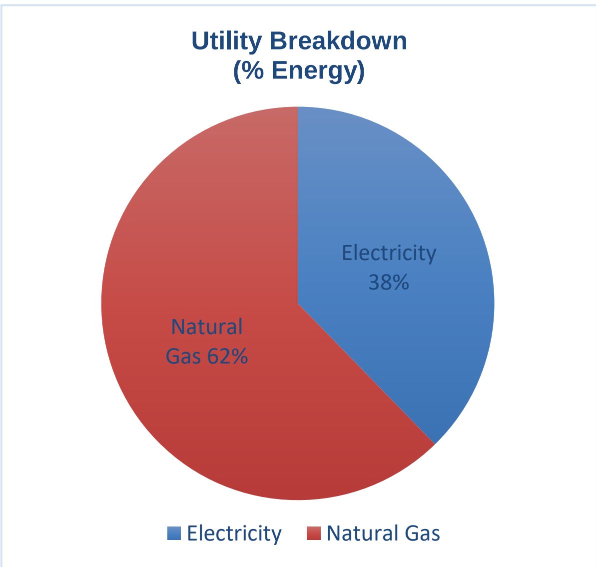
A summary of monthly utility consumption and costs for the David Brearley Middle/High School was analyzed for the 12-month period between January 2019 and December 2019. This summary is useful for understanding the various uses of energy and the annual variation in energy usage. The total electricity consumed by the facility in the analyzed period was 1,164,702 kWh. Additionally, the facility also consumed 65,685 therms of natural gas based on the utility bills provided by the facility.

The utility cost data was used to determine a blended rate. The blended rate is the overall annual rate per unit of consumption that the facility pays for electricity and natural gas. The blended rate is determined by dividing the total electric/natural gas cost for a time period by the total electric/natural gas consumption in kWh/therms for the same time period.

The blended rate for electricity was determined to be $0.131 per kilowatt-hour. The blended rate for natural gas was determined to be $0.849 per therm.

Table 36: MSHS - Base Building Energy Consumption and Costs (1/2019 – 12/2019)

Energy Type	Total Annual Use	Units	kBTU	% Energy	Total Annual Cost ($)	% Cost	kBTU/SF	$/SF
Electricity	1,164,702	kWh	3,973,963	38%	$153,088	73%	25.96	$1.00
Natural Gas	65,685	Therms	6,566,899	62%	$55,760	27%	42.90	$0.36
Total			**10,540,861**	**100%**	**$208,848**	**100%**	**68.86**	**$1.36**



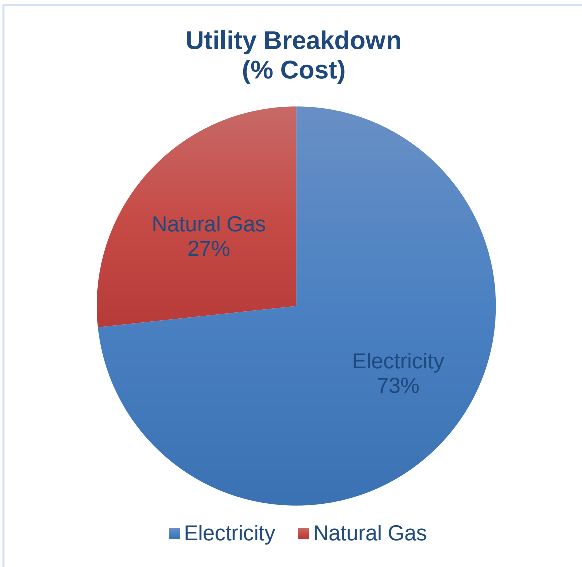


Figure 8: MSHS - Utility Breakdown (1/2019 – 12/2019)

Table 37: MSHS - Unit Energy Cost Summary (1/2019 – 12/2019)

Utility	Blended Rate	Rate Units
Electric	$0.131	$/kWh
Natural Gas*	$0.849	$/Therms

2.8.1 Electric Energy Usage

Harding Elementary School

The facility's electric energy usage for the period of January 2019 through December 2019 was 617,431 kWh, with a peak demand of 562 kW. Peak electric demand is occurred in September when the school reopens after summer break.

Table 38: ES - Electric Energy Usage (1/2019 – 12/2019)

Month-Year	Usage (kWh)	Demand (kW)	Total Electric Cost
19-Jan	50,275	162	$5,945
19-Feb	52,443	158	$6,019
19-Mar	49,260	158	$5,738
19-Apr	42,499	170	$5,216
19-May	51,666	252	$6,567
19-Jun	61,151	249	$9,690
19-Jul	49,957	160	$8,480
19-Aug	46,455	176	$7,322
19-Sep	61,179	265	$10,646
19-Oct	47,481	562	$6,256
19-Nov	47,341	159	$5,756
19-Dec	57,723	164	$6,824
Total/Peak	**617,431**	**Max: 562**	**$84,460**

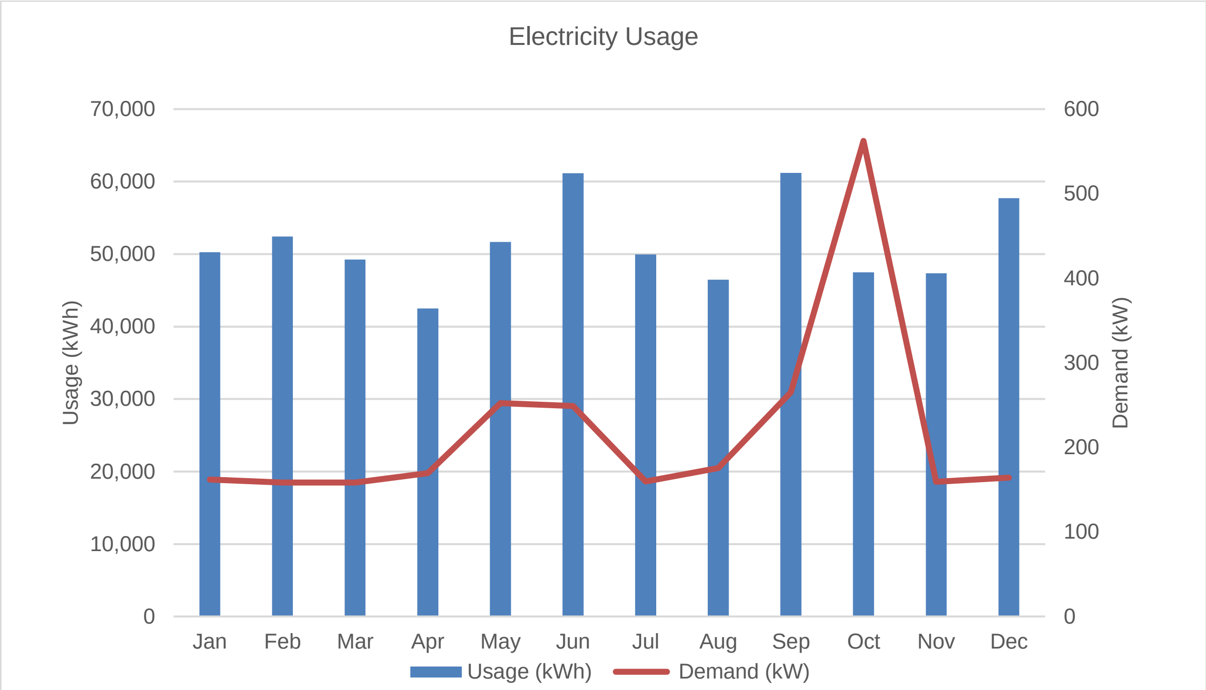


Figure 9: ES - Electric Energy Usage Data (1/2019 – 12/2019)

David Brearley Middle/High School

The facility's electric energy usage for the period of January 2019 through December 2019 was 1,164,702 kWh, with a peak demand of 866 kW. Peak electric demand is occurred in October after the school reopens after summer break. The higher electrical demand in winter months is due to the presence of electric resistance heaters in the baseboards.

Table 39: MSHS - Electric Energy Usage (1/2019 – 12/2019)

Month-Year	Usage (kWh)	Demand (kW)	Total Electric Cost
19-Jan	125,296	384	$13,816
19-Feb	129,599	379	$14,538
19-Mar	108,540	342	$12,004
19-Apr	86,035	303	$9,727
19-May	92,804	407	$11,006
19-Jun	80,370	425	$13,807
19-Jul	75,234	283	$11,580
19-Aug	77,014	280	$11,184
19-Sep	99,215	474	$19,525
19-Oct	80,927	866	$11,634
19-Nov	93,333	412	$11,175
19-Dec	116,334	379	$13,091
Total/Peak	**1,164,702**	**Max: 866**	**$153,088**

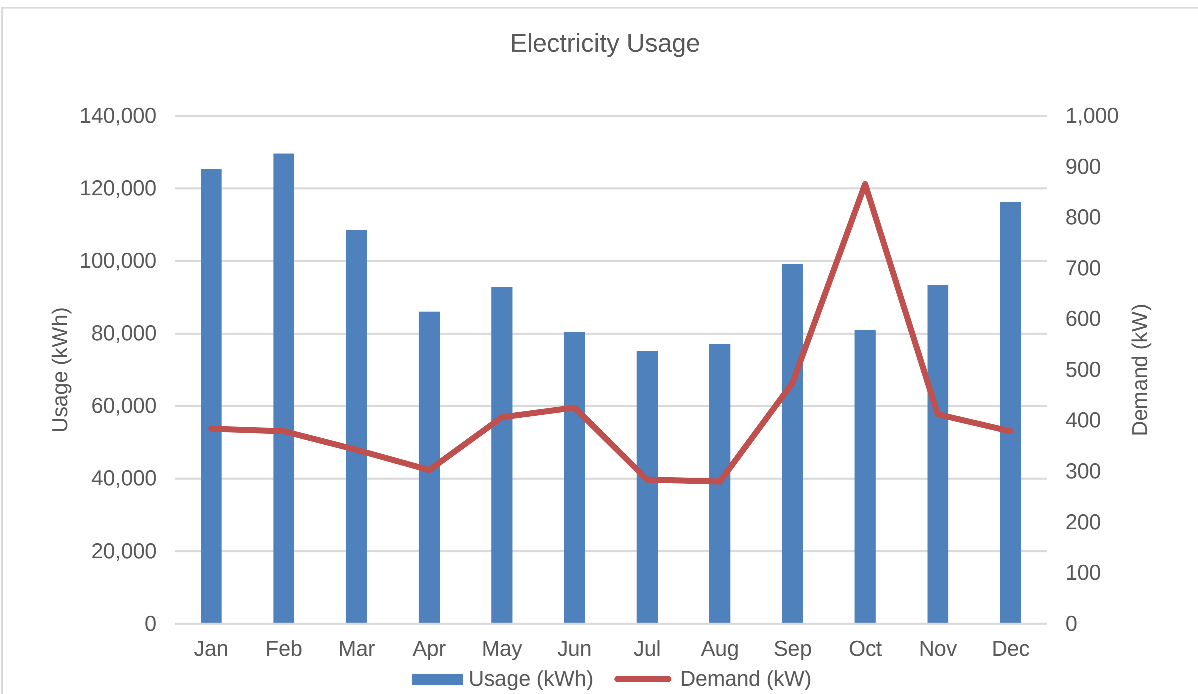


Figure 10: MSHS - Electric Energy Usage Data (1/2019 – 12/2019)

2.8.2 Natural Gas Usage

Harding Elementary School

The facility's total natural gas usage for the period of January 2019 through December 2019 was 49,564 therms. Majority of the natural gas consumption occurs during winter season as the boilers are utilized for space heating.

Table 40. ES - Natural Gas Energy Use (1/2019 – 12/2019)

Month-Year	Usage (Therms)	Total Gas Cost
19-Jan	11,875	$9,882
19-Feb	9,230	$7,175
19-Mar	6,722	$5,312
19-Apr	2,999	$2,639
19-May	752	$1,079
19-Jun	36	$621
19-Jul	15	$547
19-Aug	23	$586
19-Sep	77	$621
19-Oct	1,227	$1,455
19-Nov	7,897	$6,610
19-Dec	8,711	$7,259
Total	**49,564**	**$43,785**

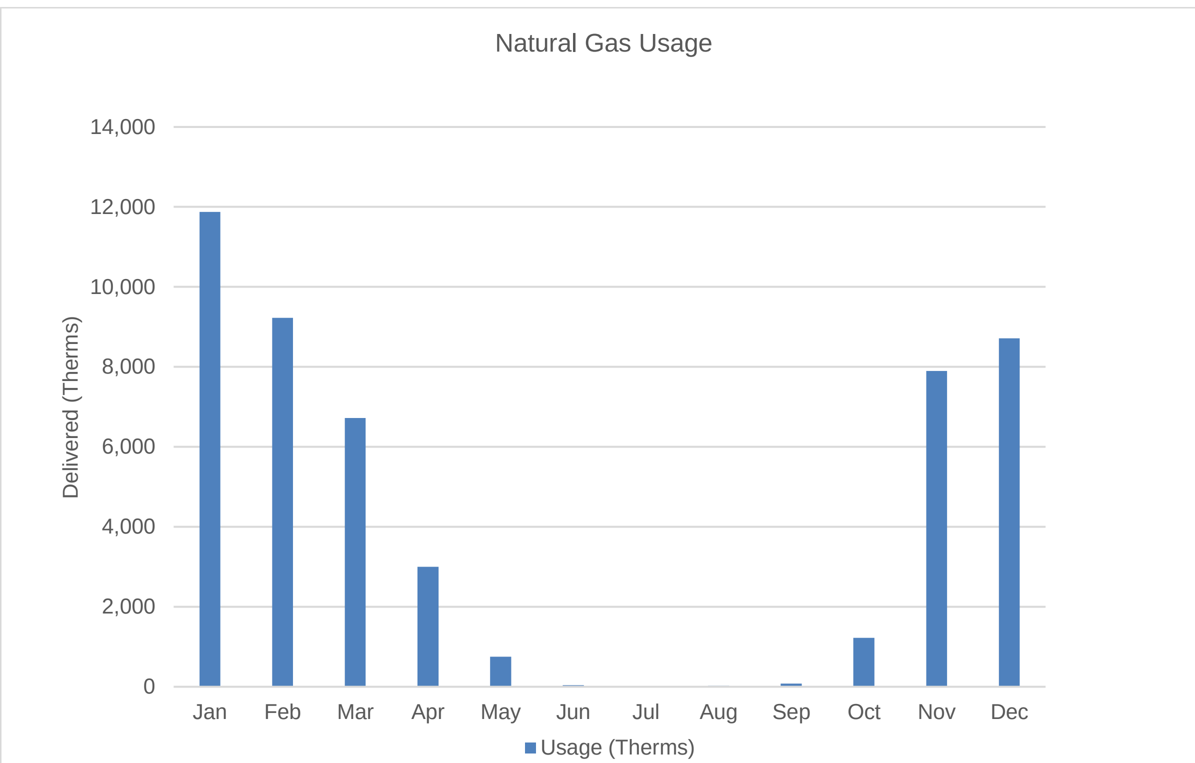


Figure 11: ES - Natural Gas Usage Data (1/2019 – 12/2019)

David Brearley Middle/High School

Elizabethtown Gas delivers natural gas under various rate classes, with natural gas supply provided by UGI, a third-party supplier.

Table 41. MSHS - Natural Gas Energy Use (1/2019 – 12/2019)

Month-Year	Usage (Therms)	Total Gas Cost
19-Jan	16,237	$13,619
19-Feb	9,745	$7,681
19-Mar	8,786	$6,672
19-Apr	3,542	$3,157
19-May	1,592	$1,872
19-Jun	563	$1,004
19-Jul	219	$997
19-Aug	295	$1,032
19-Sep	815	$1,344
19-Oct	2,481	$2,408
19-Nov	9,693	$7,260
19-Dec	11,716	$8,713
Total	**65,685**	**$55,760**

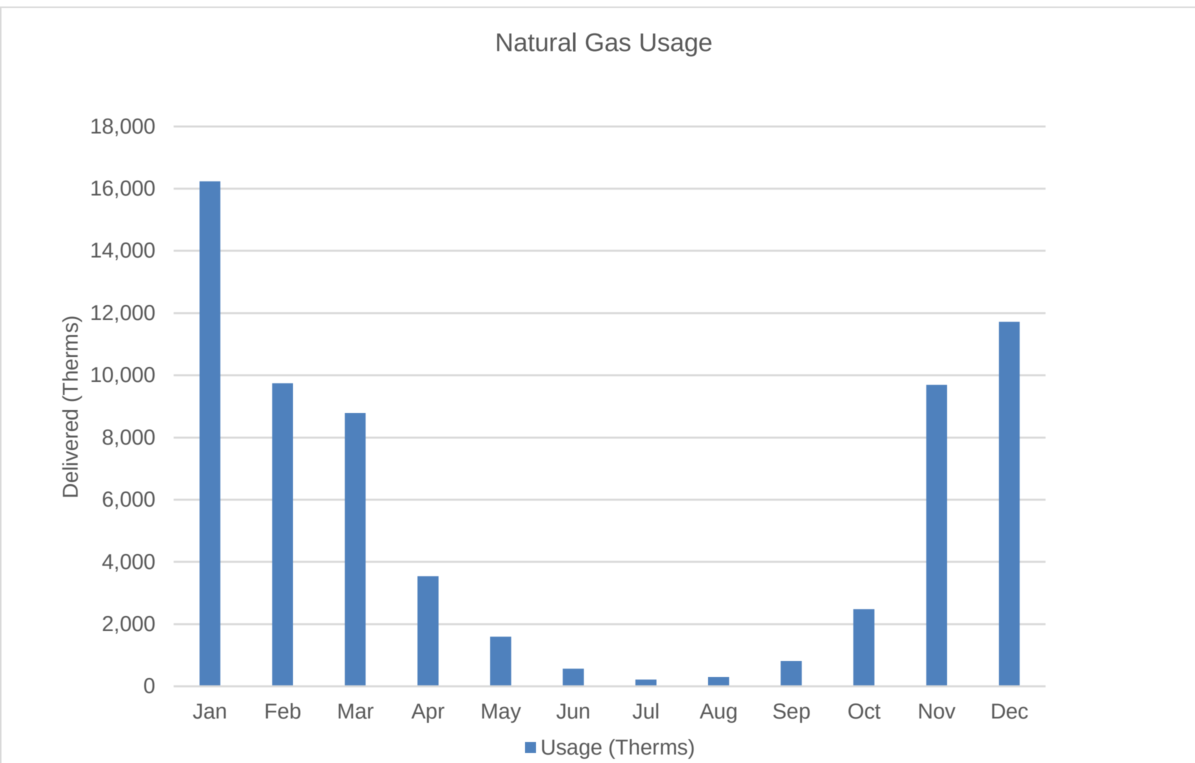


Figure 12: MSHS - Natural Gas Usage Data (1/2019 – 12/2019)

2.9 Energy End Use Breakdown

The tables below summarize the existing annual electric and natural gas end usage within the buildings. The end use breakdown is based on the eQuest Model. The eQuest baseline model was calibrated to the actual facility energy consumption using utility bills for electric and natural gas consumption. The figures and tables in this section shows an estimated distribution of electric and natural gas usage among the building systems. This breakdown is based on the energy model and, as a result, may vary from the site's actual energy distribution.

Harding Elementary School

The eQuest baseline model was calibrated to be within 2% for electricity utilities bills and 3% of the natural gas usage annually.

Table 42: ES - End Use Breakdown Summary

End Use Type	Electricity (kWh)	Electricity Usage (%)	Natural Gas (therms)	Natural Gas Usage (%)	Total Site Energy (kBTU)	Total Usage (%)
Lighting	155,050	24%	0	0%	529	7%
Misc Equip	67,380	11%	700	1%	300	4%
Primary heating	45,860	7%	49,812	96%	5,136	70%
Primary cooling	83,660	13%	0	0%	285	4%
Pumps & Aux	118,240	18%	300	1%	433	6%
Vent Fans	94,970	15%	0	0%	324	4%
Domestic Hot WTR	2,080	0%	900	2%	97	1%
Exterior Light	74,380	12%	0	0%	254	3%
Total Estimated	641,620	100%	51,712	100%	7,359	100%

David Brearley Middle/High School

The eQuest baseline model was calibrated to be within 0.4% for electricity utilities bills and 6% of the natural gas usage annually.

Table 43: MSHS - End Use Breakdown Summary

End Use Type	Electricity (kWh)	Electricity Usage (%)	Natural Gas (therms)	Natural Gas Usage (%)	Total Site Energy (kBTU)	Total Usage (%)
Lighting	256,000	22%	0	0%	874	8%
Misc Equip	117,100	10%	900	1%	490	4%
Primary heating	387,800	34%	70,217	97%	8,343	75%
Primary cooling	102,700	9%	0	0%	350	3%
Pumps & Aux	70,100	6%	500	1%	289	3%
Vent Fans	205,000	18%	0	0%	699	6%
Domestic Hot WTR	0	0%	900	1%	90	1%
Exterior Light	14,100	1%	0	0%	48	0%
Total Estimated	1,152,800	100%	72,517	100%	11,184	100%

2.9.1 Electric End Use Breakdown

Harding Elementary School

Approximately, 53% of the electrical energy used in the building was dedicated to HVAC use (fans, pumps & auxiliary equipment, cooling & heating) with lighting accounting for another 36% (interior light and exterior light). The remaining 11% was used for miscellaneous equipment and other process equipment.

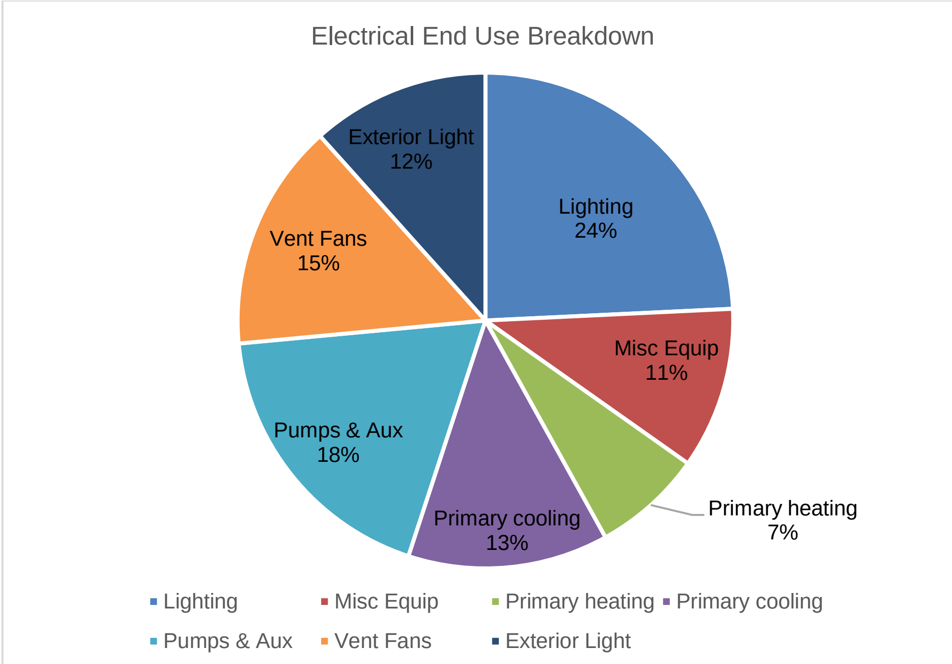


Figure 13: ES - Electric End Use Breakdown

David Brearley Middle/High School

Approximately, 67% of the electrical energy used in the building was dedicated to HVAC use (fans, pumps & auxiliary equipment, cooling & heating including electric heaters) with lighting accounting for another 23% (interior light and exterior light). The remaining 10% was used for miscellaneous equipment and other process equipment.

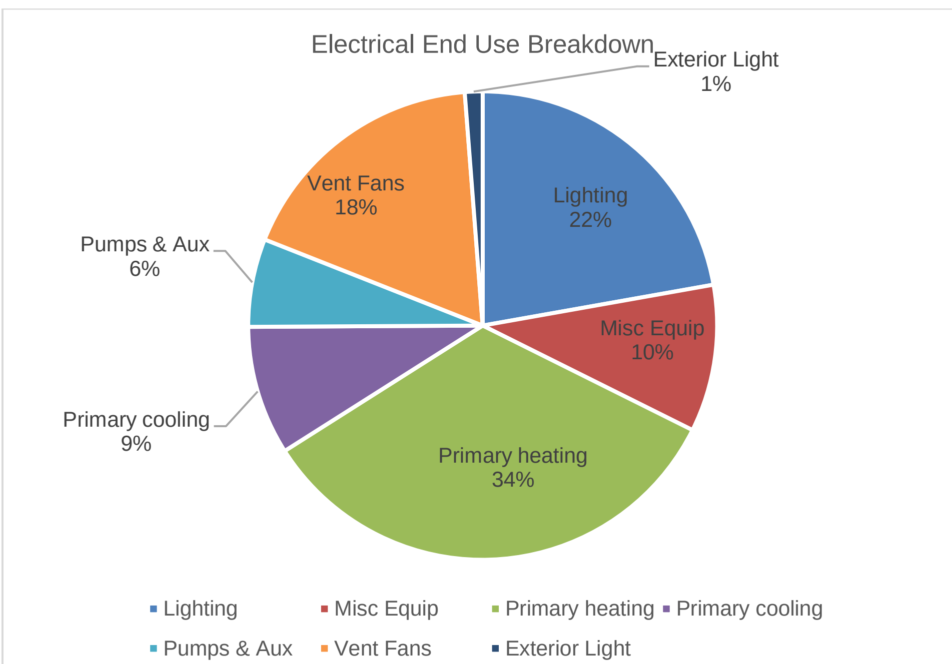


Figure 14: MSHS - Electric End Use Breakdown

2.9.2 Natural Gas End Use Breakdown

Harding Elementary School

Space heating accounted for approximately 96% of the school's natural gas usage. Domestic hot water generation accounted for approximately 2%. The remaining 2% was used for miscellaneous equipment (kitchen gas ranges) and auxiliary equipment.

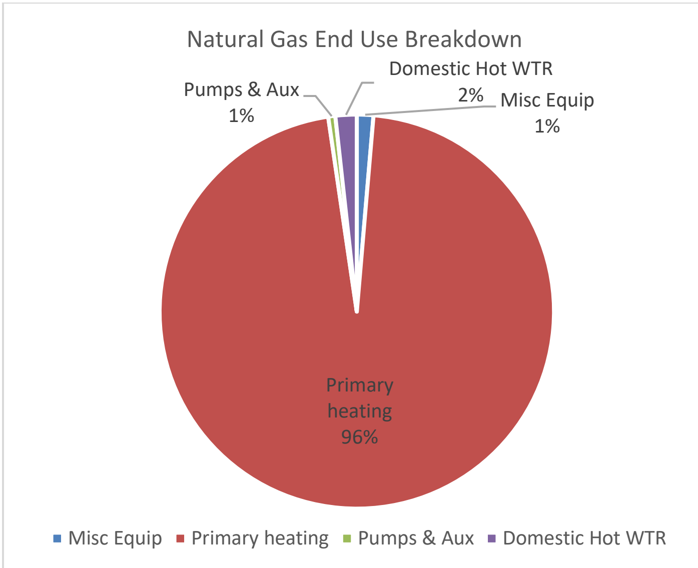


Figure 15: ES - Natural gas End Use Breakdown

David Brearley Middle/High School

Space heating accounted for 97% of the school's natural gas usage. Domestic hot water generation accounted for 1%. The remaining 2% was used for miscellaneous equipment (kitchen gas ranges) and auxiliary equipment.

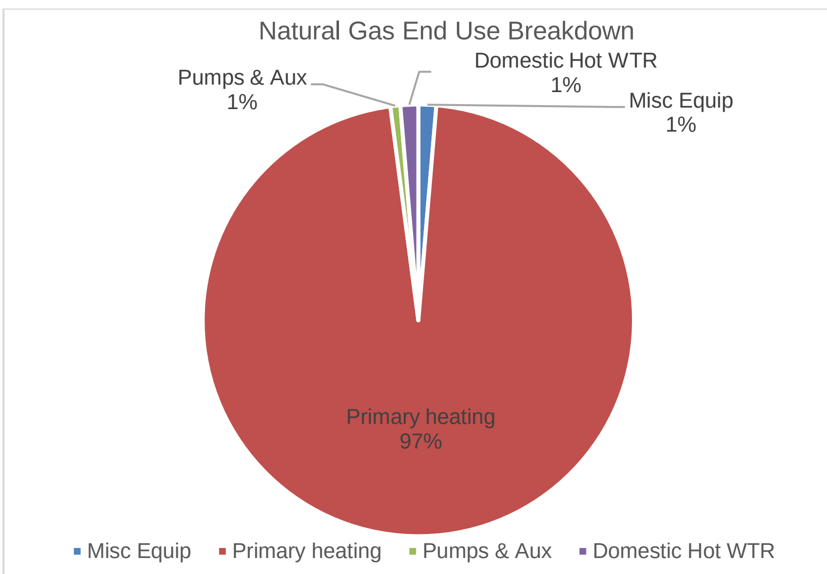


Figure 16: MSHS – Natural Gas End Use Breakdown

2.9.3 Total Energy Use Breakdown

The conversion of each utility's consumption to a common energy unit, kBTU, allows for a total energy end use breakdown to be estimated. The figures below show an estimated distribution of energy usage among the building systems. This breakdown is based on the project energy model and, as a result, may vary from the site's real distribution.

Harding Elementary School

Space heating accounted for approximately 70% of the energy usage, domestic hot water generation: 1%, space cooling: 4%, lighting: 11%, miscellaneous equipment: 4%, pumps & auxiliary: 6%, ventilation fans; 4%.

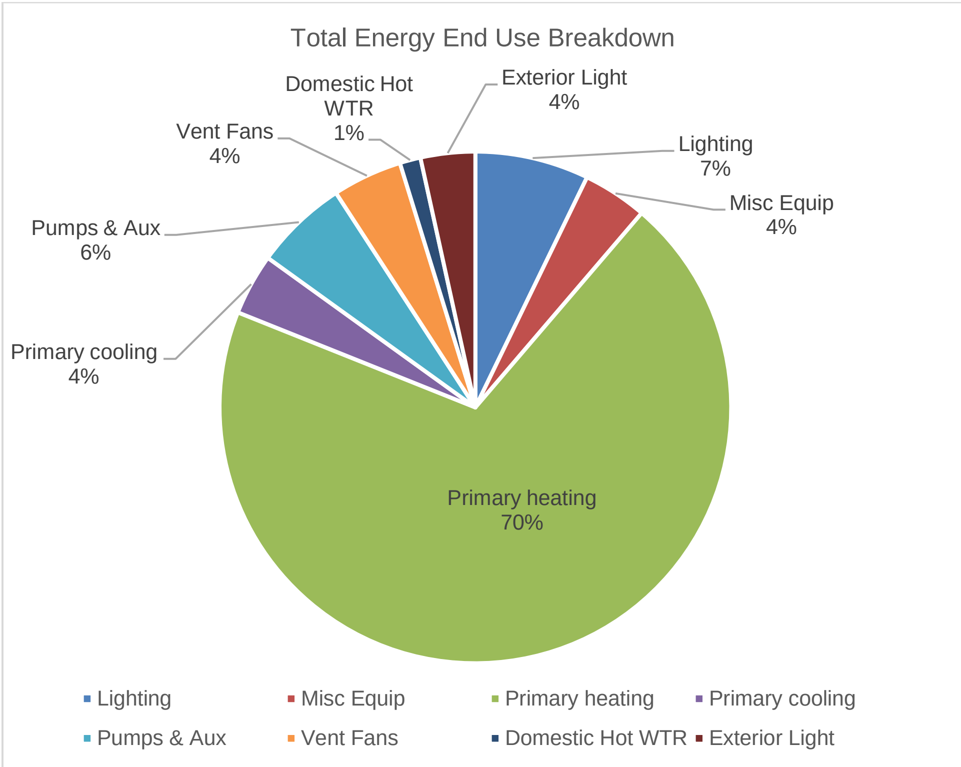


Figure 17: ES - Total Energy Use Breakdown

David Brearley Middle/High School

Space heating accounted for approximately 75% of the energy usage, domestic hot water generation: 1%, space cooling: 3%, lighting: 8%, miscellaneous equipment: 4%, pumps & auxiliary: 3%, ventilation fans; 6%.

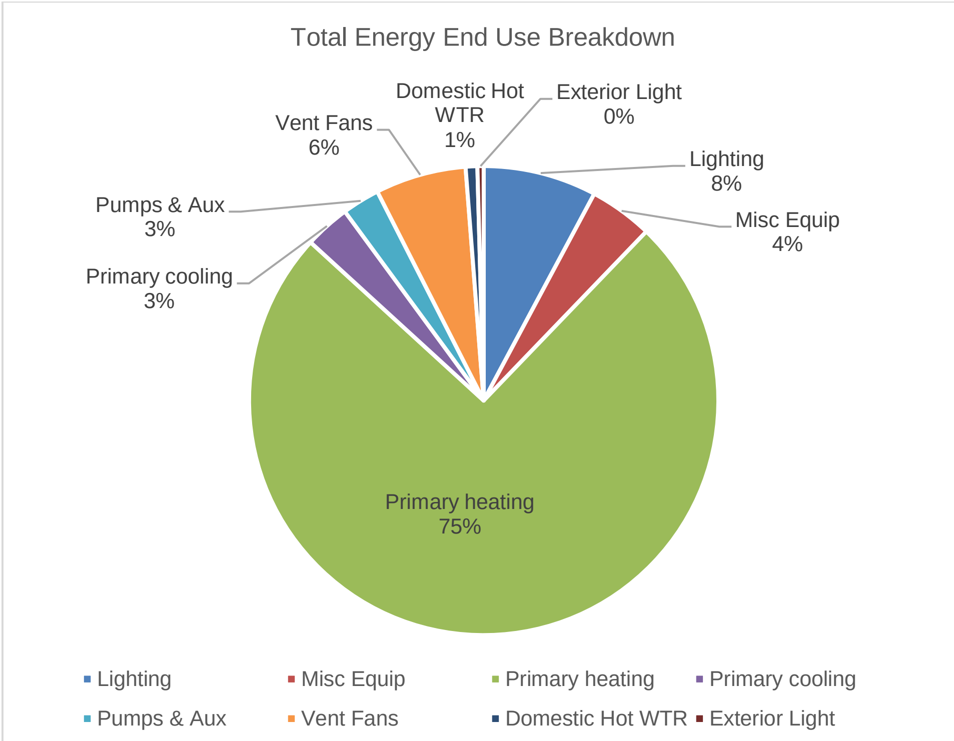


Figure 18: MSHS - Total Energy Use Breakdown

2.9.4 Average Energy Cost

Harding Elementary School

The average energy cost per square foot was calculated by dividing the total cost of all utilities – electric, and natural gas by the total conditioned area of the facility.

Table 44: ES - Average Energy Cost per Square Foot

Total Conditioned Area in SF	kBTU	Total Annual Cost ($)	$/SF
98,921	7,061,913	$128,245	$1.30

Note: Each conditioned space was created in the eQuest energy model using the floor plan drawings provided by the facility. eQuest model was used to estimate the total conditioned area.

David Brearley Middle/High School

The average energy cost per square foot was calculated by dividing the total cost of all utilities – electric, and natural gas by the total conditioned area of the facility.

Table 45: MSHS - Average Energy Cost per Square Foot

Total Conditioned Area in SF	kBTU	Total Annual Cost ($)	$/SF
153,072	10,540,861	$208,848	$1.36

Note: Each conditioned space was created in the eQuest energy model using the as-built drawings provided by the facility. eQuest model was used to estimate the total conditioned area.

2.10 Peer Group Benchmarking

Willdan uses the U.S. Environmental Protection Agency (EPA) Portfolio Manager to rate the building on a scale of 1 to 100, as defined by its Energy Star score. This score compares a property under consideration to similar properties nationwide. The building is compared using a database of similar buildings from a national survey conducted by the Department of Energy. An Energy Star score of 50 indicates that the building, from an energy consumption standpoint, performs better than 50% of all similar buildings nationwide, while a rating of 75 indicates that the building performs better than 75% of all similar buildings nationwide.

2.10.1 Current EUI

The Site Energy Use Intensity (EUI) is the amount of heat and electricity consumed by a building, as commonly reflected in utility bills, divided by the facility's conditioned square footage. The Source EUI is the total amount of natural gas consumed in the generation and use of energy consumed at a building, such as electricity and Natural Gas, divided by the facility's square footage. A facility's site and source EUI can be obtained from the Statement of Performance (SOP). The SOP for this facility has been reiterated in table below. It incorporates generation, transmission, and storage losses, thereby enabling a complete assessment of energy use in a building.

The utility bills and other information gathered during the energy audit process were analyzed to obtain the site and source EUIs of the existing facility. The site and source U.S. Median EUIs mentioned below have been obtained from the EPA Portfolio Manager.

Harding Elementary School

The Site Energy Use Intensity (EUI) for Harding Elementary School is 70.6 kBTU/SF, as compared to a national median EUI for similar buildings of 72.1 kBTU/SF. The Source EUI for the facility is 111.4 kBTU/SF, as compared to a national median EUI for similar buildings of 113.9 kBTU/SF. The following is a summary of the Portfolio Manager's results for the facility:

Table 46: ES - Benchmarking EUI

Benchmarking*	This Facility	National Median
Site Energy Use Intensity (EUI kBTU/sf/yr)*	70.6	72.1
Source Energy Use Intensity (EUI kBTU/sf/yr)*	111.4	113.9
Energy Star Score	52	50

* From EPA Portfolio Manager, Building Type: K-12 School

David Brearley Middle/High School

The Site Energy Use Intensity (EUI) for David Brearley Middle/High School is 68.7 kBTU/SF, as compared to a national median EUI for similar buildings of 68.0 kBTU/SF. The Source EUI for the facility is 117.1 kBTU/SF, as compared to a national median EUI for similar buildings of 115.9 kBTU/SF. The following is a summary of the Portfolio Manager's results for the facility:

Table 47: MSHS - Benchmarking EUI

Benchmarking*	This Facility	National Median
Site Energy Use Intensity (EUI kBTU/sf/yr)*	68.7	68
Source Energy Use Intensity (EUI kBTU/sf/yr)*	117.1	115.9
Energy Star Score	48	50

* From EPA Portfolio Manager, Building Type: K-12 School

3. Energy Efficiency Measures

The goal of this audit report is to identify and evaluate potential energy efficiency improvements, provide information about the cost effectiveness of those improvements, and recognize potential financial incentives from NJBPU as part of the final report.

The baseline for facility was obtained from monthly utility bills, equipment schedules, electric and natural gas usage data and other industry standard sources such as ASHRAE. This information was then analyzed against the local weather data. An energy models were developed for the baseline of the facility utilizing eQuest, which performs detailed hourly simulations of energy use in buildings as a function of building construction, building systems, and general building and occupant activity. The simulation provides expected energy consumption, which is then calibrated to the utility data, as necessary.

Energy consumption associated with each measure was analyzed based on the technical performance of the recommended measure. It was then compared to the corresponding baseline energy consumption data to determine the resulting energy savings. Energy cost savings for each measure was determined using the projected energy savings and blended energy rates obtained from the utility information provided by the facility.

The following were assumed when calculating the energy savings:

- Building energy usage patterns will remain relatively unchanged in the near future (no significant occupancy changes and/or space conversion).
- Energy costs will remain relatively stable in near future.
- Building system operation will remain relatively unchanged (unless a change is related to a recommended ECM).
- All energy cost savings are based on blended rates. Actual cost savings can vary based on utility tariff structures and demand charges.

An economic analysis was performed for each measure using historical implementation cost estimates from industry standard sources, data obtained from similar projects and pricing solicited from vendors. Energy cost savings and implementation costs for each ECM were used to determine a simple payback associated with each measure. The calculations account for interacting effects between various system components.

Table 48 and Table 49 and below presents a summary of energy-conservation measures. Payback in this report refers to simple payback associated with the implementation of each measure.

Harding Elementary School

Willdan performed a detailed audit of the Harding Elementary School. The facility's management provided extensive information, facility access, and made facility engineers available. This allowed for Willdan to determine ECM recommendations. The ECMs, energy savings, and cost savings are shown in the table below.

Table 48: ES - Projected Overall Savings

Measure		Annual Estimated Savings				CO_2 Emission Savings (tCO_2e)	Estimated Implementation Cost ($)	Estimated Simple Payback Period (Years)
Meas. No.	Description	Electricity (kWh)	Annual Demand (kW)	Natural Gas (Therms)	Cost Savings ($)			
ECM - 1	Replace Existing Boilers with Condensing Boilers & Install DHW Heat Exchanger	-2,394	-0.3	6,673	$5,568	34.7	$417,910	75.1
ECM - 2	Replace Existing Chiller with High Efficiency Chiller	3,619	7.5	0	$495	1.0	$296,120	598.1
ECM - 3	Replace Existing DX Units with High Efficiency DX Units	3,118	0.4	708	$1,052	1.4	$40,912	38.9
ECM – 4	LED Lighting Upgrades - Interior	97,945	44.3	-2,209	$11,447	16.6	$95,035	8.3
ECM – 5	LED Lighting Upgrades - Exterior	21,813	0.0	0	$2,984	6.3	$5,800	1.9
ECM – 6	Implement Vending Machine Miser Controls	680	0.1	-9	$85	0.0	$575	6.8
ECM – 7	Install Energy Efficient Transformers	12,173	1.4	0	$1,665	3.5	$21,644	13.0
ECM – 8	Install Low-Flow DHW Devices	0	0.0	19	$17	0.1	$426	25.4
ECM – 9**	Install Solar PV Panel	345,274	293.6	0	$16,442	99.8	-	-
Total		**136,954**	**53.4**	**5,182**	**$23,312**	**64**	**$878,421**	**37.7**

* All energy savings were calculated accounted for the interacting effects between various system components.

** Potential for onsite electricity generation for solar PV panel (ECM-9) are not included in the "Total" row.

David Brearley Middle/High School

Willdan performed a detailed audit of the David Brearley Middle/High School. The facility's management provided extensive information, facility access, and made facility engineers available. This allowed for Willdan to determine ECM recommendations. The ECMs, energy savings, and cost savings are shown in the table below.

Table 49: MSHS - Projected Overall Savings

Measure		Annual Estimated Savings				CO_2 Emission Savings (tCO_2e)	Estimated Implementation Cost ($)	Estimated Simple Payback Period (Years)
Meas. No.	**Description**	**Electricity (kWh)**	**Annual Demand (kW)**	**Natural Gas (Therms)**	**Cost Savings ($)**			
ECM – 1	Replace Existing Chiller with High Efficiency Chiller	3,486	0.3	0	$458	1	$322,520	703.9
ECM – 2	LED Lighting Upgrades - Interior	132,038	55.5	-1,636	$15,966	29	$167,510	10.5
ECM – 3	LED Lighting Upgrades - Exterior	1,515	0.0	0	$199	0	$2,645	13.3
ECM – 4	Implement Vending Machine Miser Controls	1,209	0.1	-10	$150	0	$1,045	7.0
ECM – 5	Install Controls on Walk-in Coolers and Freezers	1,640	0.2	-11	$206	0	$1,817	8.8
ECM – 6	Install Energy Efficient Transformers	37,898	4.3	0	$4,981	11	$59,475	11.9
ECM – 7	Install Low-Flow DHW Devices	0	0.0	26	$22	0	$619	28.1
ECM - 8	Install Solar PV Panels	518,735	438.0	0	$32,392	150	-	-
Total		**177,786**	**60.5**	**-1,632**	**$21,983**	**43**	**$555,631**	**25.3**

* All energy savings were calculated accounted for the interacting effects between various system components.

** Potential for onsite electricity generation (ECM-16) and solar PV panel (ECM-17) are not included in the "Total" row.

3.1 Energy Efficiency Measure Descriptions – Harding Elementary School

ECM-1: Replace Existing Boilers with Condensing Boilers & Install DHW Heat Exchanger

Existing Conditions

The hot water system consists of two (2) 4,663 MBH input capacity each, gas-fired, hot water boilers. These units were installed in 2000. The hot water supply temperature is manually adjusted between 160 ºF to 195ºF depending on the weather conditions. According to the site personnel, during peak heating season, hot water is typically generated using two boilers.

The burners on the boilers are controlled with a high fire / low fire sequence. Based on the set-points, burners switch between the low-fire and high-fire stages to meet the needs of the facility. A piston operated mechanical lever controls the air intake opening of the burner based on the mode of operation. According to building operators, the boilers have no automated outside air reset control.

DHW is produced with an 80-gallon, 190 MBH gas-fired AO Smith BTR 199 with 104 storage tank water heaters. This serves majority of the building's DHW needs. This water heater is beyond its useful service life.

ECM Description

Willdan recommends replacing the two (2) existing gas-fired hot water heaters with condensing boilers. The average expectancy of a traditional gas boiler is 20 years[1]. The existing boilers were inspected and found to be functional, but they are at the end of their useful service life. In a conventional boiler, fuel is burned, and the hot gases produced pass through a heat exchanger where much of their heat is transferred to water, thus raising the water's temperature. A substantial portion energy in the flue gases is comprised of water vapor, which arises from burning the hydrogen content of the fuel. A condensing boiler extracts additional heat from the waste gases by condensing this water vapor to liquid water, thus recovering its latent heat of vaporization. While the effectiveness of the condensing process varies depending on the temperature of the water returning to the boiler, it is always at least as efficient as a non-condensing boiler. Compared to 77 - 80% with conventional designs, the proposed condensing boiler efficiency has efficiencies that are well over 85%.

Willdan also recommends installing a DHW heat exchanger and connecting the heating hot water supply to serve the DHW load currently being served by the 80-gallon, 190 MBH gas-fired AO Smith water heater.

Measure Baseline and Proposed Upgrades

Baseline

- Two (2) 4,663 MBH input capacity, gas-fired boilers.

Proposed

- Two (2) 4,663 MBH input capacity, modulating condensing boilers.
- 190 MBH DHW exchanger to replace existing DHW heater.

Calculation Methodology

ECM-1 energy savings have been calculated using eQuest. A baseline high-fire combustion efficiency of 77% is used to model baseline performance which is calibrated to the utility bills. 77% efficiency is derived based on the boilers' cut-sheet efficiency of 81% de-rated according to the age of the equipment based on P4P guidelines. A proposed efficiency of 80% is used to be conservative based on heating hot water return temperatures of ~175 ºF.

[1] New Jersey's Clean Energy Program Technical Manual – Protocols to Measure Resource Savings

Energy Savings Metrics: Cost Savings

Table 50: ES – ECM-1 Summary Table

Electric Usage Savings	-2,394	kWh
Electric Annual Demand Savings	-0.3	kW
Electric Cost Savings	-328	$
Natural Gas Usage Savings	6,673	therms
Natural Gas Cost Savings	5,895	$
Total MMBTU Savings	659	MMBtu
Total Cost Savings	5,568	$
Estimated Installation Cost	417,910	$

Design Considerations

- Integration with the energy management system and existing distribution system.
- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- New breeching and flue design.
- Location for the new DHW heat exchanger and connections with the existing distribution system.

Maintenance Considerations

- Boilers and DHW heat exchanger shall be maintained as per manufacturer's guidelines.

ECM-2 Replace Existing Chiller with High Efficiency Chiller

Existing Conditions

One (1) 150-ton Carrier air-cooled chiller serves most of the building cooling load. The chiller was installed in 2000 and past its useful equipment life.

ECM Description

Willdan recommends replacing the existing chiller with high efficiency chiller for elementary school. The average expectancy of a traditional air-cooled chiller is 20 years [1]. The existing chillers inspected were functional, but they are approaching the end of their useful service life. Current chiller technology has significantly improved operating efficiencies and reduced downtimes for maintenance. Variable speed chiller compressors will allow capacity control during part load conditions where the chiller will typically operate.

Measure Baseline and Proposed Upgrades

Baseline

- One (1) 150-ton air-cooled chiller.

Proposed

- One (1) 150-ton air-cooled high efficiency chiller with variable speed compressors.

Calculation Methodology

ECM-2 energy savings have been calculated using eQuest. A baseline energy efficiency ratio (EER) of 9.13 is used to model baseline performance which is calibrated to the utility bills. EER of 9.13 is derived based on the chiller's cut-sheet EER of 9.6 de-rated according to the age of the equipment based on P4P guidelines. A proposed EER of 10.1 is used based on ASHRAE 90.1 – 2013.

Energy Savings Metrics: Cost Savings

Table 51: ES - ECM-2 Summary Table

Electric Usage Savings	3,619	kWh
Electric Annual Demand Savings	7.5	kW
Electric Cost Savings	495	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	12	MMBtu
Total Cost Savings	495	$
Estimated Installation Cost	296,120	$

Design Considerations

- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- Disposal of refrigerant.
- Integration with the existing energy management system and existing distribution system.

Maintenance Considerations

- Chiller shall be maintained as per manufacturer's guidelines.

[1] New Jersey's Clean Energy Program Technical Manual – Protocols to Measure Resource Savings

ECM-3 Replace Existing DX Units with High Efficiency DX Units

Existing Conditions

The school provides HVAC through a combination of RTUs, split AC units and HV units. Unit details including size, areas served, and age are discussed in the "HVAC Units" section.

ECM Description

Willdan recommends replacing existing DX units with high efficiency DX units. Replacing the DX units has a long payback period and may not be justifiable based simply on energy considerations. However, the units that are being recommended for replacement at this facility are nearing or have reached the end of their normal useful life.

Measure Baseline and Proposed Upgrades

Baseline

- Two (2) existing DX units:
  - RTU - Band Room
  - RTU - 1

Proposed

- Two (2) new high efficiency DX units.

Calculation Methodology

ECM-3 energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 52: ES - ECM-3 Summary Table

Electric Usage Savings	3,118	kWh
Electric Annual Demand Savings	0.4	kW
Electric Cost Savings	427	$
Natural Gas Usage Savings	708	therms
Natural Gas Cost Savings	625	$
Total MMBTU Savings	16	MMBtu
Total Cost Savings	1,052	$
Estimated Installation Cost	40,912	$

Design Considerations

- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- Disposal of refrigerant.
- Integration with the existing BMS and existing distribution system.

Maintenance Considerations

- RTUs shall be maintained as per manufacturer's guidelines.

ECM-4: LED Lighting Upgrades - Interior

Existing Conditions

Warren Harding Elementary School uses a variety of interior fixtures throughout the building. The most prevalent lamp type used in the school is 4-feet 32-watt linear fluorescent T8 lamps in fixtures equipped with 2, 3 or 4 lamps per fixture. Additionally, the range of lamps used in interior lighting varies from 4-feet T5 & T12 linear fluorescent lamps, 2-feet T8 linear fluorescent lamps and T8 U-bend fluorescent tubes. Fixtures using T5 and T8 lamps are equipped with electronic ballasts while T12 lamps are used with magnetic ballasts. There are also compact fluorescent and incandescent lamps used for interior lighting. Occupancy sensors are installed in classrooms and offices.

ECM Description

Willdan recommends retrofitting fixtures with T5, T8 and T12 lamps with the more efficient Linear LED tubes. The existing compact fluorescent and incandescent lamps will be replaced with compatible LED replacements. In addition to electric usage and demand savings, maintenance savings may also be achieved since LED lamps last longer than other light sources and therefore do not need to be replaced as often. All recommended lighting is DLC and/or Energy Star compliant.

Measure Baseline and Proposed Upgrades

Baseline

- Existing fluorescent and incandescent lamps

Proposed

- High-efficiency LED lighting fixtures

Calculation Methodology

ECM-4 energy savings have been calculated using eQuest. A full space-by-space lighting audit is completed to identify the baseline and the calculated lighting power density is used to calculate the baseline lighting energy consumption. A compatible LED replacement is selected for each fixture/lamp type in the facility.

Energy Savings Metrics: Cost Savings

Table 53: ES - ECM-4 Summary Table

Electric Usage Savings	97,945	kWh
Electric Annual Demand Savings	44.3	kW
Electric Cost Savings	13,398	$
Natural Gas Usage Savings	-2,209	therms
Natural Gas Cost Savings	-1,951	$
Total MMBTU Savings	113	MMBtu
Total Cost Savings	11,447	$
Estimated Installation Cost	95,035	$

Design Considerations

- Integration with lighting controls.
- Emergency lighting.

Maintenance Considerations

- Lamps/fixtures and associated ballasts shall be maintained as part of ongoing maintenance efforts by the facility engineers.

ECM-5: LED Lighting Upgrades - Exterior

Existing Conditions

Majority of the high energy consuming exterior lighting consists of metal halide HID lamps of 50, 100 or 250-watts. Fixtures equipped with incandescent, compact fluorescent, 4-feet T8 and T12 lamps are also found in exterior areas.

ECM Description

Willdan recommends replacing the existing lighting metal halide HID lamps with compatible LED retrofits. Fixtures equipped with incandescent, compact fluorescent, 4-feet T8 and T12 lamps will also be replaced with plug-and-play LED lamps.

Measure Baseline and Proposed Upgrades

Baseline

- Existing metal halide, fluorescent and incandescent lamps

Proposed

- High-efficiency LED lighting.

Calculation Methodology

ECM-5 energy savings have been calculated using eQuest. A full exterior space lighting audit is completed to identify the baseline and the calculated total exterior lighting power is used to calculate the baseline lighting energy consumption. A compatible LED replacement is selected for each fixture/lamp type being recommended for upgrades

Energy Savings Metrics: Cost Savings

Table 54: ES - ECM-5 Summary Table

Electric Usage Savings	21,813	kWh
Electric Annual Demand Savings	0.0	kW
Electric Cost Savings	2,984	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	74	MMBtu
Total Cost Savings	2,984	$
Estimated Installation Cost	5,800	$

Design Considerations

- Integration with lighting controls.
- Emergency lighting.

Maintenance Considerations

- Lamps/fixtures and associated ballasts shall be maintained as part of ongoing maintenance efforts by the facility engineers.

ECM-6: Implement Vending Machine Miser Controls

Existing Conditions

There is one (1) refrigerated cold beverage vending machine at the Warren Harding Elementary School. It is currently not equipped with an occupancy-based controls and is operated 24/7.

ECM Description

Willdan recommends installing occupancy sensor controls for vending machine. Vending machines operate continuously, even during unoccupied hours and consumes several hundred dollars per year in electrical energy costs. The installation of the Vending Miser product will reduce the run time of the vending machine during periods when no occupancy is sensed in the area surrounding the machine. The smart electronics in the device will ensure product is kept cold through a cycling process while reducing total energy consumption. Another benefit from implementing vending miser controls is extended useful equipment life due to reduced lifetime. Energy savings are dependent on the vending machine and activity level in the area surrounding the machines.

Measure Baseline and Proposed Upgrades

Baseline

- Existing refrigerated vending machine operated 24/7.

Proposed

- Install occupancy sensor (vending miser controls) for the refrigerated vending machines.

Calculation Methodology

ECM-6 energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 55: ES – ECM-6 Summary Table

Electric Usage Savings	680	kWh
Electric Annual Demand Savings	0.1	kW
Electric Cost Savings	93	$
Natural Gas Usage Savings	-9	therms
Natural Gas Cost Savings	-8	$
Total MMBTU Savings	1	MMBtu
Total Cost Savings	85	$
Estimated Installation Cost	575	$

Design Considerations

- None.

ECM-7: Install Energy Efficient Transformers

Existing Conditions

An on-site detailed survey of the dry-type transformers was performed by Powersmiths. The facility consists of four 30kVA 208V-208/120V Delta-Wye transformers. The transformers are operating at a small fraction of their nameplate capacity, resulting in very low efficiency, and are often producing large amounts of excess heat, resulting in energy losses, and higher electric costs.

ECM Description

Willdan recommends replacing the dry-type transformers with E-Saver transformers. Designed to provide the lowest life cycle cost, the E-Saver goes beyond US DOE 2016 efficiency, ensuring lower operating losses than standard off-the-shelf transformers. To provide superior performance and reduce environmental impact, the E-Saver comes with a superior Nomex based insulation system impregnated with an organic epoxy adhesive. Superior insulation prevents shorts as well, substantially prolonging the life of the transformer.

Based on the detailed field survey, the replacement E-Saver transformers will be a like-for-like, nominal kVA capacity, designed and manufactured to minimize losses for the application and fit within the existing constraints. This ECM can achieve energy saving by increasing the transformer efficiency.

Measure Baseline and Proposed Upgrades

Baseline

- Four (4) 208V-208/120V Delta-Wye transformers

Proposed

- Four (4) E-Saver-80R transformers.
- Four (4) Transformer Custom Enclosures & Adders

Calculation Methodology

ECM-7 energy savings have been calculated using excel spreadsheet.

Energy Savings Metrics: Cost Savings

Table 56: ES - ECM-7 Summary Table

Electric Usage Savings	12,173	kWh
Electric Annual Demand Savings	1.4	kW
Electric Cost Savings	1,665	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	42	MMBtu
Total Cost Savings	1,665	$
Estimated Installation Cost	21,644	$

Design Considerations

- Coordination with facility manager to minimize the effect on day-to-day operation.
- Disruption to electrical loads served by existing transformers.
- Seasonal loading on transformers.

ECM-8: Install Low-Flow DHW Devices

Existing Conditions

There are currently thirty-three (33) lavatory and classroom faucets that are not equipped with low-flow aerators located in the Warren Harding Elementary School.

ECM Description

Willdan recommends installing low-flow domestic hot water devices to reduce overall hot water demand. Energy demand from domestic hot water heating systems can be reduced by reducing water usage in general. Faucet aerators can reduce hot water usage relative to standard aerators which saves energy. Low-flow devices reduce the overall water flow from the fixture while maintaining adequate pressure for washing.

When faucets deteriorate with age, it leads to leaks and excessive water flowing through the fixtures. In general, it is common to find fixtures consuming more than 2.0 gpm due to age. It is recommended that the aerators be replaced with appropriate spray type, pressure compensating flow moderators, which typically reduces the water flow rate to 0.5 gpm.

Measure Baseline and Proposed Upgrades

Baseline

- Thirty-three (33) lavatory and classroom faucets (2.2 gpm).

Proposed

- Thirty-three (33) lavatory and classroom faucets (0.5 gpm).

Calculation Methodology

ECM-8 energy savings have been calculated using excel spreadsheet.

Energy Savings Metrics: Cost Savings

Table 57: ES - ECM-8 Summary Table

Electric Usage Savings	0	kWh
Electric Annual Demand Savings	0.0	kW
Electric Cost Savings	0	$
Natural Gas Usage Savings	19	therms
Natural Gas Cost Savings	17	$
Total MMBTU Savings	2	MMBtu
Total Cost Savings	17	$
Estimated Installation Cost	426	$

Design Considerations

- None

Maintenance Considerations

- Maintenance against leaks shall be performed by the facility maintenance staff.

ECM-9: Install Solar PV Panels

Existing Conditions

There is no solar photovoltaic system installed at the school.

ECM Description

Willdan recommends installing a solar photovoltaic system to reduce dependence on the electric grid. The solar system can provide 345,274 kWh of electricity annually. Solar panels work by absorbing sunlight with photovoltaic cells, generating direct current (DC) energy and then converting it to usable alternating current (AC) energy with the help of inverter technology. AC energy then flows through the home's electrical panel and is distributed accordingly.

The solar PV sizing in the current phase is preliminary assessment of solar potential. A more in-depth study will be performed to further evaluate the solar energy production potential.

Figure 19. ES – Preliminary Solar Assessment

Calculation Methodology

ECM-9 energy savings have been prepared by Aurora Software.

Energy Savings Metrics: Cost Savings

Table 58: ES - ECM-9 Summary Table

Electric Usage Savings	345,274	kWh
Electric Annual Demand Savings	293.6	kW
Electric Cost Savings	16,442	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	1,178	MMBtu
Total Cost Savings	16,442	$
Estimated Installation Cost	-	$

Note: A preliminary rate of $0.05 is used to project solar PV cost savings.

Design Considerations

- Effect on utility tariffs and rate structures.
- Integration with existing building infrastructure.

3.2 Energy Efficiency Measure Descriptions – David Brearley Middle/High School

ECM-1: Replace Existing Chiller with High Efficiency Chiller

Existing Conditions

One (1) 170-ton McQuay air-cooled chiller serves most of the building cooling load. The chiller was installed in 1999 and is in fair condition and standard efficiency. This system is controlled by the building energy management system (EMS).

ECM Description

Willdan recommends replacing the existing chiller with high efficiency chiller for elementary school. The average expectancy of a traditional air-cooled chiller is 20 years [1]. The existing chillers inspected were functional, but they are near or have reached the end of their useful service life. Current chiller technology has significantly improved operating efficiencies and reduced downtimes for maintenance. Variable speed chiller compressors will allow capacity control during part load conditions where the chiller will typically operate.

Measure Baseline and Proposed Upgrades

Baseline

- One (1) 170-ton air-cooled chiller.

Proposed

- One (1) 170-ton air-cooled high efficiency chiller with variable speed compressors.

Calculation Methodology

ECM-1 energy savings have been calculated using eQuest. A baseline energy efficiency ratio (EER) of 8.85 is used to model baseline performance which is calibrated to the utility bills. EER of 8.85 is derived based on the chiller's cut-sheet EER of 9.3 de-rated according to the age of the equipment based on P4P guidelines. A proposed EER of 10.1 is used based on ASHRAE 90.1 – 2013.

Energy Savings Metrics: Cost Savings

Table 59: MSHS - ECM-1 Summary Table

Electric Usage Savings	3,486	kWh
Electric Annual Demand Savings	0.3	kW
Electric Cost Savings	458	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	12	MMBtu
Total Cost Savings	458	$
Estimated Installation Cost	322,520	$

Design Considerations

- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- Disposal of refrigerant.
- Integration with the existing energy management system and existing distribution system.

Maintenance Considerations

- Chiller shall be maintained as per manufacturer's guidelines.

[1] New Jersey's Clean Energy Program Technical Manual – Protocols to Measure Resource Savings

ECM-2: Lighting Upgrade – Interior

Existing Conditions

Similar to the elementary school the most prevalent lamp type used in the David Brearley Middle/High School is 4-feet 32-watt linear fluorescent T8 lamps in fixtures equipped with 1 and up to 4 lamps per fixture. 4-feet T5 & T12 linear fluorescent lamps, compact fluorescent & incandescent lamps, 2-feet T8 linear fluorescent lamps and T8 U-bend fluorescent tubes are also commonly used in interior lighting fixtures. In some areas such as gym, auditorium, restrooms and storage spaces fixtures are already upgraded with LED screw-in, LED linear tubes and LED high-bay lamps. However, vast majority of the existing interior lighting inventory still comprise of non-LED lighting.

ECM Description

Willdan recommends retrofitting fixtures with T5, T8 and T12 lamps with the more efficient Linear LED tubes. The existing compact fluorescent and incandescent lamps will be replaced with compatible LED replacements. In addition to electric usage and demand savings, maintenance savings may also be achieved since LED lamps last longer than other light sources and therefore do not need to be replaced as often. All recommended lighting is DLC and/or Energy Star compliant.

Measure Baseline and Proposed Upgrades

Baseline

- Existing fluorescent and incandescent lamps

Proposed

- High-efficiency LED lighting fixtures

Calculation Methodology

ECM-2 energy savings have been calculated using eQuest. A full space-by-space lighting audit is completed to identify the baseline and the calculated lighting power density is used to calculate the baseline lighting energy consumption. A compatible LED replacement is selected for each fixture/lamp type in the facility.

Energy Savings Metrics: Cost Savings

Table 60: MSHS - ECM-2 Summary Table

Electric Usage Savings	132,038	kWh
Electric Annual Demand Savings	55.5	kW
Electric Cost Savings	17,355	$
Natural Gas Usage Savings	-1,636	therms
Natural Gas Cost Savings	-1,389	$
Total MMBTU Savings	287	MMBtu
Total Cost Savings	15,966	$
Estimated Installation Cost	167,510	$

Design Considerations

- Integration with lighting controls.
- Emergency lighting.

Maintenance Considerations

- Lamps/fixtures and associated ballasts shall be maintained as part of ongoing maintenance efforts by the facility engineers.

ECM-3: Lighting Upgrade – Exterior

Existing Conditions

Majority of the exterior lighting has already been upgraded to LED lighting. There are only a handful of fixtures remaining that are equipped with metal halide HID and compact fluorescent lamps serving the exterior spaces.

ECM Description

Willdan recommends replacing the existing lighting metal halide HID lamps with compatible LED retrofits. Fixtures equipped with incandescent, compact fluorescent, 4-feet T8 and T12 lamps will also be replaced with plug-and-play LED lamps.

Measure Baseline and Proposed Upgrades

Baseline

- Existing metal halide, fluorescent and incandescent lamps

Proposed

- High-efficiency LED lighting

Calculation Methodology

ECM-3 energy savings have been calculated using eQuest. A full exterior space lighting audit is completed to identify the baseline and the calculated total exterior lighting power is used to calculate the baseline lighting energy consumption. A compatible LED replacement is selected for each fixture/lamp type being recommended for upgrades

Energy Savings Metrics: Cost Savings

Table 61: MSHS - ECM-3 Summary Table

Electric Usage Savings	1,515	kWh
Electric Annual Demand Savings	0.0	kW
Electric Cost Savings	199	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	5	MMBtu
Total Cost Savings	199	$
Estimated Installation Cost	2,645	$

Design Considerations

- Integration with lighting controls.
- Emergency lighting.

Maintenance Considerations

- Lamps/fixtures and associated ballasts shall be maintained as part of ongoing maintenance efforts by the facility engineers.

ECM-4: Implement Vending Machine Miser Controls

Existing Conditions

There are two (2) refrigerated beverage vending machines at David Brearley Middle/High School. They are currently not equipped with an occupancy-based controls and are operated 24/7.

ECM Description

Willdan recommends installing occupancy sensor controls for vending machines. Vending machines operate continuously, even during unoccupied hours and consumes several hundred dollars per year in electrical energy costs. The installation of the Vending Miser product will reduce the run time of the vending machines during periods when no occupancy is sensed in the area surrounding the machines. The smart electronics in the device will ensure product is kept cold through a cycling process while reducing total energy consumption. Another benefit from implementing vending miser controls is extended useful equipment life due to reduced lifetime. Energy savings are dependent on the vending machine and activity level in the area surrounding the machines.

Measure Baseline and Proposed Upgrades

Baseline

- Two (2) existing refrigerated vending machines operated 24/7.

Proposed

- Install occupancy sensor (vending miser controls) for the two (2) refrigerated vending machines.

Calculation Methodology

ECM-4 energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 62: MSHS - ECM-4 Summary Table

Electric Usage Savings	1,209	kWh
Electric Annual Demand Savings	0.1	kW
Electric Cost Savings	159	$
Natural Gas Usage Savings	-10	therms
Natural Gas Cost Savings	-9	$
Total MMBTU Savings	4	MMBtu
Total Cost Savings	150	$
Estimated Installation Cost	1,045	$

Design Considerations

- None.

ECM-5: Install Controls on Walk-in Coolers and Freezers

Existing Conditions

There are currently one (1) walk-in medium temperature freezer and one (1) walk-in cooler in High School cafeteria equipped with standard motors and no controls implemented.

ECM Description

Willdan recommends replacing shaded pole or permanent split capacitor (PSC) motors with electronically commutated (EC) motors in existing walk-in cooler and freezer. These fractional horsepower EC motors are significantly more efficient than mechanically commutated, brushed motors particularly at low speeds or at partial loads. By employing variable-speed technology, EC motors can optimize fan usage. Because these motors are brushless and utilize DC power, losses due to friction and phase shifting are eliminated. Savings for this measure consider both the increased efficiency of the motor as well as the reduction in refrigeration load due to motor head loss. This measure also recommends installing controls on the walk-in cooler and the freezer in the High School Cafeteria which will reduce evaporator fan and door/frame heater operation.

Measure Baseline and Proposed Upgrades

Baseline

- One (1) Walk-in medium temperature freezer and one (1) walk-in cooler in High School cafeteria equipped with standard motors.

Proposed

- Replace existing motors with EC motors.
- Implement CoolTrol Control System on the freezer and cooler evaporator fans, doors and frames.

Calculation Methodology

ECM-5 energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 63: MSHS - ECM-5 Summary Table

Electric Usage Savings	1,640	kWh
Electric Annual Demand Savings	0.2	kW
Electric Cost Savings	215	$
Natural Gas Usage Savings	-11	therms
Natural Gas Cost Savings	-8	$
Total MMBTU Savings	5	MMBtu
Total Cost Savings	206	$
Estimated Installation Cost	1,817	$

Design Considerations

- None

ECM-6: Install Energy Efficient Transformers

Existing Conditions

An on-site detailed survey of the dry-type transformers throughout the facilities was performed by Powersmiths. The facility consists of seven transformers with various kVA capacities ranging from 15 kVA to 150 kVA. The transformers are operating at a small fraction of their nameplate capacity, resulting in very low efficiency, and are often producing large amounts of excess heat, resulting in energy losses, and higher electric costs.

ECM Description

Willdan recommends replacing the dry-type transformers with E-Saver transformers. Designed to provide the lowest life cycle cost, the E-Saver goes beyond US DOE 2016 efficiency, ensuring lower operating losses than standard off-the-shelf transformers. To provide superior performance and reduce environmental impact, the E-Saver comes with a superior Nomex based insulation system impregnated with an organic epoxy adhesive. Superior insulation prevents shorts as well, substantially prolonging the life of the transformer.

Based on the detailed field survey, the replacement E-Saver transformers will be a like-for-like, nominal kVA capacity, designed and manufactured to minimize losses for the application and fit within the existing constraints. This ECM can achieve energy saving by increasing the transformer efficiency.

Measure Baseline and Proposed Upgrades

Baseline

- Seven (7) transformers

Proposed

- Seven (7) E-Saver-80R transformers.
- Four (4) Transformer Custom Enclosures & Adders

Calculation Methodology

ECM-6 energy savings have been calculated using excel spreadsheet.

Energy Savings Metrics: Cost Savings

Table 64: MSHS - ECM-6 Summary Table

Electric Usage Savings	37,898	kWh
Electric Annual Demand Savings	4.3	kW
Electric Cost Savings	4,981	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	129	MMBtu
Total Cost Savings	4,981	$
Estimated Installation Cost	59,475	$

Design Considerations

- Coordination with facility manager to minimize the effect on day-to-day operation.
- Disruption to electrical loads served by existing transformers.
- Seasonal loading on transformers.

ECM-7: Install Low-Flow DHW Devices

Existing Conditions

There are currently forty-eight (48) lavatory and classroom faucets that are not equipped with low-flow aerators located in the David Brearly Middle/High School.

ECM Description

Willdan recommends installing low-flow domestic hot water devices to reduce overall hot water demand. Energy demand from domestic hot water heating systems can be reduced by reducing water usage in general. Faucet aerators can reduce hot water usage relative to standard aerators which saves energy. Low-flow devices reduce the overall water flow from the fixture while maintaining adequate pressure for washing.

When faucets deteriorate with age, it leads to leaks and excessive water flowing through the fixtures. In general, it is common to find fixtures consuming more than 2.0 gpm due to age. It is recommended that the aerators be replaced with appropriate spray type, pressure compensating flow moderators, which typically reduces the water flow rate to 0.5 gpm.

Measure Baseline and Proposed Upgrades

Baseline

- Forty-eight (48) lavatory and classroom faucets (2.2 gpm).

Proposed

- Forty-eight (48) lavatory and classroom faucets (0.5 gpm).

Calculation Methodology

ECM-7 energy savings have been calculated using excel spreadsheet.

Energy Savings Metrics: Cost Savings

Table 65: MSHS - ECM-7 Summary Table

Electric Usage Savings	0	kWh
Electric Annual Demand Savings	0.0	kW
Electric Cost Savings	0	$
Natural Gas Usage Savings	26	therms
Natural Gas Cost Savings	22	$
Total MMBTU Savings	3	MMBtu
Total Cost Savings	22	$
Estimated Installation Cost	619	$

Design Considerations

- None

Maintenance Considerations

- Maintenance against leaks shall be performed by the facility maintenance staff.

ECM-8: Install Solar PV Panels

Existing Conditions

There is no solar photovoltaic system installed in the school.

ECM Description

Willdan recommends installing a solar photovoltaic system to reduce dependence on the electric grid. The solar system can provide 680,487 kWh of electricity annually. Solar panels work by absorbing sunlight with photovoltaic cells, generating direct current (DC) energy and then converting it to usable alternating current (AC) energy with the help of inverter technology. AC energy then flows through the home's electrical panel and is distributed accordingly.

The solar PV sizing in the current phase is preliminary assessment of solar potential. A more in-depth study will be evaluated to finalize the solar energy production potential.

Figure 20. MSHS - Preliminary Solar Assessment

Calculation Methodology

ECM-8 energy savings have been prepared by Aurora Software.

Energy Savings Metrics: Cost Savings

Table 66: MSHS - ECM-8 Summary Table

Electric Usage Savings	518,735	kWh
Electric Annual Demand Savings	438.0	kW
Electric Cost Savings	32,392	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	1,770	MMBtu
Total Cost Savings	32,392	$
Estimated Installation Cost	-	$

Design Considerations

- Effect on utility tariffs and rate structures.
- Integration with existing building infrastructure.

3.3 Energy Efficiency Measure Descriptions – Harding Elementary School – Not Recommended

ECM-1R: Replace Existing Unit Ventilators with New Unit Ventilators

Existing Conditions

Most classrooms and offices are conditioned by unit ventilators that supply heating and cooling to the zones. There is a total of fifty-three (53) unit ventilators one of which is replaced recently due to a failure. These unit ventilators have supply fan motors and outside air dampers that operate with the building energy management system (BMS). However, facility staff reported that the controls tend to fail, and the control system components are in poor condition and not upgradable. Unit ventilators have three-way control valves that no longer function. Facility staff reported that these valves are now manually controlled; and teachers often complain about the malfunction of UVs that have been causing overheating and undercooling. The outside air dampers are manually closed to prevent water coil freezing in the winter and therefore, required ventilation rates are not being met under current operation.

ECM Description

This measure proposes replacing the existing unit ventilators with new, high-efficient unit ventilators. Willdan developed an energy model to quantify energy savings that would result from replacing existing unit ventilators with like-to-like units of similar capacities but with higher efficiency. Replacing the existing unit ventilators will also ensure proper ventilation rates being met in the school as currently the outside air dampers are manually shut down by the operators.

Measure Baseline and Proposed Upgrades

Baseline

- Fifty-two old (52) unit ventilators.

Proposed

- Fifty-two (52) new unit ventilators.

Calculation Methodology

ECM-1R energy savings have been calculated using eQuest. With required ventilation rates properly met according to the building code, replacing the unit ventilators will result in an increase in both electric and natural gas usage since the units are currently operated with no outside air. As per P4P guidelines, the energy model baseline is updated to ASHRAE 62.1 compliant operation with proper ventilation rates in order to project savings for this measure.

Energy Savings Metrics: Cost Savings

Table 67: ES – ECM-1R Summary Table

Electric Usage Savings	35,331	kWh
Electric Annual Demand Savings	8.5	kW
Electric Cost Savings	4,833	$
Natural Gas Usage Savings	-859	therms
Natural Gas Cost Savings	-759	$
Total MMBTU Savings	35	MMBtu
Total Cost Savings	4,074	$
Estimated Installation Cost	1,134,458	$

Design Considerations

- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- Fixing of non-operational dampers and actuators.
- Architectural fit with using space occupied by existing UVs.
- Integration with the existing BMS and existing distribution system.

Maintenance Considerations

- Unit ventilators shall be maintained as per manufacturer's guidelines.

ECM-2R: Install VFDs on Heating Hot Water Pumps

Existing Conditions

The hydronic distribution system consists of a four-pipe, heating and cooling system. Pipe insulation appeared to be in good condition. The hot water system is configured in a constant flow primary distribution with two (2) 20 hp constant speed hot water pumps operating with a lead-lag control sequence. The boilers provide hot water to radiators, unit ventilators, and air handling units throughout the building.

ECM Description

Willdan recommends installing VFDs on the constant speed hot water pumps and installing tw-way valves at the terminal units. Instead of bypassing the water across the hot water coils using three-way valves, the pumps will run at variable speed in order to maintain the desired differential pressure set point. Since motor power consumption is proportional to the cube of the shaft speed under ideal conditions, running pumps at lower speeds provides energy savings when compared to operating pumps at full speed. For example, a 20% reduction in pump motor speed results in approximately a 50% reduction in pumping energy consumption. Willdan also recommends upgrading the standard efficiency motors on existing heating hot water pumps to premium efficiency pump motors (inverter duty motors).

Table 68: ES - Heating Hot Water Pump Upgrades

Tag	Location	Service	Make	Motor HP	Speed Control	VFD Upgrades (Y/N)	Premium Efficiency Motor Upgrades (Y/N)
HWP-1	Boiler Room	Hot Water Loop	Baldor Industrial Motor	20	Constant	Y	Y
HWP-2	Boiler Room	Hot Water Loop	Baldor Industrial Motor	20	Constant	Y	Y

Measure Baseline and Proposed Upgrades

Baseline

- Two (2) 20-hp constant speed hot water pumps equipped with non-premium efficiency motors.

Proposed

- Install VFDs on two (2) heating hot water pumps.
- Premium efficiency motors on two (2) heating hot water pumps.
- Convert all three-way valves to two-way valves for proper operation of VFDs.
- Testing and balancing of heating hot water systems.
- Provide connections to BMS to monitor and control new equipment.

Calculation Methodology

ECM-2R energy savings have been calculated using eQuest. Baseline motor efficiencies are based on the nameplate of the existing motors.

Energy Savings Metrics: Cost Savings

Table 69: ES - ECM-2R Summary Table

Electric Usage Savings	15,988	kWh
Electric Annual Demand Savings	2.2	kW
Electric Cost Savings	2,187	$
Natural Gas Usage Savings	-735	therms
Natural Gas Cost Savings	-649	$
Total MMBTU Savings	-19	MMBtu
Total Cost Savings	1,538	$
Estimated Installation Cost	41,544	$

Design Considerations

- Integration with BMS and hydronic distribution system.

Maintenance Considerations

- VFDs, pumps and pump motors shall be maintained as per manufacturer's guidelines.

ECM-3R: Install VFDs on Chilled Water Pumps

Existing Conditions

The hydronic distribution system consists of a four-pipe, heating and cooling system. Pipe insulation appeared to be in good condition. The chilled water system is configured in a constant flow distribution with two (2) 15 hp constant speed chilled water pumps operating with a lead-lag control scheme. The chilled water is supplied to unit ventilators.

ECM Description

Willdan recommends installing VFDs on the constant speed chilled water pumps and installing two-way valves at the terminal units. Instead of bypassing the water across the chilled water coils using three-way valves, the pumps will run at variable speed in order to maintain the desired differential pressure set point. Since motor power consumption is proportional to the cube of the shaft speed under ideal conditions, running pumps at lower speeds provides energy savings when compared to operating pumps at full speed. For example, a 20% reduction in pump motor speed results in approximately a 50% reduction in pumping energy consumption. Willdan also recommends upgrading the standard efficiency motors on existing heating chilled water pumps to premium efficiency pump motors (inverter duty motors).

Table 70: ES - Chilled Water Pump Upgrades

Tag	Location	Service	Make	Motor HP	Speed Control	VFD Upgrades (Y/N)	Premium Efficiency Motor Upgrades (Y/N)
CHWP-1	Boiler Room	Chilled Water Loop	Baldor Industrial Motor	15	Constant	Y	Y
CHWP-2	Boiler Room	Chilled Water Loop	Baldor Industrial Motor	15	Constant	Y	Y

Measure Baseline and Proposed Upgrades

Baseline

- Two (2) 15-hp constant speed chilled water pumps equipped with non-premium efficiency motors.

Proposed

- Install VFDs on two (2) chilled water pumps.
- Premium efficiency motors on two (2) chilled water pumps.
- Convert all three-way valves to two-way valves for proper operation of VFDs.
- Testing and balancing of heating hot water systems.
- Provide connections to BMS to monitor and control new equipment.

Calculation Methodology

ECM-3R energy savings have been calculated using eQuest. Baseline motor efficiencies are based on the nameplate of the existing motors.

Energy Savings Metrics: Cost Savings

Table 71: ES – ECM-3R Summary Table

Electric Usage Savings	2,229	kWh
Electric Annual Demand Savings	1.9	kW
Electric Cost Savings	305	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	8	MMBtu
Total Cost Savings	305	$
Estimated Installation Cost	35,298	$

Design Considerations

- Integration with BMS and hydronic distribution system.

Maintenance Considerations

- VFDs, pumps and pump motors shall be maintained as per manufacturer's guidelines.

ECM-4R: Implement Demand Controlled Ventilation for Auditorium Unit

Existing Conditions

Currently, the supply fan is operated at constant speed based on a schedule implemented at the BMS. Regardless of the level of occupancy in the auditorium, the unit provides constant ventilation and air conditioning to the space during scheduled hours.

ECM Description

Willdan recommends implementing DCV for the auditorium. DCV is a control scheme that matches outdoor air ventilation rates to the occupancy of the space, based on the real-time measurement of CO2 levels. Carbon dioxide sensors installed in the breathing zone of the auditorium or at the return duct will monitor the parts per million (ppm) of CO2 and accordingly, vary the quantity of ventilation air delivered into the spaces served.

When the occupancy levels in the auditorium are low, the outside airflow can be reduced, resulting in both fan and air-conditioning energy savings. The CO2 sensors will constantly provide feedback to the unit and the outside air dampers will be modulated to provide adequate amount of ventilation air into the space. VFDs will be installed on the supply and return/exhaust air fans that will be balanced to maintain adequate pressurization while providing required air flow rates for ventilation. This measure also recommends installing premium efficiency motors on the supply and return/exhaust air fans. The implementation of this measure will ensure both the ventilation requirements being met effectively while providing fan, cooling and heating energy/demand savings.

Measure Baseline and Proposed Upgrades

Baseline

- Conditioned OA supplied and exhausted by auditorium unit regardless of the occupancy except during unoccupied mode.

Proposed

- Install CO2 sensor(s) in return duct of auditorium unit or at the zone level and an additional CO2 sensor for monitoring outdoor air CO2. Quantity and appropriate location should be determined at the design stage.
- Upgrade the existing supply and return/exhaust fans with premium efficiency motors.
- Install VFDs on the supply and return/exhaust fan motors.
- Implement outside air and return air control based on occupancy levels according to CO2 sensor feedback.
- Perform air side testing and balancing.

Calculation Methodology

ECM-4R energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 72: ES – ECM-4R Summary Table

Electric Usage Savings	-82	kWh
Electric Annual Demand Savings	0.0	kW
Electric Cost Savings	-11	$
Natural Gas Usage Savings	335	therms
Natural Gas Cost Savings	296	$
Total MMBTU Savings	33	MMBtu
Total Cost Savings	285	$
Estimated Installation Cost	40,348	$

Design Considerations

- Integration with the existing BMS and operating sequences, as applicable.

Maintenance Considerations

- VFDs, CO_2 sensors and fan motors shall be maintained as per manufacturer's guidelines.

ECM-5R: BMS Upgrades

Existing Conditions

There are two energy management systems, TBS control system and Johnson control Metasys control system. The TBS system controls the boilers and heating system, the chiller and chilled water system, gymnasium heating-ventilation units, auditorium air handling unit, and most of the unit. Currently, Harding Elementary School has older EMS installed from multiple vendors with dated software which requires recommission and update. The existing EMS do not communicate or report with consistent capabilities or data within each associated HVAC and lighting systems.

This BMS is capable of controlling equipment scheduling and monitoring space temperatures, supply air temperatures, humidity, heating water loop temperatures, and chilled water loop temperatures and trending the unit operation performance. However, some unit trending functions is not operational. And the unit ventilators have a lot of supply fan failure alarms. Per discussion with the facility personnel, teachers continuously complained about overheating and undercooling in some classrooms.

A Johnson Controls Metasys controls the make-up air units, exhaust fans, roof top units, fan coil units, and newer unit ventilators. Facility staff reported that there are no effective temperature setbacks for HVAC equipment. However, the teachers manually turn off the unit when the school is off. The site staff expressed a great interest in replacing both EMS systems with a new EMS.

ECM Description

This measure includes installation of new direct digital control (DDC) systems for all the major HVAC equipment and lighting systems replacing the controls controlling various pieces of equipment. The new EMS will combine all HVAC and lighting equipment that are currently being controlled by the two existing EMSs under a single user interface. With the communication between the control devices and the new updated digital interface/software, will give the opportunity to take advantage of better scheduling, temperature set-back controls based on outside air temperature and occupancy levels while maintaining adequate heating, cooling and ventilation requirements in the facility. The DDC system will also aid in the response time to service/maintenance issues when the facility is not under normal maintenance supervision i.e. after-hours. Implementation of this measure is also important in achieving full potential of other measures recommended by providing the necessary means of properly controlling the equipment. Several control strategies that were evaluated are described below:

Implement CHW Reset

Chilled-water reset adjusts the chilled-water set point to improving the efficiency of the chiller, reducing the energy consumption of the chiller. Usually, a chilled-water-reset strategy raises the set-point temperature when the building load is at less-than-design conditions. When the outside air temperature is relatively low, the building cooling load is at less-than-design conditions. Producing warmer chilled water lessens the burden on the compressor, which means that the chiller consumes less energy.

Implement HHW Reset

Hot-water outside air reset adjusts the hot-water set point based on the outside air temperature to reducing the energy consumption of the boiler. As the outdoor air temperature warms, the temperature to which the hot water is heated gradually reduces from a maximum value to a minimum value. During this process, the energy consumption to produce the heat decreases. Additionally, condensing boilers that are recommended as part of ECM-1 sees an increase in combustion efficiency as the heating hot water return temperature decreases.

BMS Upgrades - Implement SAT Reset

Supply air temperature reset is a control scheme that allows an airside system to modulate the supply air temperature based on outside air temperature. When enabled, the temperature of supply air is increased, which allows for reduced compressor energy or reheat energy, but also increases fan energy in a VAV system. When supply air temperature reset is based on outside air temperature, the supply air temperature can be increased as the outside air temperature decreases.

BMS Upgrades - Schedule Setback

As discussed, most of the HVAC equipment in the facility is operated based on a schedule implemented at the existing BMS. This measure recommends implementing a stricter schedule than the one currently implemented for air-side HVAC units that are serving areas other than classrooms and offices. Willdan reviewed the existing unit schedules on a space-by-space in order to determine units that are eligible for operating schedule reset.

Measure Baseline and Proposed Upgrades

Baseline
- CHW supply temperature kept constant regardless of the building load.
- HHW supply temperature manually adjusted based on operators' judgement.
- SAT on DX rooftop and make-up air units kept constant.
- Air-side HVAC unit scheduling implemented at the BMS.

Proposed
- Upgraded BMS to include:
  - Implement CHW automated supply temperature reset.
  - Implement HHW automated supply temperature reset.
  - Implement SAT reset on air-side HVAC units.
  - Implement optimized operational schedules for units serving areas other than classrooms and offices.

Calculation Methodology

ECM-5R energy savings have been calculated using eQuest. Interactivity effects of different control strategies are taken into account with the use of eQuest modelling software.

Energy Savings Metrics: Cost Savings

Table 73: ES - ECM-5R Summary Table

Electric Usage Savings	3,525	kWh
Electric Annual Demand Savings	0.3	kW
Electric Cost Savings	482	$
Natural Gas Usage Savings	439	therms

Natural Gas Cost Savings	388	$
Total MMBTU Savings	56	MMBtu
Total Cost Savings	870	$
Estimated Installation Cost	469,370	$

Design Considerations

- Raising the chilled water temperature in variable volume systems increases the energy consumption of the pumps. If VFDs are installed as recommended in ECM-8, CHWS temperature reset schedule should be optimized in consideration of both pumping and chiller energy consumption.
- The sizing of these heating coils places a lower limit on the degree to which the entering boiler water temperature can be reduced in mild weather.
- Cooling loads that are being served by higher supply air temperatures often require more air and increased fan energy. SAT reset schedule should be optimized in consideration of both fan and compressor energy consumption.

Maintenance Considerations

- Ongoing maintenance shall be performed by the controls contractor.

3.4 Energy Efficiency Measure Descriptions – David Brearley Middle/High School – Not Recommended

ECM-1R: Replace Existing Boilers with Condensing Boilers

Existing Conditions

The hot water system consists of two (2) 6,894 MBH output, gas-fired, hot water boilers. These units were installed in 1999. The hot water supply temperature is manually adjusted between 160 ºF to 195ºF depending on the weather conditions. According to the site personnel, during peak heating season, hot water is typically generated using one boiler.

The burners on the boilers are controlled with a high fire / low fire sequence. Based on the set-points, burners switch between the low-fire and high-fire stages to meet the needs of the facility. A piston operated mechanical lever controls the air intake opening of the burner based on the mode of operation. According to building operators, the boilers have no automated outside air reset control.

ECM Description

Willdan recommends replacing the two (2) existing gas-fired hot water heaters with condensing boilers. The average expectancy of a traditional gas boiler is 20 years[1]. The existing boilers inspected were inspected and found to be functional, but they are at the end of their useful service life. In a conventional boiler, fuel is burned, and the hot gases produced pass through a heat exchanger where much of their heat is transferred to water, thus raising the water's temperature. A substantial portion energy in the flue gases is comprised of water vapor, which arises from burning the hydrogen content of the fuel. A condensing boiler extracts additional heat from the waste gases by condensing this water vapor to liquid water, thus recovering its latent heat of vaporization. While the effectiveness of the condensing process varies depending on the temperature of the water returning to the boiler, it is always at least as efficient as a non-condensing boiler. Compared to 77 - 80% with conventional designs, the proposed condensing boiler efficiency was conservatively taken as 83% based on the expected heating hot water return temperatures in the building.

Measure Baseline and Proposed Upgrades

Baseline

- Two (2) 6,894 MBH input capacity, gas-fired boilers.

Proposed

- Two (2) 6,894 MBH input capacity, modulating condensing boilers.

Calculation Methodology

ECM-1R energy savings have been calculated using eQuest. A baseline high-fire combustion efficiency of 81% is used to model baseline performance which is calibrated to the utility bills. 81% efficiency is derived based on the boilers' cut-sheet efficiency of 85% de-rated according to the age of the equipment based on P4P guidelines. A proposed efficiency of 81% is used based on heating hot water return temperatures of ~175 ºF.

[1] New Jersey's Clean Energy Program Technical Manual – Protocols to Measure Resource Savings

Energy Savings Metrics: Cost Savings

Table 74: MSHS - ECM-1R Summary Table

Electric Usage Savings	964	kWh
Electric Annual Demand Savings	0.2	kW
Electric Cost Savings	127	$
Natural Gas Usage Savings	8,973	therms
Natural Gas Cost Savings	7,617	$
Total MMBTU Savings	900	MMBtu
Total Cost Savings	7,744	$
Estimated Installation Cost	573,547	$

Design Considerations

- Integration with the energy management system and existing distribution system.
- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- New breeching and flue design

Maintenance Considerations

- Boilers shall be maintained as per manufacturer’s guidelines.

ECM-2R: Replace Existing DX Units with High Efficiency DX Units

Existing Conditions

The school provides HVAC through a combination of RTUs, split AC units and HV units. Unit details including size, areas served, and age are discussed in the "HVAC Units" section.

ECM Description

Willdan recommends replacing exiting DX units with high efficiency DX units. Replacing the DX units has a long payback period and may not be justifiable based simply on energy considerations. However, the units that are being recommended for replacement at this facility are nearing or have reached the end of their normal useful life.

Measure Baseline and Proposed Upgrades

Baseline

- Eleven (11) existing DX units:
  - AHU-1
  - AHU-2
  - AHU-3
  - AHU-4
  - AHU-5
  - AHU-6
  - AHU-7
  - AHU-8
  - AHU-9
  - AC-212
  - AC-190

Proposed

- Eleven (11) new high efficiency DX units.

Calculation Methodology

ECM-2R energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 75: MSHS - ECM-2R Summary Table

Electric Usage Savings	10,183	kWh
Electric Annual Demand Savings	2.4	kW
Electric Cost Savings	1,338	$
Natural Gas Usage Savings	-22	therms
Natural Gas Cost Savings	-19	$
Total MMBTU Savings	33	MMBtu
Total Cost Savings	1,320	$
Estimated Installation Cost	611,366	$

Design Considerations

- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- Disposal of refrigerant.
- Integration with the existing BMS and existing distribution system.

Maintenance Considerations

- RTUs shall be maintained as per manufacturer's guidelines.

ECM-3R: Replace Existing Unit Ventilators with New Unit Ventilators

Existing Conditions

There is a total of sixty (60) unit ventilators in the David Brearley Middle/High School. While six (6) of these unit ventilators were replaced in 2009 and one (1) in 2013, majority of the unit ventilators are older original units. Most classrooms and offices are conditioned by unit ventilators that supply heating and cooling to the zones. These unit ventilators have supply fan motors, outside air dampers, and 3-way valves on the heating hot water and chilled water coils. However, facility staff reported that the control board on unit ventilators are out of date and no longer upgradeable. Therefore, over nights and weekends, the valves open to 100% unoccupied mode and the boiler will cycle on and off for freezer protection during the colder seasons.

ECM Description

This measure proposes replacing the existing unit ventilators with new, high-efficient unit ventilators. Willdan developed an energy model to quantify energy savings that would result from replacing existing unit ventilators with like-to-like units with higher efficiency. Replacing the existing unit ventilators will also ensure proper ventilation rates being met in the school as currently the outside air dampers are manually shut down by the operators.

Measure Baseline and Proposed Upgrades

Baseline

- Sixty (60) unit ventilators.

Proposed

- Sixty (60) new unit ventilators.

Calculation Methodology

ECM-3R energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 76: MSHS - ECM-3R Summary Table

Electric Usage Savings	14,039	kWh
Electric Annual Demand Savings	4.3	kW
Electric Cost Savings	1,845	$
Natural Gas Usage Savings	-324	therms
Natural Gas Cost Savings	-275	$
Total MMBTU Savings	16	MMBtu
Total Cost Savings	1,570	$
Estimated Installation Cost	1,185,019	$

Design Considerations

- Rigging & demolition of existing units.
- Scheduling of unit downtime during construction.
- Fixing of non-operational dampers and actuators.
- Architectural fit with using space occupied by existing UVs.
- Integration with the existing BMS and existing distribution system.

Maintenance Considerations

- Unit ventilators shall be maintained as per manufacturer’s guidelines.

ECM-4R Install VFDs on CHW/HHW Pumps

Existing Conditions

The hydronic distribution system is a two-pipe, heating and cooling system. The constant flow primary distribution is lead-lag system served by three (3) 10 hp constant speed pumps. According to the site personnel, the operating pump is rotated every season.

ECM Description

Willdan recommends installing VFDs on the constant speed chilled water/heating hot water pumps and installing two-way valves at the terminal units. Instead of bypassing the water across the coils using three-way valves, the pumps will run at variable speed in order to maintain the desired differential pressure set point. Since motor power consumption is proportional to the cube of the shaft speed under ideal conditions, running pumps at lower speeds provides energy savings when compared to operating pumps at full speed. For example, a 20% reduction in pump motor speed results in approximately a 50% reduction in pumping energy consumption. Willdan also recommends upgrading the standard efficiency motors on existing heating hot water pumps to premium efficiency pump motors (inverter duty motors).

Table 77: MSHS - Chilled Water/Heating Hot Water Pump Upgrades

Tag	Location	Service	Make	Motor HP	Speed Control	VFD Upgrades (Y/N)	Premium Efficiency Motor Upgrades (Y/N)
CHW/HWP-1	Boiler Room	Chilled/Hot Water Loop	Marathon Electric	10	Constant	Y	Y
CHW/HWP-2	Boiler Room	Chilled/Hot Water Loop	Marathon Electric	10	Constant	Y	Y
CHW/HWP-3	Boiler Room	Chilled/Hot Water Loop	Marathon Electric	10	Constant	Y	Y

Measure Baseline and Proposed Upgrades

Baseline

- Three (3) 10-hp constant speed hot water pumps

Proposed

- Install VFDs on three (3) chilled water / hot water pumps.
- Premium efficiency motors on three (3) chilled water / hot water pumps.
- Convert all three-way valves to two-way valves for proper operation of VFDs.
- Testing and balancing of chilled water / hot water systems.
- Provide connections to BMS to monitor and control new equipment.

Calculation Methodology

ECM-4R energy savings have been calculated using eQuest. Baseline motor efficiencies are based on the nameplate of the existing motors.

Energy Savings Metrics: Cost Savings

Table 78: MSHS - ECM-4R Summary Table

Electric Usage Savings	3,066	kWh
Electric Annual Demand Savings	0.33	kW
Electric Cost Savings	403	$
Natural Gas Usage Savings	-126	therms
Natural Gas Cost Savings	-107	$
Total MMBTU Savings	-2	MMBtu
Total Cost Savings	296	$
Estimated Installation Cost	47,515	$

Design Considerations

- Integration with BMS and hydronic distribution system.

Maintenance Considerations

- VFDs, pumps and pump motors shall be maintained as per manufacturer's guidelines.

ECM-5R: BMS Upgrades

Existing Conditions

A Johnson Controls Metasys EMS controls the HVAC systems and other equipment including the boilers, the chiller, the air handlers, exhaust fans, and most of the unit ventilators. The EMS provides equipment scheduling control and monitors space temperatures, supply air temperatures, humidity, and hydronic water temperatures.

There are several sensors which were currently off-line or mis-calibrated. Per discussions with facility personnel, there has never been a retro-commissioning of the control system and the system is over 20 years old.

ECM Description

This measure includes installation of new direct digital control (DDC) systems for all the major HVAC equipment and lighting systems replacing the controls controlling various pieces of equipment. The new EMS will combine all HVAC and lighting equipment. With the communication between the control devices and the new updated digital interface/software, will give the opportunity to take advantage of better scheduling, temperature set-back controls based on outside air temperature and occupancy levels while maintaining adequate heating, cooling and ventilation requirements in the facility. The DDC system will also aid in the response time to service/maintenance issues when the facility is not under normal maintenance supervision i.e. after-hours. Implementation of this measure is also important in achieving full potential of other measures recommended by providing the necessary means of properly controlling the equipment. Several control strategies that were evaluated are described below;

Implement CHW Reset

Chilled-water reset adjusts the chilled-water set point to improving the efficiency of the chiller, reducing the energy consumption of the chiller. Usually, a chilled-water-reset strategy raises the set-point temperature when the building load is at less-than-design conditions. When the outside air temperature is relatively low, the building cooling load is at less-than-design conditions. Producing warmer chilled water lessens the burden on the compressor, which means that the chiller consumes less energy.

Implement HHW Reset

Hot-water outside air reset adjusts the hot-water set point based on the outside air temperature to reducing the energy consumption of the boiler. As the outdoor air temperature warms, the temperature to which the hot water is heated gradually reduces from a maximum value to a minimum value. During this process, the energy consumption to produce the heat decreases. Additionally, condensing boilers that are recommended as part of ECM-1 sees an increase in combustion efficiency as the heating hot water return temperature decreases.

BMS Upgrades - Implement SAT Reset

Supply air temperature reset is a control scheme that allows an airside system to modulate the supply air temperature based on outside air temperature. When enabled, the temperature of supply air is increased, which allows for reduced compressor energy or reheat energy, but also increases fan energy in a VAV system. When supply air temperature reset is based on outside air temperature, the supply air temperature can be increased as the outside air temperature decreases.

BMS Upgrades - Schedule Setback

As discussed, most of the HVAC equipment in the facility is operated based on a schedule implemented at the existing BMS. This measure recommends implementing a stricter schedule than the one currently implemented for air-side HVAC units that are serving areas other than classrooms and offices. Willdan reviewed the existing unit schedules on a space-by-space in order to determine units that are eligible for operating schedule reset.

Measure Baseline and Proposed Upgrades

Baseline

- CHW supply temperature kept constant regardless of the building load.
- HHW supply temperature manually adjusted based on operators' judgement.
- SAT on DX rooftop and make-up air units kept constant.
- Air-side HVAC unit scheduling implemented at the BMS.

Proposed

- Upgrade BMS to include:
    - Implement CHW automated supply temperature reset.
    - Implement HHW automated supply temperature reset.
    - Implement SAT reset on air-side HVAC units.
    - Implement optimized operational schedules for units serving areas other than classrooms and offices.

Calculation Methodology

ECM-5R energy savings have been calculated using eQuest. Interactivity effects of different control strategies are taken into account with the use of eQuest modelling software.

Energy Savings Metrics: Cost Savings

Table 79: MSHS - ECM-5R Summary Table

Electric Usage Savings	36,554	kWh
Electric Annual Demand Savings	3.7	kW
Electric Cost Savings	4,805	$
Natural Gas Usage Savings	884	therms
Natural Gas Cost Savings	751	$
Total MMBTU Savings	213	MMBtu
Total Cost Savings	5,555	$
Estimated Installation Cost	712,993	$

Design Considerations

- Raising the chilled water temperature in variable volume systems increases the energy consumption of the pumps. If VFDs are installed as recommended in ECM-8, CHWS temperature reset schedule should be optimized in consideration of both pumping and chiller energy consumption.
- The sizing of these heating coils places a lower limit on the degree to which the entering boiler water temperature can be reduced in mild weather.
- Cooling loads that are being served by higher supply air temperatures often require more air and increased fan energy. SAT reset schedule should be optimized in consideration of both fan and compressor energy consumption.

Maintenance Considerations

- Ongoing maintenance shall be performed by the controls contractor.

ECM-6R: Implement Kitchen Hood Exhaust Control System

Existing Conditions

The current kitchen exhaust hood fan is run at full speed during the hours the kitchen is open.

ECM Description

This measure recommends installing a kitchen exhaust hood control system. Measuring temperature and smoke in the hood; the controls adjust the fan speed as appropriate to save both fan energy and conditioned air. The proposed control system reduces the supply and exhaust fan speeds to the kitchen when there is no cooking. During actual cooking, the speed increases as needed up to 100% until smoke and vapors are removed, keeping the ambient temperature and conditions in the kitchen comfortable.

Measure Baseline and Proposed Upgrades

Baseline

- Constant speed operation of the supply and exhaust fans serving the cafeteria.

Proposed

- Variable speed kitchen exhaust fan and make-up air supply fan.
- Reduced operation at partial exhaust air flow based on temperature and exhaust smoke.

Calculation Methodology

ECM-6R energy savings have been calculated using eQuest.

Energy Savings Metrics: Cost Savings

Table 80: MSHS - ECM-6R Summary Table

Electric Usage Savings	56	kWh
Electric Annual Demand Savings	0.0	kW
Electric Cost Savings	7	$
Natural Gas Usage Savings	443	therms
Natural Gas Cost Savings	376	$
Total MMBTU Savings	44	MMBtu
Total Cost Savings	384	$
Estimated Installation Cost	49,645	$

Design Considerations

- Maintaining pressurization is the building.
- Testing and balancing.
- Integration with the BMS.

ECM-7R: Implement Voltage Management

Existing Conditions

Grid volatility is a known cause of premature equipment failure. VFD's, motors, process controls and plug load electronics are all susceptible to increased failure due to adverse power conditions. Three of the most common challenges in school buildings, which result in costly down time are:

- Variable Frequency Drive failing and tripping due to sustained high-voltage, often failing overnight resulting in costly service calls the next morning.
- Control systems lockout/failure – voltage sags, as measured in your facility, will disrupt the regular operation of many electronically controlled systems - relays and other control mechanism are highly sensitive to voltage sags.

- Motors operate poorly (lifetime and efficiency) at the edges of the ANSI voltage band. Plus, phase imbalance is a leading cause of motor failure due to heat buildup, causing premature insulation failure and mechanical breakdown.

ECM Description

Willdan recommends installing the SmartGate platform to evaluate the incoming voltages and automatically optimize it. All the data collected through our integrated utility grade meter is available to the Building Automation System to streamline performance and visibility. Additionally, the ability to gain visibility into power grid conditions, will help a facility operator identify energy saving opportunities and identify potential power problems before they cause damage. This ECM achieve electricity saving by reduce the kWh usage and peak kW charges.

Measure Baseline and Proposed Upgrades

Baseline

- No voltage optimization currently implemented.

Proposed

- Install SmartGate voltage optimization platform.

Calculation Methodology

ECM-7R energy savings have been calculated using excel spreadsheet.

Energy Savings Metrics: Cost Savings

Table 81: MSHS - ECM-7R Summary Table

Electric Usage Savings	27,267	kWh
Electric Annual Demand Savings	15.3	kW
Electric Cost Savings	3,584	$
Natural Gas Usage Savings	0	therms
Natural Gas Cost Savings	0	$
Total MMBTU Savings	93	MMBtu
Total Cost Savings	3,584	$
Estimated Installation Cost	64,000	$

Design Considerations

- Coordination with facility manager to minimize the effect on day-to-day operation.
- Disruption to electrical loads served by existing transformers.
- Seasonal loading on transformers.

4. Utility and Other Rebates and Incentives Available for Project

Willdan will work with you to apply for and maximize all available rebates, utility incentives, PJM incentives or tax incentives. Willdan will also work with Kenilworth to explore all available markets for Carbon Credits. There are a number of programs available to help incentivize utility customers to reduce their dependence on the grid and move towards more energy efficient technology. The developers of the incentive programs understand, as we do, that the most efficient technology is not always the least expensive from a "first cost" standpoint, but they will lead to reduced operational costs and an improved environment over the "lifecycle" of your facilities. Willdan is an approved Pay for Performance and Direct Install partner, so any building that qualify for either program, we would be able to help Kenilworth to apply for incentive. Following two (2) incentive programs were evaluated under the Energy Savings Plan for the Harding Elementary School and the David Brearley Middle/High School.

- New Jersey Clean Energy Direct Install Incentive Program.
- PJM Interconnection Incentive Programs (Demand Response and Frequency Regulation).

4.1 New Jersey Office of Clean Energy Direct Install Program

As we indicated above, Willdan is an approved Direct Install Program Contractor, who has been selected by NJBPU to implement Direct Install Program. As outlined in the table below, three of the buildings would qualify for Direct Install Program. We potentially have total of $4Million chance to go through Direct Install program to maximize up to 80% of the project paid by the NJOCE Program.

Let us pay up to 80% of your energy efficiency upgrade.

Existing small to mid-sized commercial and industrial facilities with an average peak electric demand that did not exceed 200 kW in any of the preceding 12 months are eligible to participate in Direct Install. Applicants will submit the last 12 months of electric utility bills indicating that they are below the demand threshold and have occupied the building during that time. Buildings must be in New Jersey and served by one of the state's public, regulated electric or natural gas utility companies.

Included Measures:

- Lighting
- Heating, Cooling & Ventilation (HVAC)
- Refrigeration
- Motors
- Natural Gas
- Variable Frequency Drives

Measures eligible for Direct Install are limited to specific equipment categories, types and capacities. Boilers may not exceed 1,500,000 Btuh and furnaces may not exceed 140,000 Btuh. Limitations on packaged HVAC, motors and other equipment also apply. Larger capacity equipment may be eligible for financial incentives through NJ SmartStart Buildings.

See how other small businesses owners have saved! View a step-by-step description of the program or read the Program Guide to understand what to expect.

A. CONTACT US
Give us a call at 866-NJSMART to learn more about this offer. If your building meets eligibility requirements, we'll refer you to the Participating Contractor serving your region to schedule an Energy Assessment. Or, if you prefer, you may contact the contractor right away to get started!
B. REVIEW RESULTS
After the energy assessment, the contractor will review the results with you, including what measures qualify and your share of the project cost.
C. MOVE FORWARD
You will sign a scope of work document to proceed with implementation of qualifying measures and arrange for payment of your portion of the project costs with your contractor.
D. ARRANGE INSTALLATION
You and your contractor will set a convenient start date for the installation.
E. CONFIRM INSTALLATION
Once the participating contractor completes the installation, you accept the work by signing a project completion form.
F. COMPLETE TRANSACTION

You pay the participating contractor any remaining balance of your share of the project cost and New Jersey's Clean Energy Program pays the rest.

Benefit of Direct Install Program:

- Turnkey Process - A network of selected participating contractors addresses your project from start to finish, beginning with an assessment of your facility, and ending with the installation of eligible energy-efficient equipment.

- Minimal Cost - Your share of the project's cost could be as low as 20%, in which case the program pays the remaining amount. With incentives so dramatic, your upgrade project can very quickly pay for itself.

- Fast Turnaround Time - Project installations are typically completed within 90 days from the time of scheduling your energy assessment.

Ongoing Savings - Your new energy-efficient equipment will provide savings for years to come through dramatically reduced energy costs on your monthly utility bills.

Table 82: Kenilworth Schools DI Incentive Summary

School Name	NJOCE DI Incentive
Harding Elementary School	$88,181.18
David Brearley Middle/High School	-

4.2 PJM Incentives

PJM's Energy Efficiency program pays businesses for permanent load reduction resulting from energy efficiency projects they have completed or will be complete in the future. The program pays organization capacity revenue for up to four years following the completion of a qualified project. Qualifying projects include those with permanent energy reductions involving lighting, refrigeration equipment, HVAC, motors, VFDs, and more. There is revenue to be earned from your organization using less energy and helping PJM reduce the overall load on the grid.

- Summer EE performance period: June-Aug between 2-6pm not including weekends or public holidays.
- Winter EE performance period: Jan-Feb between 7-9am and between 6-8pm not including weekends or public holidays.
- Solar PV systems are not eligible as PJM Energy Efficiency Resources.
- BMS Systems load reductions are difficult to qualify under PJM's Manual 18B as "permanent, continuous".
- Savings achieved by fuel switching are not eligible as PJM EE Resources.
- Transformers and Motors/VFDs may have potential but at this stage for estimated value it is not simple enough to be viable to make that analysis.
- **Lighting upgrades** have represented 100% of the PJM EE Capacity kWs that we have qualified with PJM for school district projects. (>50 school districts in NJ in last five years).

Table 83: Kenilworth Schools PJM Incentive Summary

PJM Delivery Years	PJM Incentives
DY 2021/22	$2,234
DY 2022/23	$1,446
DY 2023/24	$1,446
DY 2024/25	$1,446

Note: Incentives presented in the table above are based on completion of the lighting upgrades by May 31st, 2021. Payments to customers are made in two equal instalment each PJM Delivery Year. The first instalment for DY 2021/22 will be made in Dec 2021 and the second one in June 2022. Other checks will continue every six months.

4.3 Operational and Maintenance Savings

ESIP Law allows energy savings as an energy cost reduction and maintenance cost reduction resulting from implementing energy conservation measures, when compared against established baseline of a previous energy cost, operating and maintenance cost including but not limited to future capital expenditure avoided because of equipment installed or services performed as part of the ESIP program. As part of the initial evaluation, Willdan estimated an operational savings of $152,850. Based on input from the Kenilworth Board of Education and the facility staff during the initial review of the ESP, this estimated value shall be updated.

5. Measurement and Verification (M&V) Plan

Measurement and Verification
The M&V protocol developed collaboratively between Willdan and Kenilworth Board of Education during the IGA process and as outlined in the M&V Plan will be utilized to measure and verify the project energy savings. Willdan will assign a dedicated M&V engineer familiar with Kenilworth Board of Education facilities and its systems to work on-site throughout the M&V period. The dedicated M&V engineer will work closely with Kenilworth staff on continuous optimization and commissioning of systems to ensure savings are achieved.

The International Performance Measurement and Verification Protocol (IPMVP) is the industry standard protocol that Willdan follows. The IPMVP provides four methods to measure energy savings. Willdan generally prefers IPMVP Option C – measuring savings at the utility meter – in cases where realizing the project savings on the utility bill is critical; however, Option C is limited on a facility that undergoes significant changes or projects that also impact the utility meter. For this reason, more measure-specific savings tracking using submetering may be most appropriate.

Computation of Baseline
Willdan's preferred approach, IPMVP Option C: Whole Facility, whenever appropriate based upon ECM selection, facility type, and customer preference. Willdan's straightforward calculations for both the baseline and any adjustments are outlined in this section.

Methodology to Determine Baseline Energy Use
In the simplest terms, the baseline is the sum of the energy consumption and costs for a specific, 12-month period prior to the installation of an energy efficiency project. The Baseline Year is the period that establishes the pre-retrofit conditions used as the point of reference for calculating energy savings. This baseline is developed prior to contract execution and established with input and agreement of Kenilworth Board of Education.

Willdan's approach to calculating a baseline for Option C is summarized in this section; Option A and B baselines are customized based on ECMs implemented and measured.

Data Collection
Building and system information gathered during the IGEA is documented in the Energy Savings M&V Plan to document the conditions present that resulted in the baseline energy use. This data includes, but is not limited to:

- Building metered utility data (from utility provider meters).
- Weather conditions collected from the nearest National Weather Service Station.
- An inventory of the HVAC and domestic water heating systems serving the building.
- An inventory of the lighting equipment serving the building.
- The operating hours of each building.
- Function and utilization of each space within the building.
- Building plans showing current construction and floorplans showing physical layout of spaces.

Baseline Year Consumption Calculations – IPMVP Option C: Whole Facility
For IPMVP Option C: Whole Facility M&V methodology, utility consumption and demand are obtained from utility bills, shown below, for the Guarantee Meters during the baseline period, which forms the basis of the energy baseline.

The following equations will be used to determine baseline electrical consumption and demand:

Baseline Energy (or Demand) Consumption = ∑ Tracked Utility Meters' Consumption (of Demand) ± Baseline Adjustments, where:

> Baseline Adjustment = ∑ ± Routine Adjustment to reporting period conditions ± Non-Routine Adjustments to reporting-period conditions
>
> Routine Adjustments include, but are not limited to, weather and billing period length
>
> Non-Routine Adjustments include changes in key conditions from the baseline period to the reporting period, including, but no limited to, occupancy; hours of operation; changes to building function and use; changes to operation, capacity or quantity of equipment or systems within the facility; and additions to the building

M&V activities are performed to assure guaranteed savings are met to satisfy the contract and legislation. A general M&V approach is necessary to outline the methods that will significantly affect how the baseline is defined and the energy savings justified. An Adjusted Baseline is also used to incorporate any changes with facility use, such as operating hours, occupancy, renovation or any other reason that will impact a significant use in energy as compared to the baseline. Willdan Energy Solutions calculates the baseline for any facility based on actual existing systems and operating conditions. There are various approached that WES takes to accumulate the necessary data to construct the baseline. Such methods are listed below:

- Site measurements for electrical loads such as lighting, HVAC equipment, plug loads, circulation pumps, process loads, etc.
- Equipment operating hours based on trend data.

This section contains a description of the types of Measurement and Verification (M&V) methodologies that Willdan Energy Solutions will use to guarantee the performance of this project. They have been developed and defined by two independent authorities:

- International Performance Measurement and Verification Protocol (IPMVP)
- Federal Energy Management Program (FEMP)

There are four guarantee options that may be used to measure and verify the performance of an energy conservation measure. Each of the option is described below.

Option A – Retrofit Isolation: Key Parameter Measurement

Energy savings is determined by field measurement of the key parameters affecting the energy use of the system(s) to which an improvement measure was applied separate from the energy use of the rest of the facility. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the reporting period.

Measurement of key parameters means that those parameters not selected for field measurement will be estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter will be described in the M&V plan in the contract. Energy savings is determined through engineering calculations of the baseline and post-retrofit energy used based on the combination of measured and estimated parameters, along with any routine adjustments.

Option B – Retrofit Isolation: All Parameter Measurement

Like Option A, energy savings is determined by field measurement of the energy use of the systems to which an improvement measure was applied separate from the energy use of the rest of the facility. However, all of the key parameters affecting energy use are measured; there are no estimated parameters used for Option B. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period. Energy savings is determined through engineering calculations of the baseline and post-retrofit energy used based on the measured parameters, along with any routine adjustments.

Option C – Whole Building Metering/Utility Bill Comparisons

Option C involves the use of utility meters or whole building sub-meters to assess the energy performance of a total building. Option C assesses the impact of any type of improvement measure, but not individually if more than one is applied to an energy meter. This option determines the collective savings of all improvement measures applied to the part of the facility monitored by the energy meter. In addition, since whole building meters are used, savings reported under Option C include the impact of any other change made in facility energy use (positive or negative).

Option C may be used in cases where there is a high degree of interaction between installed improvement measures or between improvement measures and the rest of the building or the isolation and measurement of individual improvement measures is difficult or too costly.

This Option is intended for projects where savings are expected to be large enough to be discernable from the random or unexplained energy variations that are normally found at the level of the whole facility meter. The larger the savings, or the smaller the unexplained variations in the baseline, the easier it will be to identify savings. In addition, the longer the period of savings analysis after installing the improvement measure, the less significant is the impact of short-term unexplained variations. Typically, savings should be more than 20% of the baseline energy use if they are to be separated from the noise in the baseline data.

Periodic inspections should be made of all equipment and operations in the facility after the improvement measure installation. These inspections will identify changes from baseline conditions or intended operations. Accounting for changes (other than those caused by the improvement measures) is the major challenge associated with Option C-particularly when savings are to be monitored for long periods.

Savings are calculated through analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.

Option D – Calibrated Simulation

Option D involves the use of computer simulation software to predict energy use, most often in cases where baseline data does not exist. Such simulation models must be calibrated so that it predicts an energy use and demand pattern that reasonably matches actual utility consumption and demand data from either the base-year or a post-retrofit year.

Option D may be used to assess the performance of all improvement measures in a facility, akin to Option C. However, different from Option C, multiple runs of the simulation in Option D allow estimates of the savings attributable to each improvement measure within a multiple improvement measure project.

Option D may also be used to assess just the performance of individual systems within a facility, akin to Option A and B. In this case, the system's energy use must be isolated from that of the rest of the facility by appropriate meters.

Savings are calculated using energy use simulation models, calibrated with hourly or monthly utility billing data and/or end-use metering.

Using the given options, Kenilworth schools will be going through various M&V options. The following is the decision per school.

Harding Elementary School

Willdan has recommended option C for Measurement and Verification at Harding Elementary School. Existing building has been modeled using eQuest 3.65-7175. A site survey was conducted to gather information on existing system and the maintenance department was interviewed for operational conditions. The baseline has been calibrated against recent 12 months of utility bills. This calibration has given an understanding of the building's operating schedule. Savings calculated will be verified using 12 months of utility bills post installation to justify the interactive effects between newly installed system and the building as whole.

David Brearley Middle/High School

Willdan has recommended option C for Measurement and Verification at David Brearley Middle/High School. Existing building has been modeled using eQuest 3.65-7175. A site survey was conducted to gather information on existing system and the maintenance department was interviewed for operational conditions. The baseline has been calibrated against recent 12 months of utility bills. This calibration has given an understanding of the building's operating schedule. Savings calculated will be verified using 12 months of utility bills post installation to justify the interactive effects between newly installed system and the building as whole.

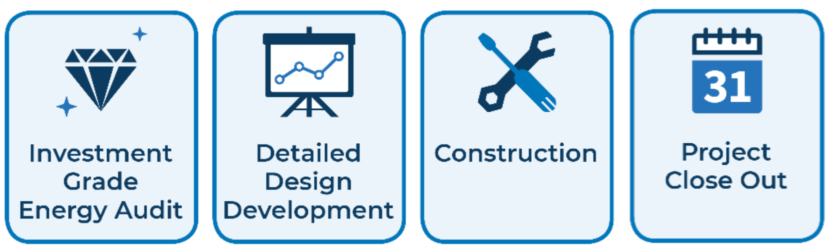
6. Project Development and Management Overview

Project Development and Management Overview

Energy Performance project development and management Approach

Willdan's approach to energy performance project development and management of Energy Savings Plans (ESP) and Energy Savings Improvement Plans (ESIP) intentionally evolved to address the common pitfalls we experienced while working for vendor based ESCOs as well as managing "traditional" performance contracting projects from the owner's side of the table. Our ESP process is designed around core principles that have earned us the reputation of delivering the best value to our clients.

The following components set our ESP and ESIP process apart from others for Kenilworth Board of Education:



Detailed Design Development
Willdan's Product and Vendor Independent Approach

Willdan does not manufacture, sell, distribute or install any specific equipment or system and are not tied to any brand. We recommend equipment based on customer preference, what is best and most cost effective for the application. Our standard approach is to select the best long-term equipment and systems based on Life Cycle Cost (LCC) analysis and then competitively bid sub-contracted work to obtain the best price value for our clients.

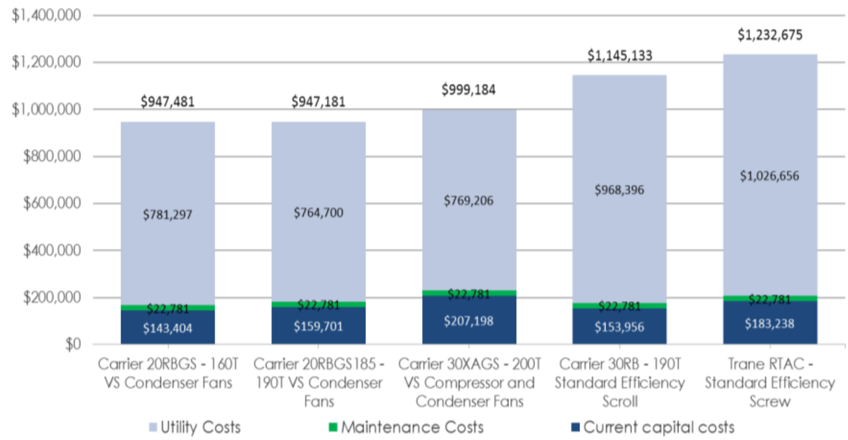
Willdan knows a competitive atmosphere is essential to ensuring that our clients receive the highest quality project delivered at the lowest total cost. Willdan's independence from specific equipment or contractors provides us the freedom to incorporate our clients' preferences for products and contractors on every project.

Our engineering team will work closely with Kenilworth Board of Education' engineering and facilities staff to understand their product preferences. Qualitative and quantitative benefits of these preferred products relative to alternatives will be evaluated and discussed with staff to arrive at a final basis of design and to inform the project specifications.

Willdan began as – and remains – an engineering company with the in-house engineering resources to effectively serve public entities.

Our engineers will develop design documents, they remain involved in the construction management process to ensure that the design intent and requirements are properly installed, preventing contractors from omitting, neglecting, or modifying essential components of the original design intent.

Table below compares traditional the ESCO approach with Willdan's approach to energy performance contacting.



Construction

The top priority of Willdan's project implementation team is to ensure that the installed project stays on schedule, maintains the highest standards during installations, and promptly addresses Kenilworth Board of Education's questions or concerns. Willdan will provide as requested oversight during construction.

Willdan's Construction Management Process Key Elements

Process Element	Overview
Equipment Submittals	Willdan's methodical approach to receiving and reviewing equipment submittals from contractors is essential because it ensures that appropriate equipment is ordered and installed. Detailed submittal requirements are presented in "SECTION 013300 - SUBMITTAL PROCEDURES" of Willdan's standard specification package.
Construction Oversight	The construction management team works with the design engineer to ensure systems are properly installed and operating efficiently, comfortably, and with minimal maintenance. Willdan monitors project installation daily, and all construction issues are addressed by our team.
Client Communication	Willdan ensures contractors implement projects as designed, and keeps clients apprised of the project through construction update meetings, update memos, and additional avenues as requested. Any challenges, scheduling conflicts, etc., are resolved at these meetings.
Operations and Maintenance Manuals	Prior to closing out projects, contractors are required to submit detailed Operation and Maintenance manuals for all equipment specified. Detailed Operations and Maintenance requirements are presented in "SECTION 017823 - OPERATION AND MAINTENANCE" of Willdan's specification package.
Warranty Procedures	Willdan protects equipment warranties and lays out expectations and requirements related to warranties in "SECTION 016000 - PRODUCT REQUIREMENTS" of our specification package. This portion – in addition to the remainder of Willdan's specifications – will be transferred to specifications. Willdan maximizes the benefit of warranties to our clients by providing subcontractors with specific required steps and actions related to product, manufacturers', and workmanship warranties.

During the design phase of our projects, Willdan selects systems, regardless of manufacturer or distributor. Every facility will receive customized solutions designed to maximize occupant comfort, efficiency, maintenance, and total life cycle cost.

Throughout the project Willdan is the sole source of contact and accountability for Kenilworth Board of Education for warranty-related issues. These costs are included within the Willdan standard pricing model.

Safety Practices and Procedures

All Willdan employees and managed contractors are required to follow well-defined safety procedures that not only protect themselves, but more importantly, protect Kenilworth Board of Education students, staff and the general public. Incident prevention is our highest priority. As such, our Safety Coordinator will perform risk assessments of all projects and develop Site- and Task-Specific Safety Plans. Well-marked access restrictions, visible signage, and daily clean-ups all are strictly enforced to ensure the safety of everyone at the facility. Willdan's safety plan and procedures are consistent with the requirements of the State of New Jersey and Kenilworth Board of Education. Willdan maintains an impeccable safety record and continues to promote safety as its #1 priority.

Management of Hazardous Materials

Willdan adheres to a Corporate Environmental Health and Safety Plan (EHASP) that provides the basic policies, objectives, organizational structure, and guidelines that govern all work we perform. The EHASP identifies potential hazards and specifies an appropriate level of response to protect the health and safety of our workers, subcontractors, clients and the public. This includes the management of hazardous materials encountered in the installation of energy conservation measures, such as asbestos, PCB ballasts, lead, etc. For each contract, Willdan updates our EHASP to account for specific hazards that may be encountered.

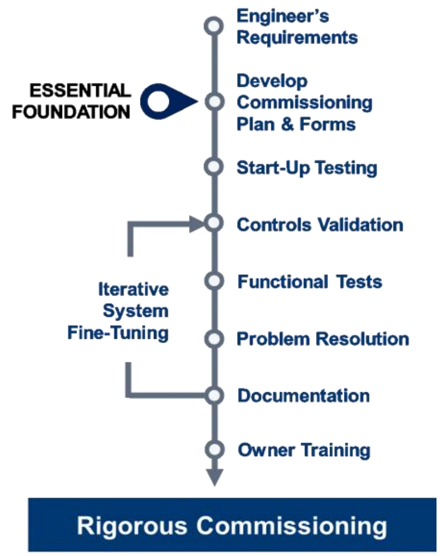
Project Closeout

Construction close-out inspections, punch lists, operation and management documents, owner training, commissioning, and warranty information are all important to the successful completion of any project. Willdan takes this process one step further with its comprehensive commissioning process described below.

Systems Commissioning

Commissioning (Cx) is the systematic process of ensuring that all facility systems perform interactively and acceptable to the owner's operational needs and Willdan's design intent. This process requires the preparation of facility operations personnel, as all HVAC, controls, and lighting systems will be commissioned.

Willdan's commissioning process is the fundamental quality control mechanism that ensures the final installation efficiently satisfies the Owner's Project Requirement (OPR). This process begins at project inception and remains in operation throughout project development to prevent – or catch – potential issues during design, construction, and final system testing. Ideally, this process works preemptively, but Willdan also recognizes the importance of continuous commissioning after construction completion to guarantee appropriate system installation and optimized system performance.



The Willdan team uses a systematic commissioning process that eliminates the common disconnects between the owner's goals, the engineers' design, the contractor installation, and the final operation and performance of each building system. It is this systematic process coupled with our use of in-house commissioning group that eliminates disjointed handoffs.

Willdan's commissioning process begins in the pre-design phase and ends one-year after construction. At the commencement of construction system functional testing is conducted.

Subsequent testing of HVAC systems and controls continues to capture performance in all four seasons. A comprehensive commissioning plan, extensive documentation, and a complete "issues checklist" is maintained through project management software. This rigorous process ensures every issue is corrected before the project is considered complete.

Specific components of our commissioning process are described in more detail below.

- Continual Quality Assurance – Willdan's engineers and construction teams continually build quality into all project phases. They monitor construction progress and verify compliance with design and specification documents and overall standards of quality to preemptively address issues. This attention to detail throughout the construction process means issues that could potentially cost a great deal of time, money, and aggravation are eliminated before they have a chance to fester.
- Commissioning Plan – Willdan develops and utilizes the Commissioning Plan to define the scope and format of the commissioning process and the responsibilities of all involved parties. This plan is provided to all commissioning team members to inform them of the commissioning work intent and scope, ensure inclusion in the project scope, document all process steps, and expedite the overall commissioning process.
- Preparation for Functional Testing – Willdan's commissioning team verifies preparations before functional testing begins by reviewing construction documents, submittals, and signed documentation from contractors certifying all systems are installed in compliance with the construction documents and manufacturer's recommendations, are clean and properly prepared

for operation, are functional for test and balance (TAB), and are ready for functional performance testing.

- Functional Testing – Willdan's engineers verify proper sequencing, operation, and performance of installed equipment and systems under real operating conditions, including seasonal commissioning. Qualified technicians working for the contractor who installed the equipment and implemented the programming perform these tests under Willdan's certified commissioning engineers' supervision.
- Documentation – Startup forms, TAB forms, and functional test procedures guide the commissioning process, and specific written documentation is maintained for all commissioning activities. Willdan's commissioning team generates commissioning reports documenting project issues and resolutions, deficiencies, and the status of testing, and these reports are tracked for the duration of a project.
- Problem Resolution – When a report is issued to address an identified deficiency, Willdan's construction manager forwards it to the appropriate parties to initiate immediate corrective action. Willdan's engineers are responsible for any design modification and issuing final design details.

Provision of Record Drawings

Accurate as-built drawings are as important to future facility operation as the O&M manuals delivered at the end of the construction process. Up-to-date documentation makes the generation of record drawings seamless at the end of construction and provide an accurate basis for discussion of field changes with all project stakeholders when they occur. Documents are provided in both hard copy and electronic form (AutoCAD and PDF format) to our clients, or as requested.

Post-Implementation Reporting

Willdan will provide Kenilworth Board of Education a full description of the energy baseline(s) corresponding with the M&V plan at the end of the construction period during a dedicated M&V kickoff meeting. This report details parameters that describe both the energy and water consumed in the baseline year and the conditions that caused that consumption to occur to facilitate accurate M&V of guaranteed savings.

Factors including utility consumption and demand data; weather; building physical and thermal properties; energy consuming equipment and system parameters; space temperature setpoints and schedules; facility use and occupancy schedules; and other key information describing base-year conditions are outlined in this report. Willdan does not adjust our baseline or savings for changes necessary for project implementation. Only Kenilworth Board of Education-initiated scope changes during construction are subject to adjustment.

Description of Post Construction Training and Services

Willdan does not use Operation and Maintenance services as a source of profit; our role is to ensure Kenilworth Board of Education has resources in place to provide sufficient ongoing maintenance – either with a third-party subcontractor or using in-house personnel. If outside assistance is desired or required, Willdan facilitates a competitive process to obtain preventative maintenance from local, high-quality contractors.

Kenilworth Board of Education Staff Training

Willdan recognizes that the success – both in terms of performance and client satisfaction – hinges on operators understanding how to properly operate and maintain the systems. We will deliver technical training to Kenilworth Board of Education staff and operations personnel on all new equipment and dynamic systems. We will arrange and facilitate these trainings at Kenilworth Board of Education, and we bring in equipment experts to provide advanced technical training and advocate that Kenilworth engineering and facilities staff participate in the functional testing of major systems to gain first-hand knowledge of their design and operation.

Customized Maintenance Staff Training and Cross Training:

Personal interviews of maintenance staff are conducted by Willdan as an integral part of the equipment handover process. We then can develop a maintenance staff training program targeted to staff skill levels, experience, education, and prior training. Interviews conducted during IGA site surveys and equipment installation provides an opportunity to educate the maintenance staff about the project, as well as obtain their support and assistance from the beginning of the project. Willdan will work with Kenilworth Board of Education personnel to evaluate individual capabilities and propose tailored training programs that meet the needs of the staff.

Willdan has significant in-house resources and advanced technical capabilities to provide Kenilworth Board of Education with a better understanding of energy conservation technologies and their energy usage. The complete understanding of overall facility operations and energy consumption that Willdan incorporates into its energy cost reduction training will be of great benefit to Kenilworth. The use of in-house Willdan personnel for this component of the training, and their extensive experience in identifying and implementing energy conservation methods, will ensure the Board realizes all available energy and operational savings.

Manufacturer Training

Willdan is vendor and product neutral, with no vested interest in any vendor or manufacturer. This impartiality allows us to incorporate the training from the appropriate manufacturer or service provider as the situation warrants. Most manufacturing companies offer excellent training programs, but the training is often focused solely on their product lines. Willdan will coordinate and organize vendor training on proper equipment operation for personnel and will work with the manufacturer of each major piece of equipment to develop training manuals and a core curriculum that includes assembly/reassembly instructions, troubleshooting tips and parts lists.

This training will include operation, maintenance, and troubleshooting for all major equipment items. Willdan provides on-site training for all equipment installed under the performance contracting program. Our research indicates that the most effective training takes place when performed on the actual equipment.

Training is performed throughout the term of the contract to update skills, provide the latest information and train new personnel. Training programs are recorded as a reference tool for personnel and new staff. Willdan will prepare tutorials and other training materials (including videos, CDs, and text) that will assist the Board of Education in training new staff, as well as providing a library of training materials for existing personnel.

7. Disclaimer

For various combinations of HVAC measures, ECMs have complex interactive effects which cannot always be isolated on an individual measure basis.

The intent of this energy analysis report is to estimate energy savings associated with recommended upgrades to the HVAC systems, lighting systems, and other relevant energy consumers at your facility. Appropriate detail is included to make decisions about implementing energy efficiency measures at the facility. However, this report is not intended to serve as a detailed engineering design document, as the description of the improvements are diagrammatic in nature only in order to document the basis of cost estimates and savings, and to demonstrate the feasibility of constructing the improvements. Interactive effects between the individual measures can cause the total project savings to be larger or smaller depending on which recommendations are selected for implementation.

While the recommendations in this report have been reviewed for technical accuracy and are believed to be reasonable and accurate, the findings are estimates and actual results may vary. As a result, Willdan are not liable if projected estimated savings or economics are not actually achieved. All savings and cost estimates in the report are for informational purposes and are not to be construed as a design document or as guarantees.

In no event will Willdan be liable for the failure of the customer to achieve a specified amount of energy savings, the operation of customer's facilities, or any incidental or consequential damages of any kind in connection with this report or the installation of recommended measures.