Massachusetts Department of Energy Resources

Energy Conservation Improvement Program Energy Audit

The Town of Tewksbury Public Schools

Tewksbury John F. Ryan School
Tewksbury, MA

May 15, 2008

Prepared by

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SECTION 1: EXECUTIVE SUMMARY

American Development Institute (ADI) has been retained by the Division of Energy Resources (MA – DOER) to prepare a scoping energy audit for a number of municipal buildings and school department buildings for the Town of Tewksbury, Massachusetts.

This energy study for the Tewksbury John F. Ryan School was commissioned in order to identify cost-effective energy conservation measures (ECMs) that would qualify for funding under the Energy Conservation Improvement Program (ECIP). The ECIP may fund a portion of this project.

The ECMs recommended in this study, if implemented, will yield annual energy savings of approximately $5,556, or 18,866 kWh and 196 MMBTU. These savings represent 3.7% of the present annual energy costs of $149,922. With a total installed cost of approximately $28,290, the overall project payback is 5.1years. There may be utility incentives available from NGrid Electric Company, the electric utility company, for lighting occupancy sensors and efficient lighting retrofits, which will improve the retrofit payback to 4.2 years. In addition to the proposed measures, ADI recommends the facility implement retro-commissioning to optimize the operational efficiency of the building systems.

The costs, annual savings, and simple paybacks for the qualified ECMs are summarized in Table 1.1 below. Detailed descriptions of each ECM are presented in Section 3. To estimate cost savings, we have used the school's blended electric rate of $0.1188 per kWh and $16.90 per MMBtu for fuel. Savings calculations are estimates only, based on field observations, building plans, interviews with school employees, or assumptions based on ADI's experience on similar projects. Similarly, cost estimates were made using R.S. Means, vendor information, or ADI experience.

Acknowledgements

The cooperation and assistance of Scott Durkee of the Massachusetts DOER and John Quinn of the Town of Tewksbury is greatly appreciated in making this study possible.

Table 1.1: Summary of Energy Efficiency Measures

ECM #	ECM Description	Annual Savings			Installed Cost ($)	Simple Payback (years)	Utility Funding ($)	Net Cost $	Net Payback yrs
		Electricity (kWh)	Fuel (MMBTU)	Total Savings ($)					
	Retro-commissioning		196	$ 3,314	$ 10,600	3.2		$ 10,600	3.2
ECM 87	Use High-Efficiency Fluorescent Lighting	14,918		$ 1,772	$ 14,760	8.3	$ 3,600	$ 11,160	6.3
ECM 91	Install Occupancy Sensors	3,949		$ 469	$ 2,930	6.2	$ 1,500	$ 1,430	3.0
Totals		**18,866**	**196**	**$ 5,556**	**$ 28,290**	**5.1**	**$ 5,100**	**$ 23,190**	**4.2**

SECTION 2: FACILITY OVERVIEW

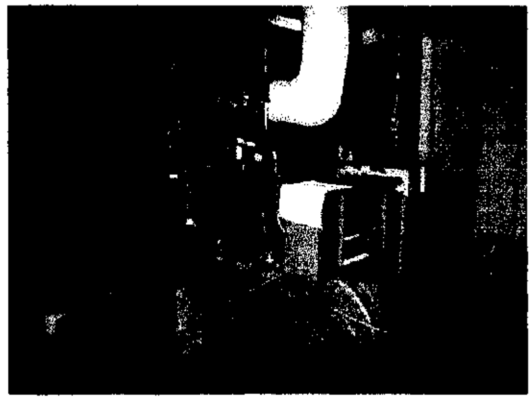
BUILDING DESCRIPTION

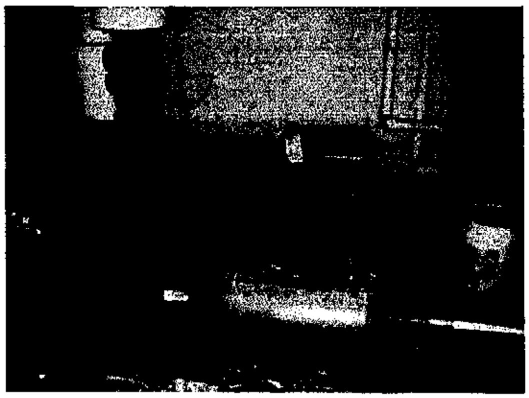
The Tewksbury John F. Ryan School building was constructed in 1999 and comprises 106,000 ft^2 of floor space. The building is of masonry construction with a brick exterior. The operating hours for the building are Monday through Friday from 7 am to 4 pm, with evening activities in the gym. The exterior windows double pane and are in very good condition. The primary lighting systems in the school are newer technology fluorescent T8 fixtures, except for the gymnasium, which is served by metal halide lighting systems. Exit signs are LED.

The building is heated by a central hot water system that is supplied by two gas-fired cast iron sectional boilers. Terminal equipment consists primarily of unit ventilators in the individual classrooms, with associated cabinet unit heaters, fintube convectors, and some heating and ventilating units. Administrative offices are cooled by window air conditioning units. Domestic hot water is provided by gas fired water heater.

Temperature control systems are pneumatic. A Johnson Controls Inc. Energy Management System (EMS) provides supervisory and scheduling control and monitoring of the boiler plant and the HVAC systems. ADI staff reviewed the operation of the EMS in the field including a review of the schedules implemented for unoccupied setback control. The building staff members are operating the EMS effectively with aggressive scheduling in place to maximize efficiency.

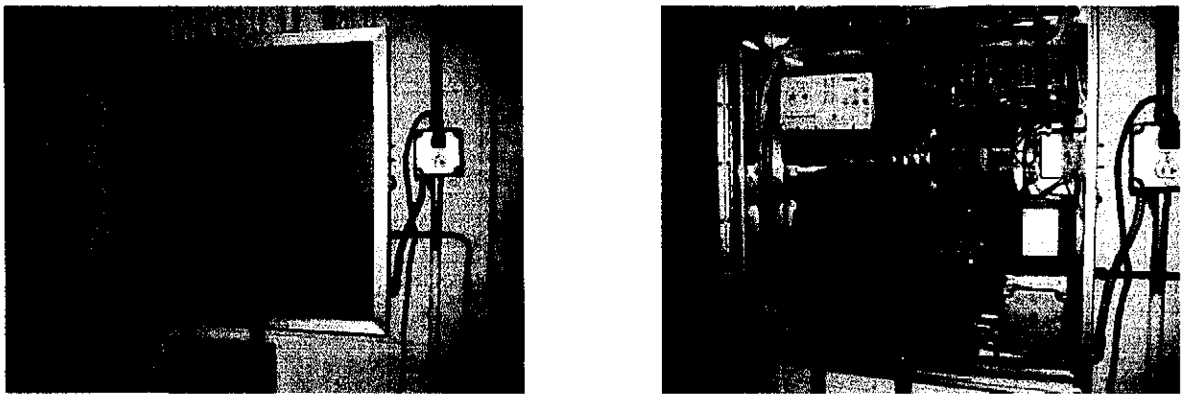
The Annual Energy Index (AEI) for the school, as shown in the Facility Energy Profile presented here, is 59,667 BTU/SF/Year. This value could be lower for a building of this type in the New England climate, reflecting a relatively lower level of energy efficiency.





Hot Water Boiler Plant

Domestic Hot Water System



Energy Management System

ENERGY PROFILE

Based on the electric billing history for fiscal year 2006-2007, the total electrical consumption for the school was 703,906 kWh, with a total cost of $83,634. Electricity is provided by NGrid Electric Company. ADI has utilized the average blended rate for the School of $0.1188 per kWh for our electric energy saving calculations.

The facility utilizes natural gas for heating and domestic hot water, with an annual total of 38,080 ccf of natural gas annually for a total of $66,288. ADI has used the average cost of $16,90/MMBtu for our energy savings calculations.

Table 2.1: Profile of Annual Energy Use

	Electric	Fuel	Total
Total Energy Usage	703,906 kWh	3,922 MMBtu	6,325 MMBtu
Total Energy Cost	$ 83,634	$ 66,288	$ 149,922
Total Energy per sf	6.641 kWh per sf	0.037 MMBtu per sf	0.060 MMBtu per sf
Total Cost per unit	$ 0.12 $/kWh	$ 16.90 $/MMBtu	$ 23.70 $/MMBtu
Total Cost per sf	$ 0.79	$ 0.63	$ 1.41

UTILITY PURCHASING SAVINGS OPPORTUNITIES

There are a number of ways that the Town of Tewksbury can reduce their energy bills in addition to energy conservation. They are outlined below.

Energy Procurement

Municipalities can derive large savings by employing a number of energy procurement strategies:

1. Electricity: Municipalities should consider getting their electricity supply from a licensed electricity supplier.[1]
    a. *Real-time Pricing*: The savings from a variable priced offering can be great because the customer assumes the risk of price fluctuations. It is important for customers to understand the risk and potential savings of a real-time index product as compared to a fixed price contract by looking carefully at electricity usage during peak price periods and comparing those trends to the elements of the variable priced offerings. In the event that a customer's usage tends to be during off-peak periods, large savings can be derived. Suppliers should be asked if they have a real-time rate and be requested to give an estimate for what a customer would have paid in the last year using the customer's specific usage data, indicating the supplier's charge (in $/kWh) for such a product and other charges that may apply.
2. Aggregation: It is recommended for municipal offices to aggregate as many electric and gas accounts as possible when going out to bid for energy procurement contracts. In some cases, municipalities have benefited even more by aggregating with other bordering municipalities.

Demand Response

ADI has determined that the Town of Tewksbury may be a good candidate for enrolling in the ISO New England Demand Response Program. This program pays customers for reducing their demand by at least 100 kW *when called upon*. This location may not be individually eligible but could be included in an aggregation of all the Town of Tewksbury accounts, if acceptable to the ISO New England Demand Response Program.

- There are a number of ways that customers can reduce their load when called upon: onsite generation, shifting usage to *non event periods*.
- ISO-NE usually calls upon participants depending upon the system conditions.-reliability and or high prices. In 2007 there were three DR events and 10 in 2006.
- Response time depends on the program; either day ahead or within 30 minutes.
- Entities can enroll in demand response through their utility or a third party.

Forward Capacity Payments

ADI has determined that the Town of Tewksbury may be a good candidate for enrolling in the ISO New England Forward Capacity Market. This program pays customers for reducing their demand by at least 100 kW *during performance hours*

Things to consider:

[1] A list of licensed suppliers can be found at the Dept. of Public Utilities Commission website: http://db.state.ma.us/dpu/qorders/frmElectricitySuppliers.asp

- There are a number of things that customers can enroll: onsite generation, shifting usage to off peak periods.
- The measure (or project) enrolled must be metered or verified to demonstrate the customer's demand was reduced during the performance hours.
- Energy efficiency measures that received a rebate from the utility are NOT eligible.
- It is recommended for entities to enroll in FCM through their utility or a third party; this reduces the payment, but, requires less attention from facility managers.

It is recommended for the proper representative to contact the Division of Energy Resources to learn more about opportunities for the Energy Procurement, Forward Capacity Market, and Demand Response. These programs would apply to the aggregation of all buildings in the Town of Tewksbury.

SECTION 3: ENERGY CONSERVATION MEASURES

This section describes all the ECMs that are recommended for inclusion in the ECIP. The selected measures meet the cost-effectiveness criteria of the program, and are eligible for funding under the ECIP.

The following measures were considered in our evaluation:

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Table 3.1: Energy Conservation Measures Evaluated

Building System	Category	ECM#	ECM Name	Y/N
BUILDING EQUIPMENT OPERATION	*Reduce Operating Hours*	ECM 1	Reduce Operating Hours for Space Heating and Cooling Systems	NO
		ECM 2	Reduce Operating Hours for Ventilation Systems	NO
		ECM 3	Reduce Operating Hours for Water Heating Systems	NO
		ECM 4	Reduce Operating Hours for Lighting Systems	NO
		ECM 5	Reduce Operating Hours for Escalators and Elevators	NO
		ECM 6	Reduce Operating Hours for Equipment and Machines	NO
	Adjust Space Temperature and Humidity Setpoints	ECM 7	Maintain Heating and Coolers Cooling Temperature at recommended Setpoints	NO
		ECM 8	Maintain Humidification and Dehumidification at Setpoints	NO
		ECM 9	Adjust Heating and Cooling Setpoints When the Building Is Not Occupied	NO
BUILDING ENVELOPE	*Reduce Heat Conduction Through Ceilings and Roofs*	ECM 10	Insulate Ceilings and Roofs	NO
		ECM 11	Install Vapor Barriers in Ceilings and Roofs	NO
	Reduce Solar Heat Gain Through Roofs	ECM 12	Install Reflective Roof Services	NO
	Reduce Heat Conduction Through Walls	ECM 13	Insulate Walls	NO
		ECM 14	Install Vapor Barriers in Walls	NO
	Reduce Heat Conduction Through Floors	ECM 15	Insulate Floors	NO
	Reduce Heat Conduction and Long-Wave Radiation Through Glazing Areas	ECM 16	Install Storm Windows and Multiple-Glazed Windows	NO
		ECM 17	Insulate Movable Windows	NO
		ECM 18	Install Operable Windows	NO
	Control Solar Heat Gain Through Glazing Areas	ECM 19	Install Exterior Shading	NO
		ECM 20	Install Interior Shading	NO
		ECM 21	Use Tinted or Reflective Glazing or Films	NO
		ECM 22	Plant Shade Trees	NO
	Reduce Infiltration	ECM 23	Seal Vertical Shafts and Stairways	NO
		ECM 24	Caulk and Weatherstrip Doors and Windows	NO
		ECM 25	Install Revolving Doors or Construct Vestibules	NO

Building System	Category	ECM#	ECM Name	Y/N
HEATING, VENTILATION AND AIR-CONDITIONING (HVAC) SYSTEMS	***Electric to Fossil Fuel Conversions***	ECM 26	Convert Existing Electric Domestic Hot Water System to Fossil Fuel or Heat Pump	NO
		ECM 27	Convert Existing Heating System from Electric to Domestic Hot Water	NO
	Reduce Ventilation	ECM 28	Reduce Ventilation Rates Without Affecting Indoor Air Quality	NO
		ECM 29	Reduce the Generation of Indoor Pollutants	NO
		ECM 30	Install Air-to-Air Heat Exchangers	NO
		ECM 31	Install Air Cleaners	NO
		ECM 32	Install Local Ventilation Systems	NO
	Improve Chiller Efficiency	ECM 33	Clean Evaporator and Condenser Surfaces of Fouling	NO
		ECM 34	Raise Evaporator or Lower Condenser Water Temperature	NO
		ECM 35	Isolate Off-Line Chillers and Cooling Towers	NO
		ECM 36	Install Evaporation-Cooled or Water-Cooled Condensers	NO
	Improve Boiler or Furnace Efficiency	ECM 37	Clean Boiler Surfaces of Fouling	NO
		ECM 38	Check Flue for Improper Draft and repair if necessary	NO
		ECM 39	Check for Air Leaks and repair if necessary	NO
		ECM 40	Install Flue Gas Analyzers for Boilers	NO
		ECM 41	Preheat Combustion Air, Feed Water or Fuel Oil with Reclaimed Waste Heat	NO
		ECM 42	Isolate Off-Line Boilers	NO
		ECM 43	Install Automatic Vent Dampers	NO
		ECM 44	Install Automatic Boiler Blow-Down Control	NO
		ECM 45	Install Pulse or Condensing Boilers/Furnaces	NO
		ECM 46	Install Air-Atomizing Burners (for Oil-Fired Systems)	NO
		ECM 47	Install Low-Excess-Air Burners (for Oil-Fired Systems)	NO
		ECM 48	Install Modular Units	NO
	Improve Air-Conditioner or Heat Pump Efficiency	ECM 49	Clean Air Filters	NO
		ECM 50	Install Add-On Heat Pumps	NO
		ECM 51	Install Ground or Ground-Water Source Heat Pump	NO
	Reduce Energy Used for Tempering Supply Air	ECM 52	Install Variable Air Volume Systems	NO
		ECM 53	Reset Supply Air Temperatures	NO
		ECM 54	Reset Hot/Chilled Water Temperatures	NO
	Use Energy-Efficient Cooling Systems	ECM 55	Install Economizer Cooling Systems	NO
		ECM 56	Install Evaporative Cooling Systems	NO
		ECM 57	Install Desiccant Cooling Systems	NO
		ECM 58	Install Cooling Tower Cooling Systems	NO
		ECM 59	Install Roof-Spray Cooling Systems	NO
		ECM 60	Create Air Movement with Fans	NO
		ECM 61	Exhaust Hot Air From Attics	NO

Building System	Category	ECM#	ECM Name	Y/N
HVAC DISTRIBUTION SYSTEMS	***Reduce Distribution System Energy Losses***	ECM 62	Repair Ducting and Piping Leaks	NO
		ECM 63	Maintain Steam Traps	NO
		ECM 64	Insulate Ducts	NO
		ECM 65	Insulate HVAC System Pipes	NO
	Reduce System Flow Rates	ECM 66	Reduce System Air Flow Rates	NO
		ECM 67	Reduce Heating/Cooling Water or Steam Flow Rates	NO
	Reduce Steam Resistance	ECM 68	Clean Air Filters in Ducts	NO
		ECM 69	Remove Scale from Water and Steam Pipes	NO
		ECM 70	Rebalance Piping Systems	NO
		ECM 71	Rebalance Ducting Systems	NO
		ECM 72	Design Ducting Systems to Reduce Flow Resistance	NO
		ECM 73	Install Booster Pumps	NO
WATER HEATING SYSTEMS	***Reduce Hot Water Loads***	ECM 74	Reduce Hot Water Consumption	NO
		ECM 75	Lower Hot Water Temperatures	NO
		ECM 76	Preheat Feedwater With Reclaimed Waste Heat	NO
	Reduce Hot Water Heating System Losses	ECM 77	Insulate Hot Water Pipes	NO
		ECM 78	Insulate Water Storage Tanks	NO
	Use Energy-Efficient Water Heating Systems	ECM 79	Install Decentralized Water Heaters	NO
		ECM 80	Use Smaller Water Heaters for Seasonal Requirements	NO
		ECM 81	Use Heat Pump Water Heaters	NO
		ECM 82	Heat Water with Solar Energy	NO
LIGHTING	***Reduce Illumination Requirements***	ECM 83	Clean and Maintain Systems	NO
		ECM 84	Reduce Illumination to recommended levels	NO
		ECM 85	Reduce Time of Operations	NO
		ECM 86	Use Task Lighting	NO
	Install Energy-Efficient Lighting Systems	ECM 87	Use High-Efficiency Fluorescent Lighting	YES
		ECM 88	Use High-Pressure Sodium Lighting in Selected Areas	NO
		ECM 89	Install Pulse Start Metal Halide Lighting in Selected Areas	NO
		ECM 90	Install High-Efficiency Ballasts	NO
		ECM 91	Install Occupancy Sensors	YES
	Use Daylight	ECM 92	Install Dimming Controls with Windows	NO
		ECM 93	Install Dimming Controls with Skylights	NO
POWER SYSTEMS	***Reduce Power System Losses***	ECM 94	Correct Power Factors	NO
		ECM 95	Install Energy-Efficient Transformers	NO
	Install Energy Efficient Motors	ECM 96	Replace Oversized Motors	NO
		ECM 97	Use High-Efficiency Motors	NO
		ECM 98	Use Variable Speed Motors	NO
	Reduce Peak Power Demand	ECM 99	Use Load-Shedding	NO
		ECM 100	Install a Cogeneration System	NO
		ECM 101	Install a Cool Storage System	NO

Building System	Category	ECM#	ECM Name	Y/N
ENERGY MANAGEMENT SYSTEMS	***Use Energy Management and Control Systems***	ECM 102	Install Temperature Setup/Setback Control System	NO
		ECM 103	Install Time-of-Day Control System	NO
		ECM 104	Install Duty-Cycling Control System	NO
		ECM 105	Install Supply Air Temperature Reset Control System	NO
		ECM 106	Install Hot/Chilled Water Supply Temperature Reset Control System	NO
		ECM 107	Install Ventilation Purging Control System	NO
		ECM 108	Install Economizer Cooling Control System	NO
		ECM 109	Install Demand Limiting Control System	NO
MISC.	***Heat Reclaim Systems***	ECM 110	Install Double-Bundle Chillers	NO
		ECM 111	Reclaim Heat from Boiler Blowdown	NO
		ECM 112	Reclaim Incinerator Heat	NO
		ECM 113	Reclaim Heat from Composition System Flue	NO
		ECM 114	Install Water-Loop Heat Pump System	NO
		ECM 115	Reclaim Heat from Prime Movers	NO
		ECM 116	Install Piggyback Absorption Systems	NO
		ECM 117	Recover Heat from Light Systems	NO
		ECM 118	Reclaim Heat from Refrigerator Hot Gas	NO
		ECM 119	Reclaim Heat from Steam Condensate	NO
		ECM 120	Reclaim Heat from Waste Water	NO
	Appliances	ECM 121	Install Energy-Efficient Appliances	NO
		ECM 122	Convert Electric Dryers to Natural Gas	NO
	Domestic Water Conservation	WCM 1	Install Low Flow Aerators on Sinks	NO
		WCM 2	Install Low Flow Toilets, Urinals	NO
		WCM 3	Install Low Flow Shower Heads	NO
		WCM 4	Install Reverse Osmosis Water Demineralizing Systems	NO
		WCM 5	Install Cooling Towers Where Once Through Cooling is Prevalent	NO

RECOMMENDED MEASURES

Based on the scoping audit and analysis, ADI recommends that the following Energy Conservation Measures be further evaluated with a detailed study. ADI believes that the implementation of these ECM's will provide a relatively short simple payback period.

Retro-Commissioning

Measure Description

ADI proposes that facility personnel enhance the operation of the HVAC and lighting systems in the buildings by providing complete Retro-Commissioning of the existing control and operation of the systems in the building. While the systems that serve the building were most likely commissioned at startup, it is our experience that regular post-commissioning or Retro-Commissioning is required in order to ensure that the HVAC systems are properly optimized and adapt to changing building requirements.

Commissioning is a systematic process to ensure that all building systems and controls perform interactively according to the current operational needs of the building occupants/users while operating at peak energy efficiency. Commissioning activities involve actual performance review and testing with upgrades and changes to building control strategies as necessary to meet the building performance requirements.

When commissioning of existing building control systems is properly executed, substantial operational cost savings opportunities can be identified. Effective commissioning has been proven to increase the energy efficiency of buildings with more complex HVAC systems and controls by as much as 5% to 10%, with lower savings resulting from less complex systems. Improved integration and optimization of the building systems will also result in improved comfort and operation of the buildings in addition to increases in energy efficiency.

Implementation of Retro-Commissioning will involve the following scope of work:

1. Gathering all available existing information on the existing systems and controls, including drawings, specifications, control point listings, control sequences, schedules, and control hardware specifications.
2. Interviewing building operating staff and building users regarding the current operation of the buildings, noting any potential problems with temperature, humidity, indoor air quality, and areas where improvement is required.
3. Reviewing existing operating control sequences and observe the operation of HVAC system components, including fans, pumps, chillers, heat exchangers, and cooling towers, and comparing existing operating schedules, ventilation rates, pressures, temperatures, etc to specifications and plans.
4. Using portable data loggers and the data logging capabilities of the existing systems to gather operating data to analyze the operation of the existing systems.
5. Based on the above steps, developing a list of recommended improvements to each system or subsystem to improve overall performance and efficiency. Improvements may include control sequence changes and/or additions of control and monitoring points.
6. Revisiting the above Retro-Commissioning process seasonally to cover the heating season, the cooling season, and in-between seasons.

Retro-Commissioning guidelines, published by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), The United States Green Buildings Council (USGBC) and Portland

Energy Conservation, inc. (PECI), can be utilized in the performance of the Retro-Commissioning process.

Economic Summary

The following table provides an economic summary of this ECM.

ECM #	Savings Electricity kWh	Savings Fuel MMBTU	Savings $	Total Cost $	Payback yrs	Utility Funding ($)	Net Cost $	Net Payback yrs
	0	196	$ 3,314	$ 10,600	3.2	$ -	$ 10,600	3.2

ECM 87: Use High-Efficiency Fluorescent Lighting

Measure Description

The existing lighting system in the gymnasium consists of 400 Watt metal halide fixtures. The replacement of these existing fixtures with new T5 HO systems would provide significant annual energy savings in addition to improvements in light levels and will also offer instant start to 100% light level, which is currently not available with the existing metal halide fixtures.

With an investment of $14,760 and estimated annual energy cost savings of $1,772, the payback for this retrofit will be 8.3 years. Incentives of approximately $5,100 may be available from National Grid USA to improve the simple payback period for the retrofit to 6.3 years.

Economic Summary

The following table provides an economic summary of this ECM.

ECM #	Savings Electricity kWh	Savings Fuel MMBTU	Savings $	Total Cost $	Payback yrs	Utility Funding ($)	Net Cost $	Net Payback yrs
ECM 87	14,918	0	$ 1,772	$ 14,760	8.3	$ 3,600	$ 11,160	6.3

ECM 91: Lighting Control—Install Occupancy Sensors

Measure Description

The existing metal halide fixtures in the gymnasium require a warm up period before the lights operate at full lighting levels, requiring the fixtures to be operated for more hours than the gym is actually operated. Typically, the lights are turned on in the mornings and left on all day, regardless of the space usage. Retrofitting the gym lights to T5 technology will allow the lights to be controlled by occupancy sensors, which will greatly reduce the hours of operation. Incentives may be available from National Grid USA to improve simple payback periods. Costs and incentive calculations are based on fixture mounted sensors.

Economic Summary

The following table provides an economic summary of this ECM.

ECM #	Savings Electricity kWh	Savings Fuel MMBTU	Savings $	Total Cost $	Payback yrs	Utility Funding ($)	Net Cost $	Net Payback yrs
ECM 91	3,949	0	$ 469	$ 2,930	6.2	$ 1,500	$ 1,430	3.0

MEASURES CONSIDERED BUT NOT RECOMMENDED

ADI reviewed the systems in the school and considered a number of potential Energy Conservation Measures (ECM's). Based on a preliminary review, most of the possible ECM's were deemed to be not applicable for implementation due to long payback periods:

Boiler Replacement

The existing space heating boilers and domestic water heater could be replaced with higher efficiency equipment to reduce fuel usage. However, due to the high capital costs involved in replacing boilers, the simple payback period would likely be in the range of 20 years.

Motor and Variable Frequency Drive Installations

In some facilities, the installation of premium efficiency motors and variable frequency drives (VFD's) can reduce energy costs. In the case of the school, the existing electric motors that drive the HVAC systems are of relatively small HP. Generally, smaller HP motors do not lend themselves to cost-effective motor and VFD retrofit opportunities.

Lighting Fixture Retrofits

Classrooms, Corridors, and Office Areas – The existing lighting systems in these areas consist primarily of fluorescent lighting fixtures with T8 lamps and electronic ballasts. While newer high performance T8 systems would use somewhat less electricity, the small annual energy cost savings would not justify the retrofit costs. Care would have to be taken to ensure that light levels would be maintained. ADI recommends that new higher efficiency T8 systems be considered when the existing lamps and ballasts have reached end of life and require replacement.