Energy Assessment Report

Clayville Elementary School | *DRAFT October 2016*

3 George Washington Highway, Clayville, RI 02815

Summary of Findings

On behalf of the School Building Authority at Rhode Island Department of Education (RIDE), Jacobs recently completed a comprehensive energy assessment of the public schools in Rhode Island. This assessment was completed to develop recommendations for improving energy efficiency, benchmark each facility against other like facilities, and assess the feasibility of using renewable energy technologies. Results from the analysis for Clayville Elementary School are summarized in this document.

Heat is provided by hot water boilers pumping heated water through perimeter mounted terminal heating equipment. Lighting is predominantly provided by T8 fluorescent lighting.

A number of energy efficiency opportunities with varying payback periods were identified during the assessment. Based on an estimated energy cost of $0.15/kWh, energy cost savings of approximately $9,922/year are possible through measures that have an average payback period of 22.9 years and represent approximately 17% savings in energy cost.

The school has potential to implement renewable energy projects and qualify for Net Zero certification. Electricity purchased from the grid can be reduced to "Net Zero" by installing a solar photovoltaic (PV) array on the school's roof or ground-mounted on school property. On site combustion can be eliminated by replacing the existing boilers with a ground sourced heat pump system. The costs for these systems are:

- 88 kW Solar PV - $350,959 (18.3 year simple payback after incentive)
- 205-ton ground sourced heat pump system - $667,275 (14.2 year simple payback after incentive)

National Grid has attractive renewable energy growth programs which are dependent upon the size of the renewable power system and the ownership arrangement (host vs. third party owner). Incentive programs available in Rhode Island are presented in Table 6.

Benchmark Utility Data Analysis

Table 1 below presents key utility data consumption and associated benchmarks. This data has not been normalized for weather, however degree day data for the period of this assessment is provided in Table 3.

Table 1 - Key Utility Data Consumption Benchmarks

	2011	2012	2013	2014
Electricity ($)	$ 23,511.44	$ 19,040.00	$ 19,724.75	$ 19,215.89
Natural Gas ($)	-	-	-	-
Fuel Oil ($)	$ 30,814.77	$ 36,932.03	$ 38,373.30	$ 38,899.66
Total Energy Cost ($)	**$ 54,326.21**	**$ 55,972.03**	**$ 58,098.05**	**$ 58,115.55**
Electricity (kWh)	145,132.35	117,530.86	128,919.93	125,103.45
Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	10,271.59	9,981.63	9,839.31	11,114.19
Total Energy Use (kBtu)	1,922,963.18	1,788,478.53	1,807,556.89	1,971,742.95
($ / SF)	$ 1.64	$ 1.69	$ 1.76	$ 1.76
EUI (kBtu / sf)	58.09	54.03	54.60	59.56

Energy consumption was approximated using cost data publically available on the Rhode Island Department of Education website in the Uniform Chart of Accounts. These assumptions are provided in Table 2.

Table 2 - Energy Cost Assumptions

	2011	2012	2013	2014
Electricity ($ / kWh)	$ 0.16	$ 0.15	$ 0.15	$ 0.15
Natural Gas ($ / Therm)	$ 1.33	$ 1.23	$ 1.24	$ 1.29
No. 2 Heating Oil ($ / Gal)	$ 3.70	$ 3.90	$ 3.90	$ 3.50
Propane ($ / Gal)	$ 3.87	$ 3.80	$ 3.50	$ 4.50

Table 3 indicates a 15.5% increase in heating degree days in 2014 compared to 2013. Resetting the heating hot water temperature set point based on outside air temperature will help to reduce energy consumption.

Table 3 - Heating and Cooling Degree Data

	2011	2012	2013	2014
Heating Degree Days (Base 65 Deg. F)	5,046	5,317	4,807	5,554
Cooling Degree Days (Base 65 Deg. F)	1,068	921	838	894
Growing Degree Days (Base 50 Deg. F)	3,446	3,203	3,160	3,128

Energy Use

During the study period the school consumed the following energy types:

- Electricity
- Fuel Oil

Figure 1 presented below shows the site energy use index (EUI) for Clayville Elementary School since 2011. The cost/SF increased by 7.3% from 2011 to 2014. The EUI dropped from 2011 to 2012 then increased to 2014. This data has not been normalized for weather and therefore reflects energy consumption dependent on heating and cooling degree days (see Table 3) and is intended to be used for comparison of schools within the weather region only.

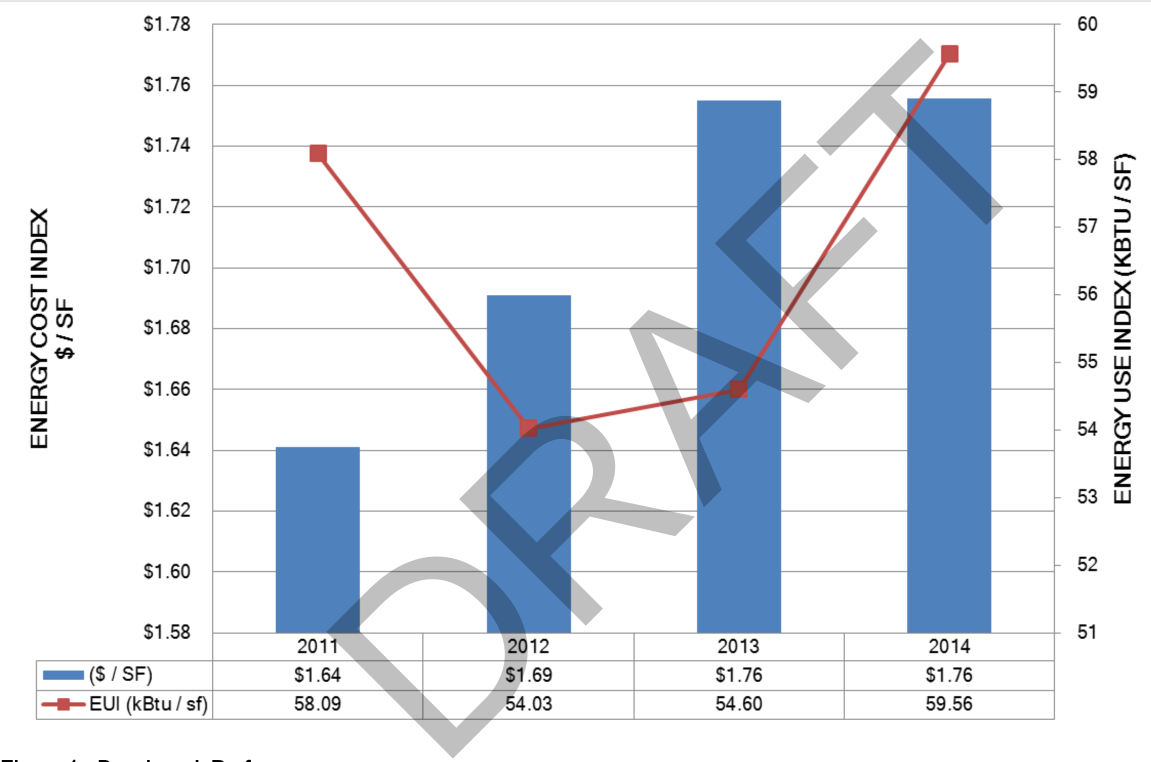


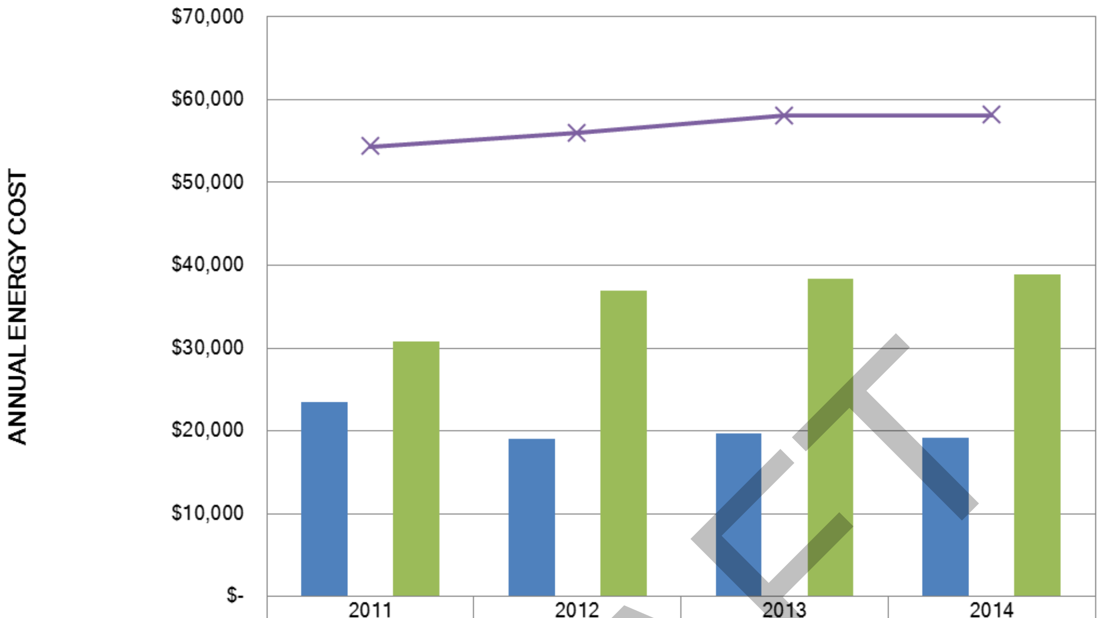
Figure 1 - Benchmark Performance

As seen in Table 4, this school operated above the public school state averages for utility cost per square foot and energy use index from 2011-2014 with the exception of a lower EUI than the average in 2014.

Table 4 - School vs. RI Averages

	2011	2012	2013	2014
School ($ / sf)	$ 1.64	$ 1.69	$ 1.76	$ 1.76
RI Schools Average ($ / sf)	$ 1.36	$ 1.21	$ 1.27	$ 1.38
School EUI (kBtu / sf)	58.09	54.03	54.60	59.56
RI Schools Average EUI	55.02	45.28	48.95	60.97

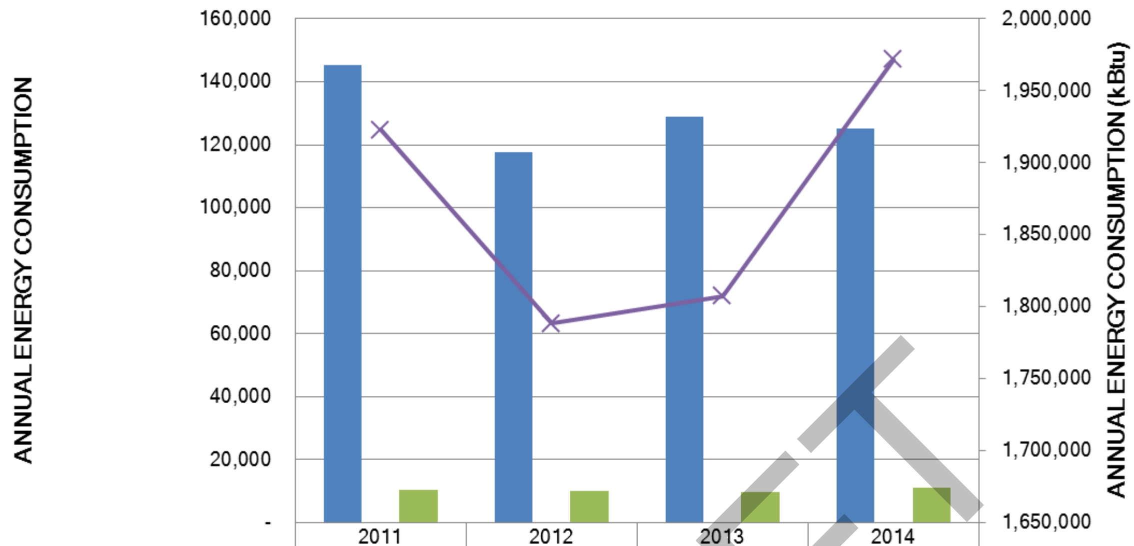
Clayville Elementary School consumed $58,115.55 in electricity and fuel oil to light, heat and satisfy the electrical, HVAC, and plugged loads of the building in 2014. This is up from $54,326.21 in 2011. Figure 2 provides a year to year graphical depiction of energy costs.



	2011	2012	2013	2014
Electricity ($)	$23,511.44	$19,040.00	$19,724.75	$19,215.89
Natural Gas ($)	$-	$-	$-	$-
Fuel Oil ($)	$30,814.77	$36,932.03	$38,373.30	$38,899.66
Total Energy Cost ($)	$54,326.21	$55,972.03	$58,098.05	$58,115.55

Figure 2 - Energy Cost

Figure 3 and Figure 4 profile the energy mix at this school. Electricity consumption fluctuated up and down each year from 2011 to 2014. Fuel oil consumption fell from 2011 to 2013 then increased in 2014. Total energy consumption (kBtu/year) increased by 2.5% from 2011 to 2014.



	2011	2012	2013	2014
Electricity (kWh)	145,132.35	117,530.86	128,919.93	125,103.45
Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	10,271.59	9,981.63	9,839.31	11,114.19
Total Energy Use (kBtu)	1,922,963.18	1,788,478.53	1,807,556.89	1,971,742.95

Figure 3 - Energy Consumption Profile (Commonly Recognized Units of Consumption)

	2011	2012	2013	2014
Electricity (kBtu)	495,212.17	401,032.00	439,893.12	426,870.74
Natural Gas (kBtu)	0.00	0.00	0.00	0.00
No. 2 Fuel Oil (kBtu)	1,427,751.01	1,387,446.53	1,367,663.77	1,544,872.21

Figure 4 - Energy Consumption Profile (kBtu)

Energy Assessment Recommendations

All building systems were evaluated and data collected during the assessment are housed in the condition assessment database. It was determined that energy consumption at this school can be reduced through engineered solutions of the following systems.

Heating

Energy efficiency improvements in the building's heating system can be achieved by implementing a variety of measures, including resetting heating hot water temperature based on the outside air temperature. This can be achieved by installing a networked mechanical room equipment controller to measure outside air temperature and adjust the set point of the heating hot water system to maximize boiler efficiency. The controller can be networked to a central monitoring station for the campus allowing expanded functionality such as alarm monitoring, trending, command and control, remote troubleshooting, service dispatch, scheduling for weekends and holidays, and night time set back.

Programmable thermostats in classrooms, administration offices, and gymnasium and hallway areas can be networked into a building automation system.

Existing lighting occupancy sensors can be used to set back space temperatures when an area has been vacant for 30 minutes or more. This feature can be used to decrease heating when teachers and students are not present at the end of the school day, weekends, and holidays.

Existing pump motors can be replaced with high efficiency motors utilizing "motor-up" efficiency incentives to defer the cost. This will reduce associated power consumption and operating costs.

Radiant panel piping in each room can be modified from series to parallel piping. This will facilitate a more uniform distribution of heat in the rooms. With a radiant panel piped in series, hot water gets progressively cooler as it flows through the radiant pane resulting in colder temperatures toward the back of a room where water enters the return line.

A considerable portion of each classroom's perimeter surface is surrounded by unconditioned space (ceiling, exterior wall, and floor). Because the temperature difference between the conditioned space and the unconditioned space is large, there is a resultant high rate of heat loss. Additional insulation above ceiling tiles and installation of thermal shades improve the R-Value of the ceiling and exterior walls which results in a reduction of heat loss in heating season and solar gain in cooling season.

Cooling

The school does not have a centralized cooling system; however, localized cooling is provided by a condensing unit and window air conditioning units. If additional cooling is necessary, heat pumps and variable refrigerant flow systems with the ability to heat and cool are options to consider in spaces where the cooling load could potentially exceed cooling which natural ventilation can provide. The addition of cooling will increase energy consumption.

Ventilation

Operable windows satisfy the building's requirement for outside air. Pressurizing the building with positive pressure relative to the outside has the potential to:

- Satisfy requirements for outside air in heating season when opening windows can cause cold drafts in occupied spaces.
- Reduce heat being lost through air infiltration at doors, windows, cracks, and crevices in the building envelope.

- Filter and condition outside air being introduced into the building.

Building pressurization can be achieved with multiple dedicated outside air systems (DOAS), providing make up air to the hallways. By design, the DOAS returns and exhausts air from the space. The energy from the returned exhaust air is recovered via an energy recovery wheel and used to heat the incoming outside air. Heating is supplemented with a heat coil when return air does not have enough energy to heat the outside air to achieve set point.

Domestic Water Heating

Domestic hot water is provided by 40-gallon electric water heaters. Domestic hot water is primarily used for hand washing sinks and kitchen cleaning.

Should the school have specific interest, a solar assisted domestic water heater could be installed. The cost effectiveness of a solar assisted water heater is typically below the acceptable threshold and therefore frequently disregarded from consideration. The demand for domestic hot water in the building is relatively low; therefore, a small system is capable of meeting the demands. Such a system reduces the carbon footprint of the building and provides an excellent teaching opportunity for students.

Lighting

Lighting fixtures in the building are predominantly T8 fixtures. Each classroom consumes between 0.95 and 1.12 watts/SF. T8 fluorescent lighting can be cost effectively replaced with LED lamps in the 10-18 watt range to help reduce consumption of electricity. Energy consumption associated with lighting can be reduced by adjusting lighting levels to IESNA Lighting Standards appropriate for space and use.

Building Automation

The school has a building automation system which can be upgraded to improve energy efficiency. These upgrades can achieve the following:

- Provide the capability to reset the heating hot water temperature set point based on outside air temperature and/or classroom temperature (i.e. control to maintain temperature in the coldest classroom).
- Provide capacity and capability to provide for classroom alarm monitoring, trending, command and control, remote troubleshooting, service dispatch, scheduling for weekends, vacancy, holidays, and nighttime or vacancy set back.
- Participation in demand response programs by shedding load when and as needed (i.e. selectively shutting off lights, allowing set points to be reduced, and turning off exhaust fans when the building is vacant).
- Measuring energy (electricity, natural gas, fuel oil, and/or propane) consumption to track usage, report, manage, and reconcile discrepancies, identifying billing errors, or alarm when consumption exceeds benchmark thresholds.

Building Envelope

Energy efficiency can be improved by replacing the roof with a new EPDM reflective white roof and replacing the underlying dense deck with a higher R-Value dense deck. Before replacing the roof, consider the installation of solar photovoltaic panels and associated structural support.

Improving the thermal breaks of the windows or installing internal thermal shade window coverings will reduce heat loss in winter when there is no solar gain and help to control space temperature when there is solar gain.

Extremely long payback periods associated with upgrading these building elements make them less viable as potential energy conservation measures; however, these upgrades or modernizations should be considered during replacement.

Net Zero Action Plan –Opportunity for Implementation of Renewable Energy Technologies

Net Zero Energy Building Certification revolves around the core requirement that "one hundred percent of the site's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion."

To approach Net Zero Energy Building Certification, a Net Zero Action Plan (NZAP) should be developed and used as a road map to this Net Zero destination. To this end, the school and The Rhode Island Department of Education can take preliminary actions to facilitate a Net Zero facility. The primary components are:

- Establish a plan: administration and enforcement
- Establish energy baseline: consumption and source mix
- Reduce energy consumption
- Improve energy efficiency
- Replace combustion energy sources with renewables
- Continuously measure, grade semi-annually, and reward/incentivize good performance and active participation

Electricity is currently provided by National Grid. Net metering is available to electrical consumers in Rhode Island with specific limitations provided by the Rhode Island Public Utilities Commission. Electricity purchased from the grid can be reduced to Net Zero by installing solar photovoltaic (PV) arrays on the school's roof or ground-mounted on school property, and/or by wind powered generators.

An analysis of the roof's structural integrity and capacity to withstand the loading associated with PV arrays would need to be conducted. PV arrays can be ground-mounted and properly oriented to take full advantage of available sunlight (perhaps tracking arrays). Further investigation and analysis will be required to determine the feasibility and cost effectiveness of solar PV and/or wind powered generators.

These systems generate electricity to satisfy a portion of the school's demand for electricity when the sun is shining and the school demands it. Any additional electricity the school needs, that is not being produced by the PV array or wind generator, is purchased from National Grid. When the sun is shining and the school is not demanding all of the power being produced by the PV array or wind generator, that excess power is fed out onto the grid. During the summer months when school is not in session, or the electrical demands are lower, the school can feed its excess electricity generation out to the grid. When properly managed, the amounts of electricity generated on site, consumed from the grid, and generated, but not consumed and fed out to the grid are summed and should net out to zero or near zero.

On site combustion can be replaced with ground sourced heat pumps. Rebates and incentives are currently being offered to assist with the transition to renewables and the elimination of on-site combustion. See Table 5 for a listing of applicable programs and technologies. Each application will be vetted to maximize rebates and incentives and minimize initial and life cycle costs.

Recommended Energy Conservation Measures

Table 5 - Energy Conservation Measures

NO.	RECOMMENDED ENERGY CONSERVATION MEASURES (ECM)	INSTALLED COST ESTIMATE	ESTIMATED ANNUAL SAVINGS ($)	SIMPLE PAYBACK (YRS)
1	Reset Heating Hot Water Based on Outside Air Temperature	$1,000	$1,162	0.9
2	Schedule Boiler Based School Vacancy	$750	$583	1.3
3	Install Building Automation System	$15,000	$389	38.6
4	Network Programmable Classroom Thermostats/Schedule	$3,000	$195	15.4
5	Replace Pneumatic Controls and Associated Compressor with DDC	$1,750	$150	11.7
6	Set Back Space Temperatures Based on Vacancy Using Lighting Occupancy Sensors	$4,000	$292	13.7
7	Upgrade Existing Pump Motors to High Efficiency Units	$19,060	$961	19.8
8	Improve R Values of Exterior Walls, Ceilings and Windows by Supplement with Insulation and Adding Thermal Shades	$44,000	$872	50.5
9	Pressurize Building/Reduce Infiltration with Dedicated Outside Air System (DOAS)	$11,750	$436	27.0
10	Install Solar Assisted Domestic Hot Water Heater	$60,000	$2,000	30.0
11	Re-lamp T8 Fluorescent Bulbs with T14 LEDs	$67,253	$2,882	23.3
	TOTALS	**$227,563**	**$9,922**	**22.9**
	Net Zero Action Plan Measures			
NZ-1	Replace existing HVAC system with Ground Source Heat Pumps	$667,275	$46,989	14.2
NZ-2	Net Meter Electricity Using Solar PV or Wind Power Generator	$350,959	$19,215	18.3

Table 6 - Incentive Programs Available in Rhode Island

	RI - Renewable Energy Fund/Grant Small Scale (up to 25 KW)	RI - Renewable Energy Fund/Grant Commercial Scale (250 KW - 1MW)	RI - Renewable Energy Growth (26-250 KW)	National Grid Energy Efficiency Programs	Net Metering	Rhode Island Renewable Energy Fund (RIREF)
Solar Photovoltaic	●	●	●		●	●
Solar Domestic Hot Water Heater	●					●
On Sight Wind Generator	●	●	●		●	●
Ground Source Heat Pump				●		●
Hydro-Electric			●		●	●
Tidal Energy					●	●
Wave			●		●	●
Ocean Thermal						●
Fuel Cells w/Renewable Fuels						●
Custom Programs				●		●

Energy Assessment Report

Hope Elementary School | *DRAFT October 2016*

391 North Road, Hope, RI 02831

Summary of Findings

On behalf of the School Building Authority at Rhode Island Department of Education (RIDE), Jacobs recently completed a comprehensive energy assessment of the public schools in Rhode Island. This assessment was completed to develop recommendations for improving energy efficiency, benchmark each facility against other like facilities, and assess the feasibility of using renewable energy technologies. Results from the analysis for Hope Elementary School are summarized in this document.

Heat is provided by a combined central heating plant comprised of water boilers and a steam boiler. Steam is converted to hot water via a heat exchanger and the heating medium is recirculated throughout the building to terminal heating equipment. Lighting is predominantly provided by T8 fluorescent lighting fixtures.

A number of energy efficiency opportunities with varying payback periods were identified during the assessment. Based on an estimated energy cost of $0.15/kWh, energy cost savings of approximately $9,545/year are possible through measures that have an average payback period of 33.8 years and represent approximately 14% savings in energy cost.

The school has potential to implement renewable energy projects and qualify for Net Zero certification. Electricity purchased from the grid can be reduced to "Net Zero" by installing a solar photovoltaic (PV) array on the school's roof or ground-mounted on school property. On site combustion can be eliminated by replacing the existing boilers with a ground sourced heat pump system. The costs for these systems are:

- 86 kW Solar PV - $342,750 (18.3 year simple payback after incentive)
- 289-ton ground sourced heat pump system - $940,695 (15.2 year simple payback after incentive)

National Grid has attractive renewable energy growth programs which are dependent upon the size of the renewable power system and the ownership arrangement (host vs. third party owner). Incentive programs available in Rhode Island are presented in Table 6.

Benchmark Utility Data Analysis

Table 1 below presents key utility data consumption and associated benchmarks. This data has not been normalized for weather, however degree day data for the period of this assessment is provided in Table 3.

Table 1 - Key Utility Data Consumption Benchmarks

	2011	2012	2013	2014
Electricity ($)	$ 21,775.97	$ 16,970.80	$ 18,142.57	$ 18,765.56
Natural Gas ($)	-	-	-	-
Fuel Oil ($)	$ 44,507.22	$ 44,314.56	$ 49,693.22	$ 49,269.01
Total Energy Cost ($)	**$ 66,283.19**	**$ 61,285.36**	**$ 67,835.79**	**$ 68,034.57**
Electricity (kWh)	134,419.57	104,758.02	118,578.89	122,171.61
Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	14,835.74	11,976.91	12,741.85	14,076.86
Total Energy Use (kBtu)	2,520,826.51	2,022,239.48	2,175,725.34	2,373,550.44
($ / SF)	$ 1.60	$ 1.48	$ 1.64	$ 1.64
EUI (kBtu / sf)	60.86	48.82	52.53	57.30

Energy consumption was approximated using cost data publically available on the Rhode Island Department of Education website in the Uniform Chart of Accounts. These assumptions are provided in Table 2.

Table 2 - Energy Cost Assumptions

	2011	2012	2013	2014
Electricity ($ / kWh)	$ 0.16	$ 0.15	$ 0.15	$ 0.15
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Table 3 indicates a 15.5% increase in heating degree days in 2014 compared to 2013. Resetting the heating hot water temperature set point based on outside air temperature will help to reduce energy consumption.

Table 3 - Heating and Cooling Degree Data

	2011	2012	2013	2014
Heating Degree Days (Base 65 Deg. F)	5,046	5,317	4,807	5,554
Cooling Degree Days (Base 65 Deg. F)	1,068	921	838	894
Growing Degree Days (Base 50 Deg. F)	3,446	3,203	3,160	3,128

Energy Use

During the study period the school consumed the following energy types:

- Electricity
- Fuel Oil

Figure 1 presented below shows the site energy use index (EUI) for Hope Elementary School since 2011. The cost/SF increased by 2.5% from 2011 to 2014 with the EUI dropping significantly from 2011 to 2012 then increasing to 2014. This data has not been normalized for weather and therefore reflects energy consumption dependent on heating and cooling degree days (see Table 3) and is intended to be used for comparison of schools within the weather region only.

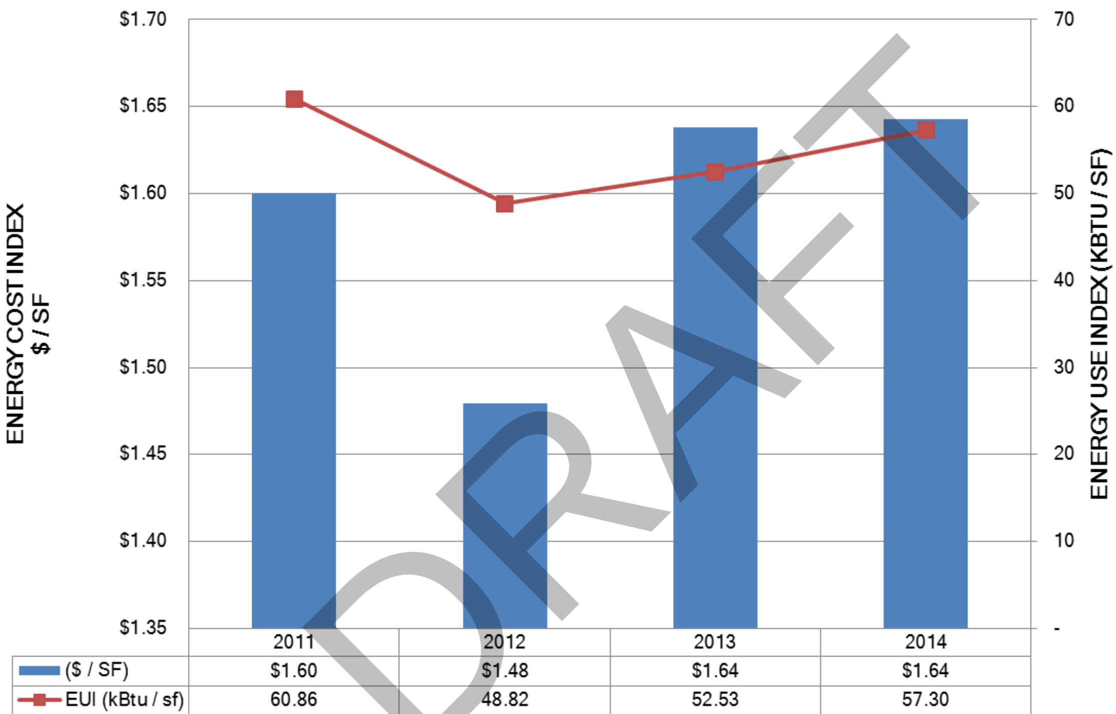


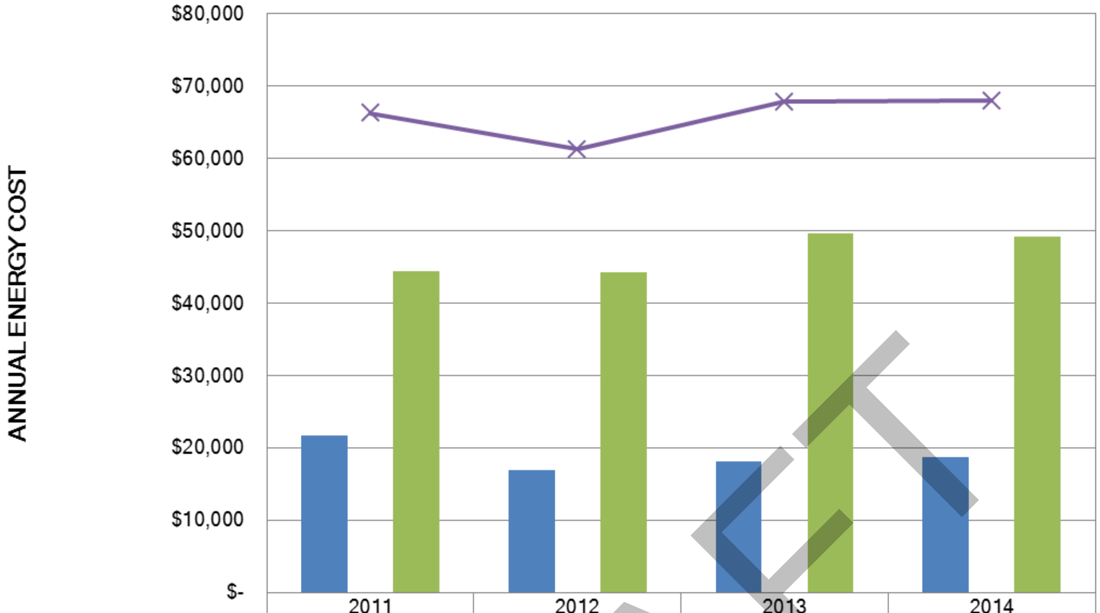
Figure 1 - Benchmark Performance

As seen in Table 4, this school operated above the public school state averages for utility cost per square foot and energy use index from 2011-2014 with the exception of a lower EUI than the average in 2014.

Table 4 - School vs. RI Averages

	2011	2012	2013	2014
School ($ / sf)	$ 1.60	$ 1.48	$ 1.64	$ 1.64
RI Schools Average ($ / sf)	$ 1.36	$ 1.21	$ 1.27	$ 1.38
School EUI (kBtu / sf)	60.86	48.82	52.53	57.30
RI Schools Average EUI	55.02	45.28	48.95	60.97

Hope Elementary School consumed $68,034.57 in electricity and fuel oil to light, heat and satisfy the electrical, HVAC, and plugged loads of the building in 2014. This is up from $66,283.19 in 2011. Figure 2 provides a year to year graphical depiction of energy costs.



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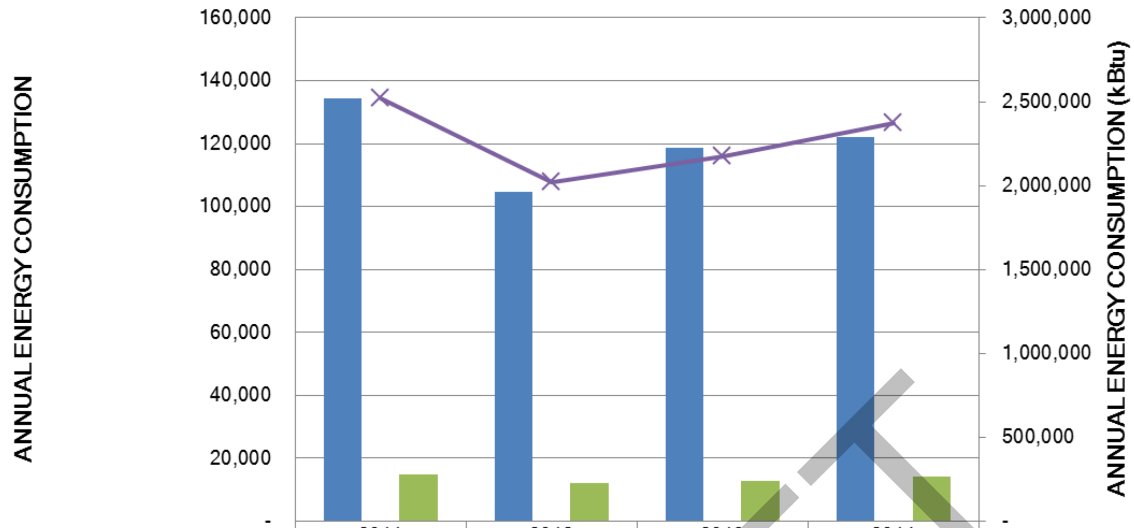
Natural Gas ($)	$-	$-	$-	$-
Fuel Oil ($)	$44,507.22	$44,314.56	$49,693.22	$49,269.01
Total Energy Cost ($)	$66,283.19	$61,285.36	$67,835.79	$68,034.57

Figure 2 - Energy Cost

Figure 3 and Figure 4 profile the energy mix at this school. Electricity and fuel oil consumption decreased from 2011 to 2012 then rose through 2014. Total energy consumption (kBtu/year) decreased by 5.8% since 2011.



	2011	2012	2013	2014
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Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	14,835.74	11,976.91	12,741.85	14,076.86
Total Energy Use (kBtu)	2,520,826.51	2,022,239.48	2,175,725.34	2,373,550.44

Figure 3 - Energy Consumption Profile (Commonly Recognized Units of Consumption)

	2011	2012	2013	2014
Electricity (kBtu)	458,658.65	357,449.26	404,608.01	416,866.90
Natural Gas (kBtu)	0.00	0.00	0.00	0.00
No. 2 Fuel Oil (kBtu)	2,062,167.86	1,664,790.23	1,771,117.33	1,956,683.54

Figure 4 - Energy Consumption Profile (kBtu)

Energy Assessment Recommendations

All building systems were evaluated and data collected during the assessment are housed in the condition assessment database. It was determined that energy consumption at this school can be reduced through engineered solutions of the following systems.

Heating

Energy efficiency improvements in the building's heating system can be achieved by implementing a variety of measures, including resetting heating hot water temperature based on the outside air temperature. This can be achieved by installing a networked mechanical room equipment controller to measure outside air temperature and adjust the set point of the heating hot water system to maximize boiler efficiency. The controller can be networked to a central monitoring station for the campus allowing expanded functionality such as alarm monitoring, trending, command and control, remote troubleshooting, service dispatch, scheduling for weekends and holidays, and night time set back.

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Lighting occupancy sensors can be used to set back space temperatures when an area has been vacant for 30 minutes or more. This feature can be used to decrease heating when teachers and students are not present at the end of the school day, weekends, and holidays.

Existing pump motors can be replaced with high efficiency motors utilizing "motor-up" energy efficiency incentives to defer the cost. This will reduce associated power consumption and operating costs.

Radiant panel piping in each room can be modified from series to parallel piping. This will facilitate a more uniform distribution of heat in the rooms. With a radiant panel piped in series, hot water gets progressively cooler as it flows through the radiant panel resulting in colder temperatures toward the back of a room where water enters the return line.

A considerable portion of each classroom's perimeter surface is surrounded by unconditioned space (ceiling, exterior wall, and floor). Because the temperature difference between the conditioned space and the unconditioned space is large, there is a resultant high rate of heat loss. Additional insulation above ceiling tiles and installation of thermal shades improve the R-Value of the ceiling and exterior walls which results in a reduction of heat loss in heating season and solar gain in cooling season.

Cooling

The school does not have a centralized cooling system; however, localized cooling is provided by window air condition units. If additional cooling is necessary, heat pumps and variable refrigerant flow systems with the ability to heat and cool are options to consider in spaces where the cooling load could potentially exceed cooling which natural ventilation can provide. The addition of cooling will increase energy consumption.

Ventilation

Operable windows satisfy the building's requirement for outside air. Pressurizing the building with positive pressure relative to the outside has the potential to:

- Satisfy requirements for outside air in heating season when opening windows can cause cold drafts in occupied spaces.
- Reduce heat being lost through air infiltration at doors, windows, cracks, and crevices in the building envelope.

- Filter and condition outside air being introduced into the building.

Building pressurization can be achieved with multiple dedicated outside air systems (DOAS), providing make up air to the hallways. By design, the DOAS returns and exhausts air from the space. The energy from the returned exhaust air is recovered via an energy recovery wheel and used to heat the incoming outside air. Heating is supplemented with a heat coil when return air does not have enough energy to heat the outside air to achieve set point.

Domestic Water Heating

Domestic hot water is provided by a 40-gallon electric water heater. Domestic hot water is primarily used for hand washing sinks and kitchen cleaning.

Should the school have specific interest, a solar assisted domestic water heater could be installed. The cost effectiveness of a solar assisted water heater is typically below the acceptable threshold and therefore frequently disregarded from consideration. The demand for domestic hot water in the building is relatively low; therefore, a small system, or an “on-demand” system is capable of meeting the demands. Such a system reduces the carbon footprint of the building and provides an excellent teaching opportunity for students.

Lighting

Lighting fixtures in the building are predominantly T8 fixtures. Each classroom consumes between 0.95 and 1.12 watts/SF. T8 fluorescent lighting can be cost effectively replaced with LED lamps in the 10-18 watt range to help reduce consumption of electricity. Energy consumption associated with lighting can be reduced by adjusting lighting levels to IESNA Lighting Standards appropriate for space and use.

Building Automation

The school does not have a building automation system. Installing one can improve energy efficiency and achieve the following:

- Provide the capability to reset the heating hot water temperature set point based on outside air temperature and/or classroom temperature (i.e. control to maintain temperature in the coldest classroom).
- Provide capacity and capability to provide for classroom alarm monitoring, trending, command and control, remote troubleshooting, service dispatch, scheduling for weekends, vacancy, holidays, and nighttime or vacancy set back.
- Participation in demand response programs by shedding load when and as needed (i.e. selectively shutting off lights, allowing set points to be reduced, and turning off exhaust fans when the building is vacant).
- Measuring energy (electricity, natural gas, fuel oil, and/or propane) consumption to track usage, report, manage, and reconcile discrepancies, identifying billing errors, or alarm when consumption exceeds benchmark thresholds.

Building Envelope

Energy efficiency can be improved by replacing the roof with a new EPDM reflective white roof and replacing the underlying dense deck with a higher R-Value dense deck. Before replacing the roof, consider the installation of solar photovoltaic panels and associated structural support.

Improving the thermal breaks of the windows or installing internal thermal shade window coverings will reduce heat loss in winter when there is no solar gain and help to control space temperature when there is solar gain.

Extremely long payback periods associated with upgrading these building elements make them less viable as potential energy conservation measures; however, these upgrades or modernizations should be considered during replacement.

Net Zero Action Plan –Opportunity for Implementation of Renewable Energy Technologies

Net Zero Energy Building Certification revolves around the core requirement that "one hundred percent of the site's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion."

To approach Net Zero Energy Building Certification, a Net Zero Action Plan (NZAP) should be developed and used as a road map to this Net Zero destination. To this end, the school and The Rhode Island Department of Education can take preliminary actions to facilitate a Net Zero facility. The primary components are:

- Establish a plan: administration and enforcement
- Establish energy baseline: consumption and source mix
- Reduce energy consumption
- Improve energy efficiency
- Replace combustion energy sources with renewables
- Continuously measure, grade semi-annually, and reward/incentivize good performance and active participation

Electricity is currently provided by National Grid. Net metering is available to electrical consumers in Rhode Island with specific limitations provided by the Rhode Island Public Utilities Commission. Electricity purchased from the grid can be reduced to Net Zero by installing solar photovoltaic (PV) arrays on the school's roof or ground-mounted on school property, and/or by wind powered generators.

An analysis of the roof's structural integrity and capacity to withstand the loading associated with PV arrays would need to be conducted. PV arrays can be ground-mounted and properly oriented to take full advantage of available sunlight (perhaps tracking arrays). Further investigation and analysis will be required to determine the feasibility and cost effectiveness of solar PV and/or wind powered generators.

These systems generate electricity to satisfy a portion of the school's demand for electricity when the sun is shining and the school demands it. Any additional electricity the school needs, that is not being produced by the PV array or wind generator, is purchased from National Grid. When the sun is shining and the school is not demanding all of the power being produced by the PV array or wind generator, that excess power is fed out onto the grid. During the summer months when school is not in session, or the electrical demands are lower, the school can feed its excess electricity generation out to the grid. When properly managed, the amounts of electricity generated on site, consumed from the grid, and generated, but not consumed and fed out to the grid are summed and should net out to zero or near zero.

On site combustion can be replaced with ground sourced heat pumps. Rebates and incentives are currently being offered to assist with the transition to renewables and the elimination of on-site combustion. See Table 5 for a listing of applicable programs and technologies. Each application will be vetted to maximize rebates and incentives and minimize initial and life cycle costs.

Recommended Energy Conservation Measures

Table 5 - Energy Conservation Measures

NO.	RECOMMENDED ENERGY CONSERVATION MEASURES (ECM)	INSTALLED COST ESTIMATE	ESTIMATED ANNUAL SAVINGS ($)	SIMPLE PAYBACK (YRS)
1	Reset Heating Hot Water Based on Outside Air Temperature	$1,000	$1,361	0.7
2	Schedule Boiler Based School Vacancy	$750	$739	1.0
3	Install Building Automation System	$15,000	$493	30.4
4	Network Programmable Classroom Thermostats/Schedule	$3,000	$246	12.2
5	Replace Pneumatic Controls and Associated Compressor with DDC	$1,750	$150	11.7
6	Set Back Space Temperatures Based on Vacancy Using Lighting Occupancy Sensors	$4,000	$370	10.8
7	Upgrade Existing Pump Motors to High Efficiency Units	$68,656	$938	73.2
8	Pressurize Building/Reduce Infiltration with Dedicated Outside Air System (DOAS)	$23,500	$510	46.1
9	Install Solar Assisted Domestic Hot Water Heater	$60,000	$985	60.9
10	Re-lamp T8 Fluorescent Bulbs with T14 LEDs	$144,970	$3,753	38.6
	TOTALS	**$322,626**	**$9,545**	**33.8**
Net Zero Action Plan Measures				
NZ-1	Replace existing HVAC system with Ground Source Heat Pumps	$940,695	$62,080	15.2
NZ-2	Net Meter Electricity Using Solar PV or Wind Power Generator	$342,750	$18,766	18.3

Table 6 - Incentive Programs Available in Rhode Island

	RI - Renewable Energy Fund/Grant Small Scale (up to 25 KW)	RI - Renewable Energy Fund/Grant Commercial Scale (250 KW - 1MW)	RI - Renewable Energy Growth (26-250 KW)	National Grid Energy Efficiency Programs	Net Metering	Rhode Island Renewable Energy Fund (RIREF)
Solar Photovoltaic	●	●	●		●	●
Solar Domestic Hot Water Heater	●					●
On Sight Wind Generator	●	●	●		●	●
Ground Source Heat Pump				●		●
Hydro-Electric			●		●	●
Tidal Energy					●	●
Wave			●		●	●
Ocean Thermal						●
Fuel Cells w/Renewable Fuels						●
Custom Programs				●		●

Energy Assessment Report

North Scituate Elementary School | *DRAFT October 2016*

46 Institute Lane, North Scituate, RI 02857

Summary of Findings

On behalf of the School Building Authority at Rhode Island Department of Education (RIDE), Jacobs recently completed a comprehensive energy assessment of the public schools in Rhode Island. This assessment was completed to develop recommendations for improving energy efficiency, benchmark each facility against other like facilities, and assess the feasibility of using renewable energy technologies. Results from the analysis for North Scituate Elementary School are summarized in this document.

Heat is provided by hot water boilers pumping heated water through perimeter mounted terminal heating equipment. Lighting is predominantly provided by T8 fluorescent fixtures.

A number of energy efficiency opportunities with varying payback periods were identified during the assessment. Based on an estimated energy cost of $0.15/kWh, energy cost savings of approximately $12,683/year are possible through measures that have an average payback period of 26.4 years and represent approximately 14% savings in energy cost.

The school has potential to implement renewable energy projects and qualify for Net Zero certification. Electricity purchased from the grid can be reduced to “Net Zero” by installing a solar photovoltaic (PV) array on the school’s roof or ground-mounted on school property. On site combustion can be eliminated by replacing the existing boilers with a ground sourced heat pump system. The costs for these systems are:

- 147 kW Solar PV - $588,740 (18.3 year simple payback after incentive)
- 251-ton ground sourced heat pump system - $817,005 (11.0 year simple payback after incentive)

National Grid has attractive renewable energy growth programs which are dependent upon the size of the renewable power system and the ownership arrangement (host vs. third party owner). Incentive programs available in Rhode Island are presented in Table 6.

Benchmark Utility Data Analysis

Table 1 below presents key utility data consumption and associated benchmarks. This data has not been normalized for weather, however degree day data for the period of this assessment is provided in Table 3.

Table 1 - Key Utility Data Consumption Benchmarks

	2011	2012	2013	2014
Electricity ($)	$ 37,609.45	$ 31,262.38	$ 30,427.04	$ 32,233.49
Natural Gas ($)	-	-	-	-
Fuel Oil ($)	$ 56,008.20	$ 63,709.37	$ 67,841.15	$ 58,868.24
Total Energy Cost ($)	**$ 93,617.65**	**$ 94,971.75**	**$ 98,268.19**	**$ 91,101.73**
Electricity (kWh)	232,157.10	192,977.65	198,869.54	209,853.45
Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	18,669.40	17,218.75	17,395.17	16,819.50
Total Energy Use (kBtu)	3,387,199.59	3,051,873.22	3,096,499.29	3,053,959.88
($ / SF)	$ 2.31	$ 2.34	$ 2.42	$ 2.25
EUI (kBtu / sf)	83.56	75.29	76.39	75.34

Energy consumption was approximated using cost data publically available on the Rhode Island Department of Education website in the Uniform Chart of Accounts. These assumptions are provided in Table 2.

Table 2 - Energy Cost Assumptions

	2011	2012	2013	2014
Electricity ($ / kWh)	$ 0.16	$ 0.15	$ 0.15	$ 0.15
Natural Gas ($ / Therm)	$ 1.33	$ 1.23	$ 1.24	$ 1.29
No. 2 Heating Oil ($ / Gal)	$ 3.70	$ 3.90	$ 3.90	$ 3.50
Propane ($ / Gal)	$ 3.87	$ 3.80	$ 3.50	$ 4.50

Table 3 indicates a 15.5% increase in heating degree days in 2014 compared to 2013. Resetting the heating hot water temperature set point based on outside air temperature will help to reduce energy consumption.

Table 3 - Heating and Cooling Degree Data

	2011	2012	2013	2014
Heating Degree Days (Base 65 Deg. F)	5,046	5,317	4,807	5,554
Cooling Degree Days (Base 65 Deg. F)	1,068	921	838	894
Growing Degree Days (Base 50 Deg. F)	3,446	3,203	3,160	3,128

Energy Use

During the study period the school consumed the following energy types:

- Electricity
- Fuel Oil

Figure 1 presented below shows the site energy use index (EUI) for North Scituate Elementary School since 2011. The cost/SF decreased by 2.6% from 2011 to 2014 with the EUI fluctuating up and down year to year during the study period. This data has not been normalized for weather and therefore reflects energy consumption dependent on heating and cooling degree days (see Table 3) and is intended to be used for comparison of schools within the weather region only.

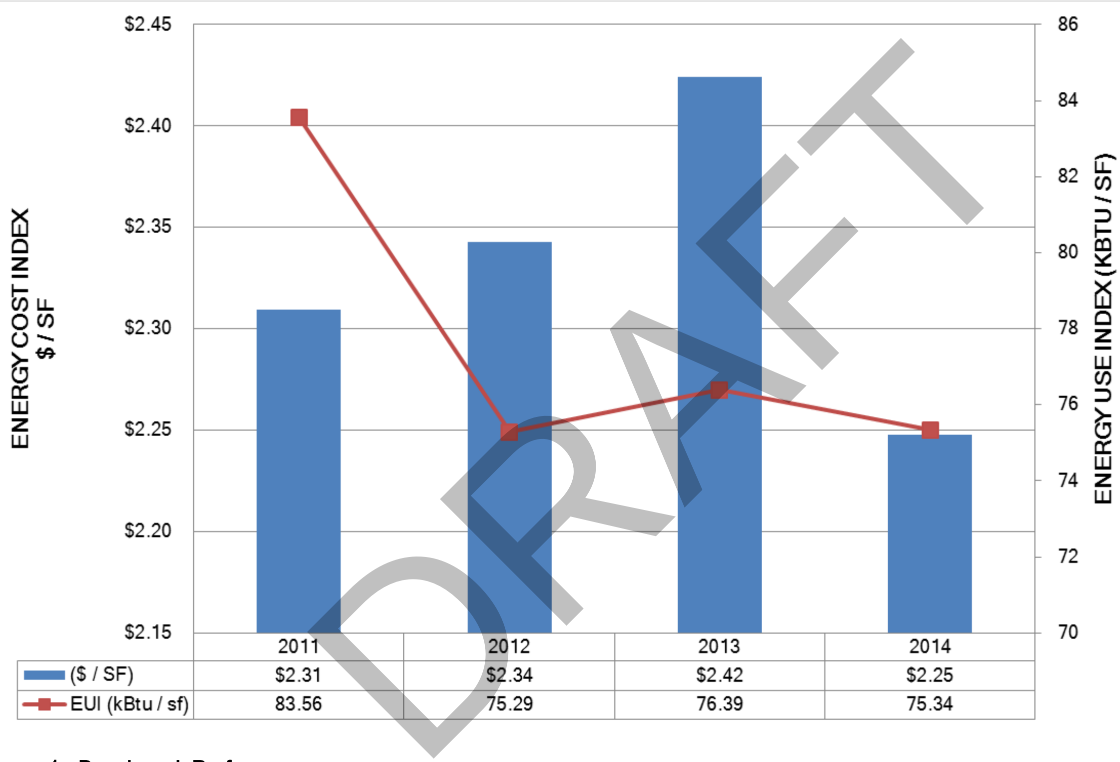


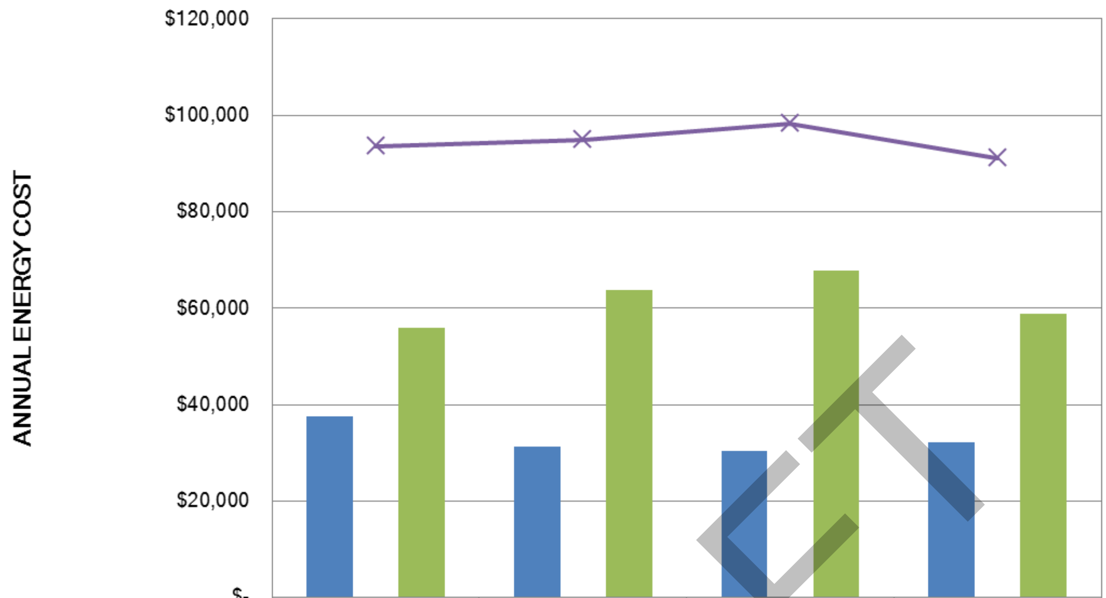
Figure 1 - Benchmark Performance

As seen in Table 4, this school operated above the public school state averages for utility cost per square foot and energy use index from 2011-2014.

Table 4 - School vs. RI Averages

	2011	2012	2013	2014
School ($ / sf)	$ 2.31	$ 2.34	$ 2.42	$ 2.25
RI Schools Average ($ / sf)	$ 1.36	$ 1.21	$ 1.27	$ 1.38
School EUI (kBtu / sf)	83.56	75.29	76.39	75.34
RI Schools Average EUI	55.02	45.28	48.95	60.97

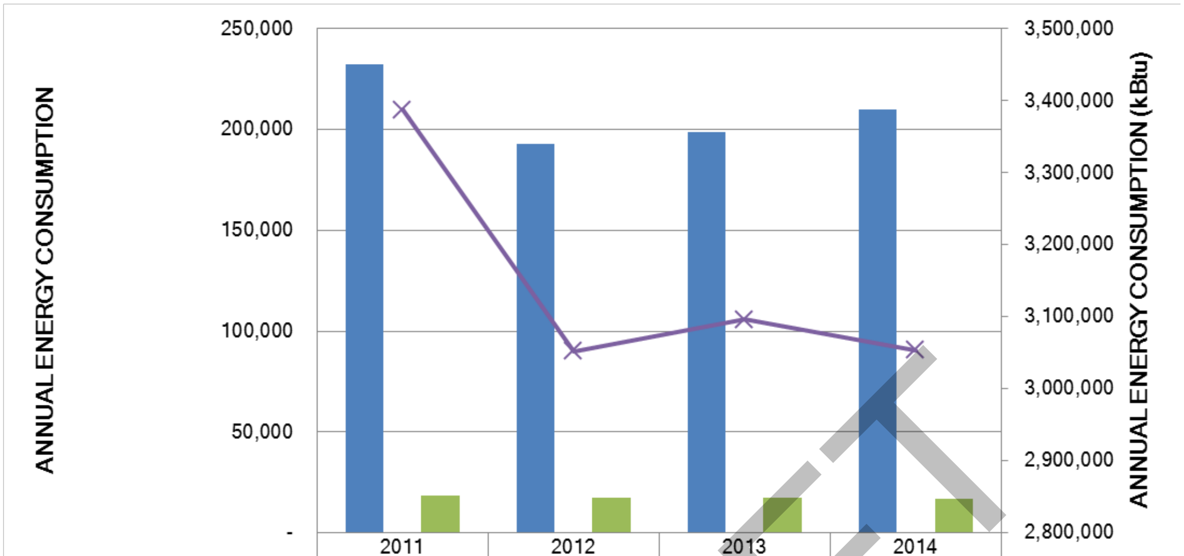
North Scituate Elementary School consumed $91,101.73 in electricity and fuel oil to light, heat and satisfy the electrical, HVAC, and plugged loads of the building in 2014. This is down from $93,617.65 in 2011. Figure 2 provides a year to year graphical depiction of energy costs.



	2011	2012	2013	2014
Electricity ($)	$37,609.45	$31,262.38	$30,427.04	$32,233.49
Natural Gas ($)	$-	$-	$-	$-
Fuel Oil ($)	$56,008.20	$63,709.37	$67,841.15	$58,868.24
Total Energy Cost ($)	$93,617.65	$94,971.75	$98,268.19	$91,101.73

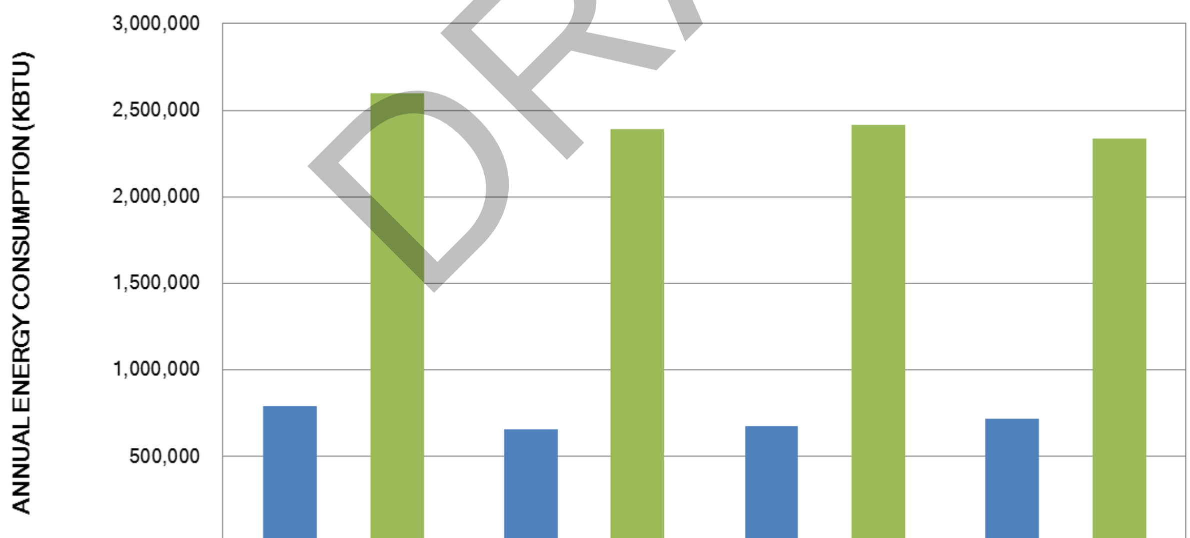
Figure 2 - Energy Cost

Figure 3 and Figure 4 profile the energy mix at this school. Electricity consumption decreased by 16.9% from 2011 to 2012 then steadily increased through 2014. Fuel oil consumption fluctuated up and down yearly during this time period. Total energy consumption (kBtu/year) decreased by 9.8% from 2011 to 2014.



	2011	2012	2013	2014
Electricity (kWh)	232,157.10	192,977.65	198,869.54	209,853.45
Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	18,669.40	17,218.75	17,395.17	16,819.50
Total Energy Use (kBtu)	3,387,199.59	3,051,873.22	3,096,499.29	3,053,959.88

Figure 3 - Energy Consumption Profile (Commonly Recognized Units of Consumption)



	2011	2012	2013	2014
Electricity (kBtu)	792,152.99	658,467.16	678,571.12	716,049.77
Natural Gas (kBtu)	0.00	0.00	0.00	0.00
No. 2 Fuel Oil (kBtu)	2,595,046.60	2,393,406.06	2,417,928.17	2,337,910.10

Figure 4 - Energy Consumption Profile (kBtu)

Energy Assessment Recommendations

All building systems were evaluated and data collected during the assessment are housed in the condition assessment database. It was determined that energy consumption at this school can be reduced through engineered solutions of the following systems.

Heating

Energy efficiency improvements in the building's heating system can be achieved by implementing a variety of measures, including resetting heating hot water temperature based on the outside air temperature. This can be achieved by installing a networked mechanical room equipment controller to measure outside air temperature and adjust the set point of the heating hot water system to maximize boiler efficiency. The controller can be networked to a central monitoring station for the campus allowing expanded functionality such as alarm monitoring, trending, command and control, remote troubleshooting, service dispatch, scheduling for weekends and holidays, and night time set back.

Programmable thermostats in classrooms, administration offices, and gymnasium and hallway areas can be networked into a building automation system.

Existing lighting occupancy sensors can be used to set back space temperatures when an area has been vacant for 30 minutes or more. This feature can be used to decrease heating when teachers and students are not present at the end of the school day, weekends, and holidays.

Radiant panel piping in each room can be modified from series to parallel piping. This will facilitate a more uniform distribution of heat in the rooms. With a radiant panel piped in series, hot water gets progressively cooler as it flows through the radiant panel resulting in colder temperatures where the water enters the return line.

A considerable portion of each classroom's perimeter surface is surrounded by unconditioned space (ceiling, exterior wall, and floor). Because the temperature difference between the conditioned space and the unconditioned space is large, there is a resultant high rate of heat loss. Additional insulation above ceiling tiles and installation of thermal shades improve the R-Value of the ceiling and exterior walls which results in a reduction of heat loss in heating season and solar gain in cooling season.

Cooling

The school does not have a central cooling system. The building is equipped with rooftop cooling units that serve administrative spaces. If additional cooling is necessary, heat pumps and variable refrigerant flow systems with the ability to heat and cool are options to consider in spaces where the cooling load could potentially exceed cooling which natural ventilation can provide.

Ventilation

Operable windows satisfy the building's requirement for outside air. Pressurizing the building with positive pressure relative to the outside has the potential to:

- Satisfy requirements for outside air in heating season when opening windows can cause cold drafts in occupied spaces.
- Reduce heat being lost through air infiltration at doors, windows, cracks, and crevices in the building envelope.
- Filter and condition outside air being introduced into the building.

Building pressurization can be achieved with multiple dedicated outside air systems (DOAS), providing make up air to the hallways. By design, the DOAS returns and exhausts air from the space. The energy from the returned exhaust air is recovered via an energy recovery wheel and used to heat the incoming outside air. Heating is supplemented with a heat coil when return air does not have enough energy to heat the outside air to achieve set point.

Domestic Water Heating

Domestic hot water is provided by an 80-gallon electric water heater. Domestic hot water is primarily used for hand washing sinks and kitchen cleaning.

Should the school have specific interest, a solar assisted domestic water heater could be installed. The cost effectiveness of a solar assisted water heater is typically below the acceptable threshold and therefore frequently disregarded from consideration. The demand for domestic hot water in the building is relatively low; therefore, a small system is capable of meeting the demands. Such a system reduces the carbon footprint of the building and provides an excellent teaching opportunity for students.

Lighting

Lighting fixtures in the building are predominantly T8 fixtures. Each classroom consumes between 0.95 and 1.12 watts/SF. T8 fluorescent lighting can be cost effectively replaced with LED lamps in the 10-18 watt range to help reduce consumption of electricity. Energy consumption associated with lighting can be reduced by adjusting lighting levels to IESNA Lighting Standards appropriate for space and use.

Building Automation

The school has a building automation system which can be upgraded to improve energy efficiency. These upgrades can achieve the following:

- Provide the capability to reset the heating hot water temperature set point based on outside air temperature and/or classroom temperature (i.e. control to maintain temperature in the coldest classroom).
- Provide capacity and capability to provide for classroom alarm monitoring, trending, command and control, remote troubleshooting, service dispatch, scheduling for weekends, vacancy, holidays, and nighttime or vacancy set back.
- Participation in demand response programs by shedding load when and as needed (i.e. selectively shutting off lights, allowing set points to be reduced, and turning off exhaust fans when the building is vacant).
- Measuring energy (electricity, natural gas, fuel oil, and/or propane) consumption to track usage, report, manage, and reconcile discrepancies, identifying billing errors, or alarm when consumption exceeds benchmark thresholds.

Building Envelope

Energy efficiency can be improved by replacing the roof with a new EPDM reflective white roof and replacing the underlying dense deck with a higher R-Value dense deck. Before replacing the roof, consider the installation of solar photovoltaic panels and associated structural support.

Improving the thermal breaks of the windows or installing internal thermal shade window coverings will reduce heat loss in winter when there is no solar gain and help to control space temperature when there is solar gain.

Extremely long payback periods associated with upgrading these building elements make them less viable as potential energy conservation measures; however, these upgrades or modernizations should be considered during replacement.

Net Zero Action Plan –Opportunity for Implementation of Renewable Energy Technologies

Net Zero Energy Building Certification revolves around the core requirement that "one hundred percent of the site's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion."

To approach Net Zero Energy Building Certification, a Net Zero Action Plan (NZAP) should be developed and used as a road map to this Net Zero destination. To this end, the school and The Rhode Island Department of Education can take preliminary actions to facilitate a Net Zero facility. The primary components are:

- Establish a plan: administration and enforcement
- Establish energy baseline: consumption and source mix
- Reduce energy consumption
- Improve energy efficiency
- Replace combustion energy sources with renewables
- Continuously measure, grade semi-annually, and reward/incentivize good performance and active participation

Electricity is currently provided by National Grid. Net metering is available to electrical consumers in Rhode Island with specific limitations provided by the Rhode Island Public Utilities Commission. Electricity purchased from the grid can be reduced to Net Zero by installing solar photovoltaic (PV) arrays on the school's roof or ground-mounted on school property, and/or by wind powered generators.

An analysis of the roof's structural integrity and capacity to withstand the loading associated with PV arrays would need to be conducted. PV arrays can be ground-mounted and properly oriented to take full advantage of available sunlight (perhaps tracking arrays). Further investigation and analysis will be required to determine the feasibility and cost effectiveness of solar PV and/or wind powered generators.

These systems generate electricity to satisfy a portion of the school's demand for electricity when the sun is shining and the school demands it. Any additional electricity the school needs, that is not being produced by the PV array or wind generator, is purchased from National Grid. When the sun is shining and the school is not demanding all of the power being produced by the PV array or wind generator, that excess power is fed out onto the grid. During the summer months when school is not in session, or the electrical demands are lower, the school can feed its excess electricity generation out to the grid. When properly managed, the amounts of electricity generated on site, consumed from the grid, and generated, but not consumed and fed out to the grid are summed and should net out to zero or near zero.

On site combustion can be replaced with ground sourced heat pumps. Rebates and incentives are currently being offered to assist with the transition to renewables and the elimination of on-site combustion. See Table 5 for a listing of applicable programs and technologies. Each application will be vetted to maximize rebates and incentives and minimize initial and life cycle costs.

Recommended Energy Conservation Measures

Table 5 - Energy Conservation Measures

NO.	RECOMMENDED ENERGY CONSERVATION MEASURES (ECM)	INSTALLED COST ESTIMATE	ESTIMATED ANNUAL SAVINGS ($)	SIMPLE PAYBACK (YRS)
1	Reset Heating Hot Water Based on Outside Air Temperature	$1,000	$1,822	0.5
2	Schedule Boiler Based School Vacancy	$750	$883	0.8
3	Install Building Automation System	$15,000	$589	25.5
4	Network Programmable Classroom Thermostats/Schedule	$3,000	$294	10.2
5	Replace Pneumatic Controls and Associated Compressor with DDC	$1,750	$150	11.7
6	Set Back Space Temperatures Based on Vacancy Using Lighting Occupancy Sensors	$4,000	$442	9.1
7	Re-Pipe Radiators, Unit Ventilators, and/or Fan Coil Units in Parallel vs. Current Series Configuration	$40,000	$442	90.6
8	Improve R Values of Exterior Walls, Ceilings and Windows by Supplement with Insulation and Adding Thermal Shades	$44,000	$1,367	32.2
9	Pressurize Building/Reduce Infiltration with Dedicated Outside Air System (DOAS)	$23,500	$683	34.4
10	Install Solar Assisted Domestic Hot Water Heater	$60,000	$1,177	51.0
11	Re-lamp T8 Fluorescent Bulbs with T14 LEDs	$141,873	$4,835	29.3
	TOTALS	**$334,873**	**$12,683**	**26.4**
	Net Zero Action Plan Measures			
NZ-1	Replace existing HVAC system with Ground Source Heat Pumps	$817,005	$74,231	11.0
NZ-2	Net Meter Electricity Using Solar PV or Wind Power Generator	$588,740	$32,233	18.3

Table 6 - Incentive Programs Available in Rhode Island

	RI - Renewable Energy Fund/Grant Small Scale (up to 25 KW)	RI - Renewable Energy Fund/Grant Commercial Scale (250 KW - 1MW)	RI - Renewable Energy Growth (26-250 KW)	National Grid Energy Efficiency Programs	Net Metering	Rhode Island Renewable Energy Fund (RIREF)
Solar Photovoltaic	●	●	●		●	●
Solar Domestic Hot Water Heater	●					●
On Sight Wind Generator	●	●	●		●	●
Ground Source Heat Pump				●		●
Hydro-Electric			●		●	●
Tidal Energy					●	●
Wave			●		●	●
Ocean Thermal						●
Fuel Cells w/Renewable Fuels						●
Custom Programs				●		●

Energy Assessment Report

Scituate Middle School & High School | *DRAFT October 2016*

94 Trimtown Road, North Scituate, RI 02857

Summary of Findings

On behalf of the School Building Authority at Rhode Island Department of Education (RIDE), Jacobs recently completed a comprehensive energy assessment of the public schools in Rhode Island. This assessment was completed to develop recommendations for improving energy efficiency, benchmark each facility against other like facilities, and assess the feasibility of using renewable energy technologies. Results from the analysis for Scituate Middle and High School are summarized in this document.

Heat is provided by a combined central heating plant comprised of hot water boilers and one steam boiler. The heating medium is recirculated throughout the building to the terminal heating equipment. Lighting is predominantly provided by T8 fluorescent fixtures.

A number of energy efficiency opportunities with varying payback periods were identified during the assessment. Based on an estimated energy cost of $0.15/kWh, energy cost savings of approximately $31,994 per year are possible through measures that have an average payback period of 25.9 years and represent approximately 11% savings in energy cost.

The school has potential to implement renewable energy projects and qualify for Net Zero certification. Electricity purchased from the grid can be reduced to "Net Zero" by installing a solar photovoltaic (PV) array on the school's roof or ground-mounted on school property. On site combustion can be eliminated by replacing the existing boilers with a ground sourced heat pump system. The costs for these systems are:

- 439 kW Solar PV - $1,756,832.88 (18.3 year simple payback after incentive)
- 1,124-ton ground sourced heat pump system - $3,658,620 (15.9 year simple payback after incentive)

National Grid has attractive renewable energy growth programs which are dependent upon the size of the renewable power system and the ownership arrangement (host vs. third party owner). Incentive programs available in Rhode Island are presented in Table 6.

Benchmark Utility Data Analysis

Table 1 presents the key utility data consumption and associated benchmarks. This data has not been normalized for weather, however degree-day data for the period of this assessment is provided in Table 3.

Table 1 - Key Utility Data Consumption Benchmarks

	2011	2012	2013	2014
Electricity ($)	$ 98,508.58	$ 84,311.09	$ 93,142.53	$ 96,186.60
Natural Gas ($)				
Fuel Oil ($)	$ 146,425.32	$ 122,541.77	$ 150,605.12	$ 186,999.57
Total Energy Cost ($)	**$ 244,933.90**	**$ 206,852.86**	**$ 243,747.65**	**$ 283,186.17**
Electricity (kWh)	608,077.65	520,438.83	608,774.71	626,214.84
Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	48,808.44	33,119.40	38,616.70	53,428.45
Total Energy Use (kBtu)	8,859,220.46	6,379,407.40	7,444,946.69	9,563,288.32
($ / SF)	$ 1.35	$ 1.14	$ 1.34	$ 1.56
EUI (kBtu / sf)	52.56	52.56	52.56	52.56

Energy consumption was approximated using cost data publically available on the Rhode Island Department of Education website in the Uniform Chart of Accounts. These assumptions are provided in Table 2.

Table 2 - Energy Cost Assumptions

	2011	2012	2013	2014
Electricity ($ / kWh)	$ 0.16	$ 0.15	$ 0.15	$ 0.15
Natural Gas ($ / Therm)	$ 1.33	$ 1.23	$ 1.24	$ 1.29
No. 2 Heating Oil ($ / Gal)	$ 3.70	$ 3.90	$ 3.90	$ 3.50
Propane ($ / Gal)	$ 3.87	$ 3.80	$ 3.50	$ 4.50

Table 3 indicates a 15.5% increase in heating degree days in 2014 compared to 2013. Resetting the heating hot water temperature set point based on outside air temperature will help to reduce energy consumption.

Table 3 - Heating and Cooling Degree Data

	2011	2012	2013	2014
Heating Degree Days (Base 65 Deg. F)	5,046	5,317	4,807	5,554
Cooling Degree Days (Base 65 Deg. F)	1,068	921	838	894
Growing Degree Days (Base 50 Deg. F)	3,446	3,203	3,160	3,128

Energy Use

During the study period the school consumed the following energy types:

- Electricity
- Fuel Oil

Figure 1 presented below shows the site energy use index (EUI) for Scituate Middle and High School since 2011. The cost/SF increased by 15.5% from 2011 to 2014 with the EUI dropping from 2011 to 2012 then steadily increasing to 2014. This data has not been normalized for weather and therefore reflects energy consumption dependent on heating and cooling degree-days (see Table 3) and is used for comparison of schools within the weather region only.

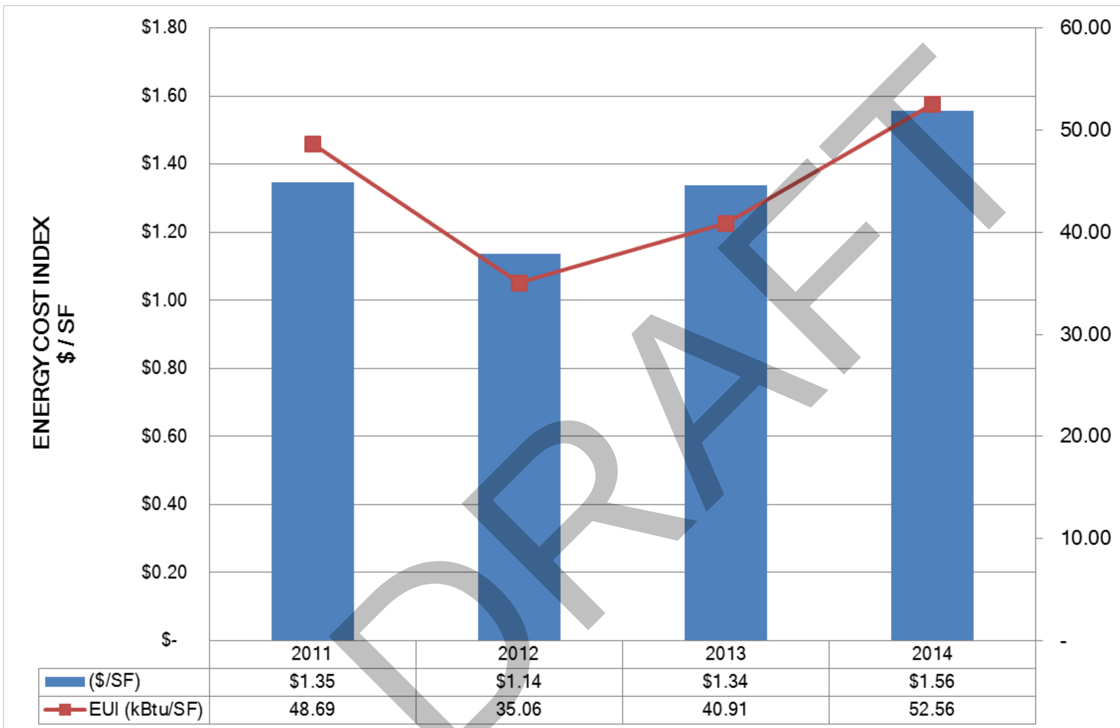


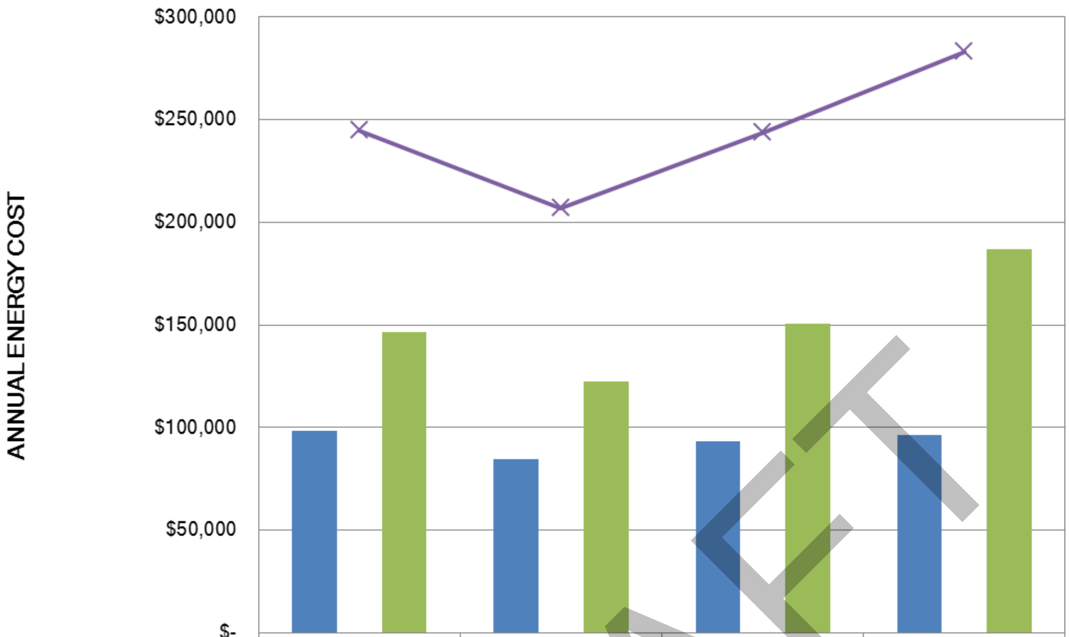
Figure 1 - Benchmark Performance

As seen in Table 4, this school operated below the public school state averages for utility cost per square foot in 2011 and 2012 and above the average in 2013 and 2014. The energy use index for the school was less than the public school averages in 2011 and 2014, but surpassed that marker in 2012 and 2013.

Table 4 - School vs. RI Averages

	2011	2012	2013	2014
School ($ / sf)	$ 1.35	$ 1.14	$ 1.34	$ 1.56
RI Schools Average ($ / sf)	$ 1.36	$ 1.21	$ 1.27	$ 1.38
School EUI (kBtu / sf)	52.56	52.56	52.56	52.56
RI Schools Average EUI	55.02	45.28	48.95	60.97

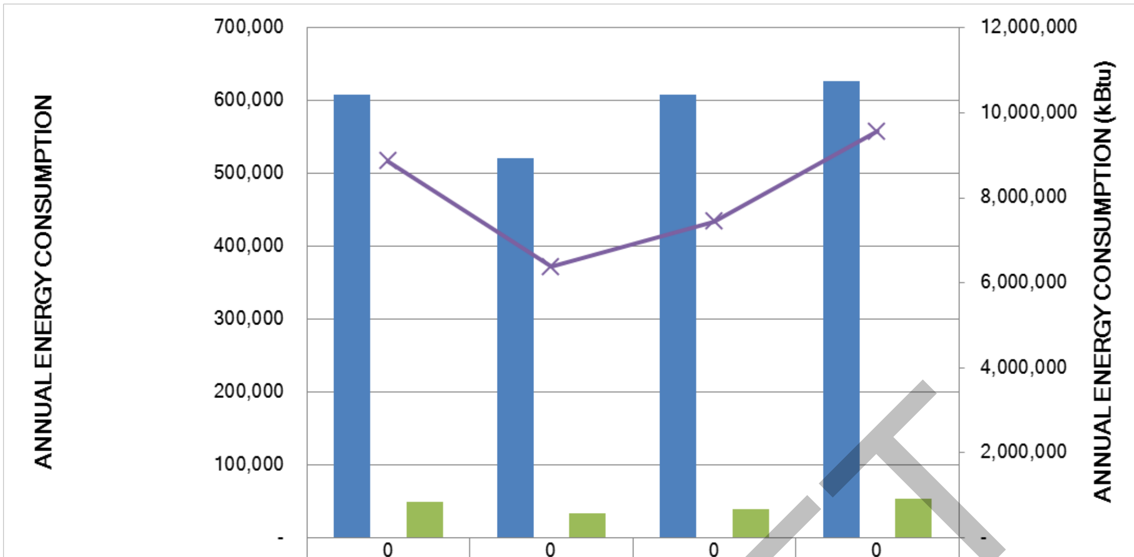
Scituate Middle and High School consumed $283,186.17 in electricity and fuel oil to light, heat and satisfy the electrical, HVAC, and plugged loads of the building in 2014. This is up from $244,933.90 in 2011. Figure 2 provides a year-to-year graphical depiction of energy costs.



	2011	2012	2013	2014
Electricity ($)	$98,508.58	$84,311.09	$93,142.53	$96,186.60
Fuel Oil ($)	$146,425.32	$122,541.77	$150,605.12	$186,999.57
Total Energy Cost ($)	$244,933.90	$206,852.86	$243,747.65	$283,186.17

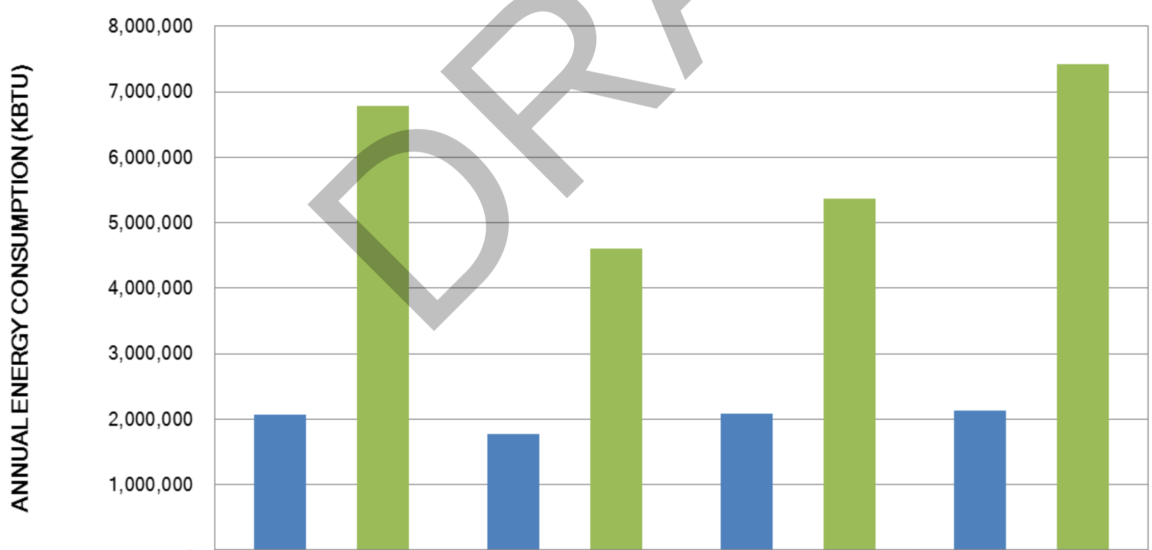
Figure 2 - Energy Cost

Figure 3 and Figure 4 profile the energy mix at this school. Overall electricity and fuel oil consumption increased from 2011-2014. Total energy consumption (kBtu/year) increased by 7.9% from 2011 to 2014.



	0	0	0	0
Electricity (kWh)	608,077.65	520,438.83	608,774.71	626,214.84
Natural Gas (ccf)	-	-	-	-
Fuel Oil (Gal)	48,808.44	33,119.40	38,616.70	53,428.45
Total Energy Use (kBtu)	8,859,220.46	6,379,407.40	7,444,946.69	9,563,288.32

Figure 3 - Energy Consumption Profile (Commonly Recognized Units of Consumption)



	2011	2012	2013	2014
Electricity (kBtu)	2,074,847.30	1,775,811.18	2,077,225.74	2,136,733.97
Natural Gas (kBtu)				
No. 2 Fuel Oil (kBtu)	6,784,373.16	4,603,596.22	5,367,720.94	7,426,554.35

Figure 4 - Energy Consumption Profile (kBtu)

Energy Assessment Recommendations

All building systems were evaluated and data collected during the assessment are housed in the condition assessment database. It was determined that energy consumption at this school can be reduced through engineered solutions of the following systems.

Heating

Energy efficiency improvements in the building's heating system can be achieved by implementing a variety of measures, including the following options:

Programmable thermostats in classrooms, administration offices, gymnasium and hallways can be networked into a building automation system.

Existing lighting occupancy sensors can be used to set back space temperatures when an area has been vacant for 30 minutes or more. This feature can be used to decrease heating when teachers and students are not present at the end of the school day, weekends, and holidays.

Cooling

The school is not completely served by a centralized cooling system; however, cooling is provided in administrative spaces, the auditorium, and the library by rooftop units or split systems. If additional cooling is necessary, heat pumps and variable refrigerant flow systems with the ability to heat and cool are options.

Ventilation

The facility is ventilated by forced mechanical air and operable windows. Additionally, the ventilation system has incorporated energy recovery units to reclaim energy that might be lost from the building's exhaust air steam and uses that to pre-condition the incoming or fresh air steam. If needed, the system will supplement the conditioning by mechanical means to ensure that it reaches the desired set-point temperature.

Domestic Water Heating

Domestic hot water is provided by a boiler and high-capacity water storage tank. Domestic hot water is primarily used for hand washing sinks and kitchen cleaning.

Should the school have specific interest, a solar assisted domestic water heater could be installed. The cost effectiveness of a solar assisted water heater is typically below the acceptable threshold and therefore frequently disregarded from consideration. The demand for domestic hot water in the building is relatively low; therefore, a small system is capable of meeting the demands. Such a system reduces the carbon footprint of the building and provides an excellent teaching opportunity for students.

Lighting

Lighting fixtures in the building are predominantly T8 fixtures. Each classroom consumes between 0.95 and 1.12 watts/SF. T8 fluorescent lighting can be cost effectively replaced with LED lamps in the 10-18 watt range to help reduce consumption of electricity. Energy consumption associated with lighting can be reduced by adjusting lighting levels to IESNA Lighting Standards appropriate for space and use.

Building Automation

The school has a building automation system which can be upgraded to improve energy efficiency. These upgrades can achieve the following:

- Provide the capability to reset the heating hot water temperature set point based on outside air temperature and/or classroom temperature (i.e. control to maintain temperature in the coldest classroom).
- Provide capacity and capability to provide for classroom alarm monitoring, trending, command and control, remote troubleshooting, service dispatch, scheduling for weekends, vacancy, holidays, and nighttime or vacancy set back.
- Participation in demand response programs by shedding load when and as needed (i.e. selectively shutting off lights, allowing set points to be reduced, and turning off exhaust fans when the building is vacant).
- Measuring energy (electricity, natural gas, fuel oil, and/or propane) consumption to track usage, report, manage, and reconcile discrepancies, identifying billing errors, or alarm when consumption exceeds benchmark thresholds.

Building Envelope

Energy efficiency can be improved by replacing the roof with a new EPDM reflective white roof and replacing the underlying dense deck with a higher R-Value dense deck. Before replacing the roof, consider the installation of solar photovoltaic panels and associated structural support.

Improving the thermal breaks of the windows or installing internal thermal shade window coverings will reduce heat loss in winter when there is no solar gain and help to control space temperature when there is solar gain.

Extremely long payback periods associated with upgrading these building elements make them less viable as potential energy conservation measures; however, these upgrades or modernizations should be considered during replacement.

Net Zero Action Plan –Opportunity for Implementation of Renewable Energy Technologies

Net Zero Energy Building Certification revolves around the core requirement that "one hundred percent of the site's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion."

To approach Net Zero Energy Building Certification, a Net Zero Action Plan (NZAP) should be developed and used as a road map to this Net Zero destination. To this end, the school and The Rhode Island Department of Education can take preliminary actions to facilitate a Net Zero facility. The primary components are:

- Establish a plan: administration and enforcement
- Establish energy baseline: consumption and source mix
- Reduce energy consumption
- Improve energy efficiency
- Replace combustion energy sources with renewables
- Continuously measure, grade semi-annually, and reward/incentivize good performance and active participation

Electricity is currently provided by National Grid. Net metering is available to electrical consumers in Rhode Island with specific limitations provided by the Rhode Island Public Utilities Commission. Electricity purchased from the grid can be reduced to Net Zero by installing solar photovoltaic (PV) arrays on the school's roof or ground-mounted on school property, and/or by wind powered generators.

An analysis of the roof's structural integrity and capacity to withstand the loading associated with PV arrays would need to be conducted. PV arrays can be ground-mounted and properly oriented to take full advantage of available sunlight (perhaps tracking arrays). Further investigation and analysis will be required to determine the feasibility and cost effectiveness of solar PV and/or wind powered generators.

These systems generate electricity to satisfy a portion of the school's demand for electricity when the sun is shining and the school demands it. Any additional electricity the school needs, that is not being produced by the PV array or wind generator, is purchased from National Grid. When the sun is shining and the school is not demanding all of the power being produced by the PV array or wind generator, that excess power is fed out onto the grid. During the summer months when school is not in session, or the electrical demands are lower, the school can feed its excess electricity generation out to the grid. When properly managed, the amounts of electricity generated on site, consumed from the grid, and generated, but not consumed and fed out to the grid are summed and should net out to zero or near zero.

On site combustion can be replaced with ground sourced heat pumps. Rebates and incentives are currently being offered to assist with the transition to renewables and the elimination of on-site combustion. See Table 5 for a listing of applicable programs and technologies. Each application will be vetted to maximize rebates and incentives and minimize initial and life cycle costs.

Recommended Energy Conservation Measures

Table 5 - Energy Conservation Measures

NO.	RECOMMENDED ENERGY CONSERVATION MEASURES (ECM)	INSTALLED COST ESTIMATE	ESTIMATED ANNUAL SAVINGS ($)	SIMPLE PAYBACK (YRS)
1	Install Building Automation System	$45,000	$1,870	24.1
2	Network Programmable Classroom Thermostats/Schedule	$6,000	$935	6.4
3	Set Back Space Temperatures Based on Vacancy Using Lighting Occupancy Sensors	$8,000	$1,402	5.7
4	Upgrade Existing Pump Motors to High Efficiency Units	$74,359	$4,809	15.5
5	Install Solar Assisted Domestic Hot Water Heater	$60,000	$3,740	16.0
6	Re-lamp T8 Fluorescent Bulbs with T14 LEDs	$636,881	$19,237	33.1
	TOTALS	**$830,240**	**$31,994**	**25.9**
Net Zero Action Plan Measures				
NZ-1	Replace existing HVAC system with Ground Source Heat Pumps	$3,658,620	$229,545	15.9
NZ-2	Net Meter Electricity Using Solar PV or Wind Power Generator	$1,756,833	$96,187	18.3

Table 6 - Incentive Programs Available in Rhode Island

	RI - Renewable Energy Fund/Grant Small Scale (up to 25 KW)	RI - Renewable Energy Fund/Grant Commercial Scale (250 KW - 1MW)	RI - Renewable Energy Growth (26-250 KW)	National Grid Energy Efficiency Programs	Net Metering	Rhode Island Renewable Energy Fund (RIREF)
Solar Photovoltaic	●	●	●		●	●
Solar Domestic Hot Water Heater	●					●
On Sight Wind Generator	●	●	●		●	●
Ground Source Heat Pump				●		●
Hydro-Electric			●		●	●
Tidal Energy					●	●
Wave			●		●	●
Ocean Thermal						●
Fuel Cells w/Renewable Fuels						●
Custom Programs				●		●