Francis W. Parker Charter Essential School Energy Assessment

(Screening survey)

Report
Prepared by:

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Site Description:
The F.W. Parker Charter School is a one story brick walled, flat roofed building with a two story steel and wood framed addition at the rear. The school was constructed in three phases. Phase one was constructed in 1958 and formed a tee shaped building housing 9 classrooms, an auditorium/general purpose room, a kitchen, offices and a mechanical room. In 1972 the school was expanded to house an additional 6 classrooms, a library, a gymnasium, faculty spaces, additional offices, an additional mechanical room, and a courtyard. In 2008 the two story rear addition was completed to add further classroom and lab space to the building. In 1999, HVAC improvements were made to the 1958 building section, including the replacement of unit ventilators and the refurbishing of rooftop exhaust fans. Within the last year a window replacement project was completed that improved the glazing within much of the 1958 building section.

Total floor area of the entire building:	59,000 square feet.
Approximate total volume of conditioned space:	649,000 cubic feet

Natural gas is used to heat the entire school and to generate service hot water. Natural gas is also used for cooking. Major electricity end uses include lighting, ventilation, forced hot water circulation, refrigeration, dishwashing, localized air conditioning, computers and office equipment.

Task:
The task was to perform a walk-through assessment of conditions in the building which would affect energy use. At the request of the school, a primary focus was the existing heating plants and heat distribution system. On-site work included accessing classrooms, corridors, office spaces, a crawlspace, and the entire exterior shell including the rooftop (excluding the new rear addition roof.) As a result of this walk-through site work, and subsequent analysis, we are able to report the following findings and recommendations.

Natural gas consumption analysis (excluding the new addition):

"Old" account	Last 12 months	35,084 CCF
Baseline cooking and hot water est.	Last 12 months	8,084 CCF estimated
Heating	Last 12 months	27,000 CCF

This equates to 75.7 kBtu per square foot annual heating use. This is a very high value. It indicates that substantial opportunities exist for improvement.

Electricity consumption (excluding the new addition):

"Old" account	Last 12 months	161,280 kWh

This equates to 4.5 kWh per square foot annual electricity use. This is not a high value for a school. Lighting efficiency opportunities exist, however.

Summary of notable measures:

Measure description	Estimated Cost	Estimated Annual Savings	See Recommendation #
Rebuild/replace steam traps	$ 7,000	$500-$1,000	Rec. # 7
Steam boiler improvements	$15,000	$2,500	Rec. # 5
Install Tekmar 269 control	$ 3,500	$570	Rec. # 6
Classroom steam zone valves & thermostats	$18,000	$750	Rec. # 8
New Condensing FHW Boiler	$24,000	$4,000	Rec. # 3
Unit Ventilator survey of dampers and controls	$ 5,000		Rec. # 1
Gas utility incentives may be available for some of the measures summarized.			

RISE Engineering is investigating possible gas utility incentives that may be applicable, and will report the availability of incentives under a separate cover.

Measure details, as well as additional recommendations, will be found in the body of this report.

Conditions noted and recommendations:

Heating and ventilation:

The school has three distinct heating sections. One section is the relatively new rooftop equipment serving the recent addition and this was not a focus of our visit. Two other sections were constructed in or around 1958 and 1972.

Each of the earlier sections is similar in that they incorporate a mixture of unit ventilators and radiation to heat the building. The heating units are supplied with either steam, in the 1958 building or forced hot water, in the 1972 building. The Unit ventilators are controlled by a pneumatic system with day-night settings. It is unknown how well this control system is working since the building was unoccupied for a number of years and present personnel have not had the resources to test or observe the operation of all components.

Recommendation #1

- Therefore, a first step in determining which energy conservation opportunities may exist in the ventilation units would be to survey the existing ventilation system in detail (greater detail than this walk-through assessment allowed.)
  Cost would be approximately $175 per unit ventilator.

The unit ventilators described above, as well as air handling units within the auditorium and the gymnasium, are configured to be able to supply a percentage of fresh outside air to the building.

According to a 1999 set of building renovation plans, found at the site, each unit ventilator on average would be controlled to provide 500 cubic feet per minute (cfm) of fresh air during occupied settings to each classroom.

One of the largest energy costs in any school is the cost of heating outside air for the classrooms. Therefore, whenever a classroom is not being used or the occupancy is very low the fresh air supply and the ventilation blowers should be off.

There are a number of strategies which can be undertaken to reduce the ventilation heating cost. While the 1999 building renovation plans indicate that replacement of all unit ventilators within the 1958 building-section was to be undertaken, some components may yet be original. It is likely that many components within the 1972 building section are original.

As a result of the recommended survey, we may find:

- that simply to change some control settings may improve the efficacy of the system.
- Or, if present control systems are found to be largely non-functioning, a change of the pneumatic system to an electric control system may be the proper, though costly, solution. A switch to electronic controls would be particularly costly since the present ventilator dampers have pneumatic actuators which would also need to be replaced.

An additional refinement of control would be to install a system which operates dependant on CO_2 levels within the rooms. This would limit ventilation to only when needed, on a room by room basis.

If the school would like to pursue room by room unit ventilator assessment to include a survey of the functionality of all present components we would welcome the opportunity.

<u>1972 Building Boiler Room</u>

In the 1972 addition, two (2) H.B. Smith 28A-7 cast-iron boilers fired by Powerflame J50A-15 burners, produce the heating water temperature. A Tekmar™ outdoor reset control is present and *may* control operation of the boilers, based on heating load. A three-way valve is also present in the boiler room and was designed to modulate the water temperature in the system. It is *unknown* whether this pneumatically operated three-way valve is working. There is an excess amount of radiation in this building, especially for the needs of unoccupied time periods.

The existing boilers operate with a combustion efficiency of 80% and probably an overall efficiency of 75%. It is very important that these boilers are tuned-up at least once <u>each</u> year. Without an annual tune-up these boilers can fall to a combustion efficiency of 70% or less in a hurry.

From the serial numbers on each of these boilers we assume that they were installed in 2003.

We do <u>not</u> advocate the total replacement of these boilers because they are relatively new and they are sized to supply the requirements of the building during extreme winter conditions.

Recommendation #2

- Connect the boiler pumps to the emergency generator to avoid freezing up portions of the forced hot water system during power outages.

  Coat ~$3,000 to 4,000 depending on panel location and wiring.

These boilers are not made to condensate internally and thus cannot operate below a 130 degree return water temperature. They are *oversized* for the vast majority of the heating season.

Recommendation #3

- The "front end" installation of a fully modulating, sealed combustion, highly efficient condensing boiler installed to preheat the return water to the present boilers would generate substantial savings. In essence, the larger boilers would not need to fire for much of the year. They would be on-line and ready to fire when the extreme loads of mid-winter call for high temperature distribution, but would automatically remain off when the moderate loads of most of the heating season occur. As the run time of the existing boilers would be greatly reduced their life expectancy would be prolonged.

Cost: ~24,000 Savings: ~$4,000 per year.

Service Hot Water:

A separate gas fired atmospheric Service Hot water tank is located in this boiler room. The mixing valve is badly corroded. The mixing valve is likely present from a time when the large heating boilers fed the hot water system as well. There should not be a need for the mixing valve in the current separate system.

Recommendation #4

- Remove the corroded mixing valve
- Install a new time clock to control hot water production to match occupancy schedules

Total cost: ~$600

1958 Building Steam Boiler Room

In the 1958 building section, one (1) H.B. Smith 28A-7 cast-iron boiler fired by a Powerflame J30A-15 burner produces low pressure steam for heating. It is curious that this boiler's burner is a modulating burner but the control necessary for modulation of the burner was never installed, and thus the boiler just operates as an on/off boiler. This means that the boiler is always either fully firing or completely off, with no reduction of firing rate at times when loads are moderate.

There is no automatic feed water system for this steam boiler. Boiler operation is based on pressure. The steam traps in this building have not been repaired or replaced in quite some time. Reportedly, atmospheric blow off from the condensate pump has been spewing steam all winter, which would cause high energy loss.

From the serial numbers on each of this boiler we assume that it was installed in 2003.

There is an additional large Smith boiler in this boiler room that is currently not operating.

There is concern regarding the condition of this relatively new steam boiler. Excessive fresh water make up will corrode the boiler. This Boiler is showing signs of such corrosion. We do not believe replacement of this boiler is warranted. However, the following measures should be taken:

Recommendation #5

- Drain the boiler
- Open controls, clean and/or replace
- Install a new manual reset low water cut off on side of boiler
- Install a condensate feed water system

- Install a main line trap before condensate feed water system with a main vent
- Install a pump controller for condensate feed water system, retaining use of some recently installed pump motors
- Install a water meter to determine how much make up water is being used
- Replace sight glass which is leaking
- Install blow off on rear of boiler and replace leaking blow off on front of boiler.
- Tune boiler
- Install modulating control

  Total Cost: ~$15,000   Estimated Savings: $2,500 per year

Not taking the above steps might lead to the need for very expensive boiler replacement.

There are a number of different control options available for this boiler. They include:
Recommendation #6

- A Tekmar 269 control with time clock, plus sensors in areas where, if overheating occurs, the Tekmar will be signaled to knock down the boiler operation to essentially the "unoccupied" settings.

  Cost: ~$2,800
- Or, a series of wireless T-stats with minimum run times

  Cost: ~$2,000
- Interlocking of boiler operation into calls by the Unit Ventilators.

  Would be costly

A combination of the Tekmar 269 control and perhaps two remote thermostats is likely the best option to gain energy savings and limit overheating in some areas. Total cost would be perhaps $3,500, with an estimated savings of $570 per year.

Replacement sections for this Smith 28A-7 boiler are readily available. The burner is common and readily available. In fact, in an emergency, a burner can be "borrowed" from the redundant FHW boiler down the hall. *Therefore, we feel there is no advantage in adding redundancy to the steam plant. <u>We do not recommend that anything be done to repair or replace the old large Smith boiler.</u>*

1958 Building Steam Distribution:
Because the 1958 building section is supplied with steam via a two pipe distribution system, the <u>maintenance</u> of steam traps is essential. Replacing or repairing steam traps on the unit ventilators and the baseboard is not a difficult or costly project. A survey can determine a firm cost for the project. However, we do not anticipate that very many steam traps are present within the crawlspace. Certainly one larger steam trap would be present at the end of each of 3 main runs; and some additional traps would be located where piping dips and rises within the crawlspace. But in total in the entire system we estimate that there would be 35 traps.

It has been our experience that because a steam system requires very little maintenance, very little or no preventative maintenance is performed over the years. A steam trap has an operation life of 5 years and it looks like a lot of the traps have not been touched in at least 10 years.

Normally steam traps are not covered by insulation. If asbestos is present on the few crawlspace traps it would need to be abated, but if the rest of the pipe covering is in good condition no further abatement may be warranted.

Recommendation #7

- Rebuild the smaller traps and replace the few larger traps in the system (excluding the two traps at the air handlers in the auditorium.) The cost might total ~$7,000. By replacing traps and balancing heat delivery, pressure is balanced and savings can result, Given the reported atmospheric blow-off that has been occurring, perhaps as much as $500 to $1,000 could be saved annually. Without knowing the rate of water replacement (*there is no dedicated water meter*) the actual savings cannot be determined.

- An additional main trap is recommended to be installed on the return within the boiler room, which will help in eliminating the wasteful dumping of steam to the atmosphere. This cost was included in the discussion of boiler improvement.

<u>Temperature control in classrooms:</u>

Individual classroom control is difficult to achieve with a steam system but not impossible.

Recommendation #8

- In each steam heated classroom, install a new steam zone valve and new room thermostat, replacing the present *pneumatic* steam zone valves with *24 volt* zone valves and *24 volt* wall mounted thermostats in the classrooms.

This would eliminate overheating in certain classrooms. The cost for this enhanced control would be ~$2,000 per each of the 9 steam heated classrooms, or ~$18,000 total. Improved control will reduce energy consumption. Estimated savings: $750 per year.

(Note: in the 1972 building, it would also be unwise to install any zone valves in the unit ventilators as that could lead to problems with freeze-up of the forced hot water units.)

<u>Other HVAC considerations:</u>

There are two air handlers in the auditorium and one in the gymnasium which introduce outside air.

Recommendation #9

- Inspect the face & bypass dampers of the gymnasium air handler (especially the outdoor air damper) to ensure they operate correctly and close fully.
- Consider abandoning-in-place the steam fed Auditorium/general purpose room air handlers and install one gas fired rooftop HVAC unit to serve this area; thus eliminating old equipment and reducing load on the steam heating system.

    Cost ~$24,000

<u>Building Envelope:</u>

<u>Windows:</u> The courtyard windows and all exterior windows of the 1972 building are single paned glass within metal frames with no thermal breaks. Some windows are

operable hoppers with deteriorated weather-stripping. A few windows are operable sliders. Some windows have been modified to allow the installation of individual air conditioning units.

The school has recently replaced most of the windows within the 1958 building section. Comfort improvement is noted by the staff.

Recommendation #10

- It is recommended that the school look toward the replacement of all single glazed metal framed window units within all building sections. It is estimated that the total single glazed area is ~3,975 square feet, including glass doors. Install Energy Star rated dual paned windows featuring Low-E coatings and argon gas fill. Window frames should incorporate thermal breaks.

  Cost: ~$190,000 Estimated savings: $4,500 per year

<u>Walls</u>: The exterior walls are block and brick and offer no easy retrofit to add insulation without major remodeling. At this time, it is not an area for the school to focus upon.

<u>Roofs:</u> The 2008 addition roof was not assessed. The 1972 building section has an EPDM roof surface over an apparent 3-4" layer of assumed rigid insulation board. The 1958 building section has an EPDM roof surface over an apparent 1" layer assumed to be merely fiberboard with limited insulating value.

Recommendation #11

- When next in need of a roof surface, install a minimum of 4" R-24 rigid foam insulation to the 1958 building section's roof, totaling 6,866 square feet.

  The additional material and labor of the insulation in a reroofing project would add $20,000 to this job. Any available gas utility incentives may reduce this cost. Estimated savings: $3,300 per year.

<u>Crawlspace:</u> Surprisingly, the new crawlspace of the rear addition affords a conservation opportunity. The crawlspace is vented. The crawlspace is heated. The crawlspace needed to be one or the other, but not both. The perimeter walls are insulated with 2" ~R-10 rigid foam board. The earth is covered with a thick layer of crushed stone. Code states that as long as the perimeter walls are fully insulated and a vapor retarder is present upon the earth, a heated crawlspace need not be vented. See Massachusetts State Building Code, Regulation 780 CMR 1203.3.2, Exception #4. There is a visible air gap between the foundation wall and the steel sill plate around the perimeter of this crawlspace. The steel sill may have insulation on the exterior side, behind the siding; but this is not evident.

Recommendation #12

- Install sprayed-in-place two part high expansion foam to seal the perimeter gap from within the crawlspace, to reduce air infiltration. 484 lineal feet.
- Continue spraying this same foam up to the subfloor level, coating the entire steel sill with insulating foam to a thickness of 2 inches. Total foam applied as

insulation on the steel sill and as a sealant at the gap described above would be ~1,200 board feet.

- Check to determine whether a vapor retarder is already present beneath the crushed stone. (I suspect that one is present.) If not, install a vapor retarder throughout the crawlspace on top of the stone.
- Seal the crawlspace vents, disconnecting the present mechanical fans.
- Turn each of the five present 3 kilowatt electric fan unit heaters in the crawlspace to the lowest possible setting. Consider turning one near the hatch entirely off as it is not near plumbing drains. Place a thermometer within the crawlspace near the hatch to check the crawlspace temperature in mid-winter to ensure that there are no concerns of freezing temperatures. Turn additional heaters off if there is little concern.

Total estimated cost of all crawlspace recommendations: $6,000

<u>Other opportunities to save electric energy:</u>

<u>Interior Lights:</u>
The new addition and the 1958 building section have 4-lamp troffer fixtures within dropped tile ceilings. These fixtures have T-8 lamps and efficient solid state ballasts.

The 1972 building section has surface mounted troffer-like fixtures with primarily T-12 fluorescent lamps and energy efficient magnetic ballasts. These fixtures offer an opportunity for reducing energy consumption while maintaining or improving light levels.

Recommendation #13

- Replace 5 eight lamp fixtures, 210 four lamp fixtures, ~25 two lamp fixtures and ~6 two-lamp u-bend fixtures with Renova, Cynergy Series, high efficiency, fluorescent luminaires.

Total cost for these lighting measures would be ~$58,000

Estimated savings: 25,660 kWh per year
23.7 kW
~$3,564 per year

<u>Exterior Lights:</u>
There is a mixture of lighting types on the exterior. Some floodlights were reported to be “low pressure sodium.” Most floodlights appear to be high pressure sodium. There are a number of incandescent floods and down-lights within the soffits of the courtyard and the exterior perimeter.

Recommendation #14

- Replace 2 sets of two-lamp incandescent floods with 2, 70 Watt high pressure sodium fixtures.
- Replace one incandescent bulb at the kitchen loading dock with a 26 Watt compact fluorescent fixture.
- Replace 20 incandescent down-light floods in the exterior perimeter soffits and courtyard soffits with 26 Watt compact fluorescent screw-in flood lamps.

Total cost for these lighting measures would be ~$1,400

Estimated savings: 5,384 kWh per year
1.6 kW
~$747 per year

<u>Air Compressor:</u>
The air compressor serving the pneumatic control system is located in the 1972 boiler room. The compressor draws very warm air when the boilers are operating. Colder air is much denser and therefore requires less electric energy to compress. Piping cooler air to the compressor will save energy.
Recommendation #15

- Install an intake air duct (pipe) from the roof or courtyard directly into the compressor air intake.
  Total estimated cost: $400

<u>Computer work stations:</u>
While computers within the Computer Lab may see near constant use, computer stations with printers and other devices in faculty office spaces may have intermittent use.
Recommendation #16

- Install motion sensor controlled power strips such as the Insole™ IDP-3050, to turn off peripherals automatically when a desk area is unoccupied.
  Total estimated cost: $85 per motion controlled power strip.