Multi-Family Building
Energy Audit

Property Management, Inc.

City Senior Tower

456 Central Ave.

Metropolis, PA 12345

February 3, 2011

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1 INTRODUCTION

On January 10 and 11, 2011, Bone Energy Services performed an on-site assessment of City Senior Tower in Metropolis, PA. The goal of this assessment was to identify potential changes that could improve the energy/water usage, comfort, and safety of the building. The basic building attributes are:

Owner:	Property Management, Inc.
Property Manager:	John Jones
Superintendent:	Roland Morris
Size:	11 Stories
	70,731 square feet
	140 units
Age:	est. 1950
Configuration:	Common Entry w/Elevators
Structure:	Concrete Slab Foundation
	Partial Basement with Concrete Block Foundation Walls
	Precast Concrete Panels Supporting Concrete Plank Floors
	Brick Facing on Stair Towers
	Concrete Plank Roof
Occupancy:	Elderly Affordable
Utilities:	Central-Metered Natural Gas for Heat and Hot Water.
	Central-Metered Electric
	Central Metered Water

Audit Methodology:

- Prior to the site visit, we performed a detailed analysis of the actual building energy and water usage and costs.
- During the site visit, we performed a thorough visual inspection as well as specific tests that quantify equipment and building performance.
- The collected information was used to create an energy model of the building using TREAT software. This model was used to estimate the cost savings likely to result from numerous possible building modifications. For those changes with substantial savings potential, cost estimates were prepared and used to estimate their financial return if implemented.
- This report is a summary of our findings and recommendations regarding cost effective changes that are expected to improve the performance of the building.

Evaluation Staff – Site Visit:

- Dave Bone – BPI Building Analyst & BPI Multifamily Building Analyst

Evaluation Staff – Written Report:

- Dave Bone – BPI Building Analyst & BPI Multifamily Building Analyst

2 Executive Summary

City Senior Tower consumes a large quantity of energy and water. Benchmarking tools indicate that its electric consumption is far above average for a building of its size in Metropolis. The natural gas and water consumption are also above average. These findings all indicate significant opportunities for improvement.

- 4 measures were identified as critical to the health and safety of the building occupants. These are outlined in Section 2.1.
- 10 specific energy conservation measures (ECM's) were identified that can be expected to cost effectively reduce the gas, electric, and water consumption of the building. These are outlined in Section 2.2.
- 3 additional ECM's were evaluated. These were determined have savings potential, but their cost was found to be too high to justify implementation. These measures are outlined in Section 2.3.

SIR > 1 Measure saves more than it will cost.

SIR < 1 Measure costs more than it will save.

SIR = Estimated Lifetime Savings / Estimated Implementation Cost

The primary financial criterion used for evaluating each ECM is the Savings-to-Investment Ratio (SIR), which is the estimated lifetime savings resulting from a measure divided by the estimated cost of its implementation.

If all of the recommended ECM's and health/safety measures are implemented, the following financial impacts are expected:

	Current Annual Usage	Estimated Post-Retrofit Annual Usage	Estimated Savings
Natural Gas (mmBtu)	3,668	2,902	21%
Electricity (kwh)	871,800	576,679	34%
Water (gallons)	5,687,044	5,300,044	7%
Total Cost	$ 173,854	$ 132,946	24%

Annual Savings = $ 40,908

Implementation Cost = $ 398,134

Savings-to-Investment Ratio = 1.04
(Over a 10 year period)

Notes:

Estimated savings are calculated using an annual discount rate of 3%. They are also calculated using current utility rates. Any future rate increases will have a proportional effect on the expected savings.

One ECM, replacement of aging refrigerators, is recommended despite having an estimated SIR below 1.0. These units are nearing the end of their service life and will require replacement in the near future. It is recommended that they be replaced with Energy Star labeled units, using a financial contribution from the building owner as necessary to attain an SIR acceptable for program funding.

2.1 Health & Safety Measures – Recommended

Health and Safety Recommendations

	Measure	Installed Cost	Annual Gas Savings	Annual Electric Savings	Annual Water/ Sewer Savings	Annual Cost Savings	Payback	S.I.R.	Life Cycle Savings	Years for LCC
			mmBtu	kwh	1000 gals	$	years		$	years
1	Apartment Bath Fan Replacement	$51,869	-531.0	-194	-	-$7,611			$ (114,165)	15
2	Carbon Monoxide Detectors	$17,400	-	-	-	-			$ -	7
3	Regrade Site at North Vestibule	$12,000	-	-	-	-			$ -	15
4	Astronomic Timer for Outdoor Lights	$408	-	-	-	-			$ -	15
	Total	**$81,677**	**-531.0**	**-$194**	**0**	**-$7,611**			**-$114,165**	

*SEE **APPENDIX** FOR DETAILED DESCRIPTIONS OF RECOMMENDED MEASURES*

Note: Health and Safety Measure #1 will provide improved ventilation for the building occupants, but will result in increased energy usage. This is deemed to be a worthwhile tradeoff and is based on the ventilation requirements listed in current building codes.

2.2 ENERGY CONSERVATION MEASURES – RECOMMENDED (SIR > 1.0)

Recommended Improvement Measures

	Measure	Installed Cost	Annual Gas Savings	Annual Electric Savings	Annual Water/ Sewer Savings	Annual Cost Savings	Savings Benefit	Payback	S.I.R.	Life Cycle Savings	Years for LCC
		$	mmBtu	kwh	1000 gals	$		years		$	years
1	First Floor HVAC Controls	$ 1,088	-3.0	13,664	0	$ 1,222	Owner	0.89	13.4	$ 13,500	15
2	Hot Water Recirc Control - Adjust Setpoint	$ 119	6.0	1,260	0	$ 208	Owner	0.57	10.9	$ 1,177	7
3	VFD - Domestic Cold Water Pumps	$ 5,540	-1.0	54,045	0	$ 5,008	Owner	1.11	7.7	$ 37,179	10
4	Air Sealing Package	$ 4,438	150.4	449	0	$ 2,191	Owner	2.03	4.9	$ 17,372	12
5	Low Flow Showerheads & Aerators	$ 5,230	98.0	0	387	$ 3,750	Owner	1.39	4.5	$ 18,132	7
6	Lighting Upgrade Package	$ 42,043	-295.0	173,609	0	$ 11,913	Both	3.53	2.7	$ 72,809	12
7	Fan Coil Improvement Package	$ 51,961	499.3	30,757	0	$ 9,994	Both	5.20	2.3	$ 67,345	15
8	Boiler Replacement - Heating & DHW	$ 96,400	606.3	8,133	0	$ 9,621	Owner	10.02	1.5	$ 46,738	20
9	Single-Pane Window Replacement	$ 48,455	251.0	988	0	$ 3,679	Owner	13.17	1.1	$ 6,279	20
10	Energy Star Refrigerators - Replace Pre-2000 Models	$ 16,050	-15.0	12,409	0	$ 933	Owner	17.20	0.8	$ (3,766)	17

Architectural & Engineering Fees	$15,000
Building Permits	$3,000
Contingency (10%)	$27,132

Total Package	**$ 316,457**	**1,297**	**295,315**	**387**	**$48,519**		**6.52**	**1.31**	**$97,418**	**10**

SEE ***APPENDIX*** *FOR DETAILED DESCRIPTIONS OF RECOMMENDED MEASURES*

2.3 ENERGY CONSERVATION MEASURES – NOT RECOMMENDED (SIR < 1.0)

Measures Evaluated But Not Recommended

(Based on Financial Return)

	Measure	Installed Cost	Annual Gas Savings	Annual Electric Savings	Annual Water/ Sewer Savings	Annual Cost Savings	Payback	S.I.R.	Life Cycle Savings	Years for LCC
			mmBtu	kwh	1000 gals	$	years		$	years
1	Elevator Room Ventilation Repairs	$ 816	2.0	113	0	$ 37	22.06	0.5	$ (374)	15
2	Energy Star Clothes Washers	$ 2,000	2.0	1	7.878	$ 75	26.66	0.3	$ (1,360)	10
3	Insulate Pipes at Fan Coils	$ 3,430	1.0	2	0	$ 8	428.74	0.0	$ (3,334)	15

Detailed Descriptions:

Item #	*Title*	*Description*
1	Elevator Room Ventilation Repairs	Repair the exhaust fan, louvers, and thermostat that serve the elevator room.
2	Clothes Washers – Replace with Energy Star	Replace the 2 low efficiency clothes washers in the laundry room with high-efficiency Energy Star labeled models.
3	Insulate Pipes at Fan Coils	Insulate the exposed sections of pipe in the fan coils in each apartment.

3 MANAGER INTERVIEW

The site manager and superintendent were interviewed during the site visit. In general, the goal of the management team is to reduce energy and water costs. Several comfort and energy issues were noted:

- The building is generally warm in the winter. Most of the senior residents find this comfortable, though some are too warm.
- The office area is warmer than desired during the winter.
- There is very little building ventilation.
- Electric costs are very high.
- The lightings systems are aging and in need of improvement.

Several health and safety issues were noted:

- Water intrusion is an issue in the north entry vestibule.
- Water has also entered some apartments. This has been particularly prevalent in the "07" apartments located at the northeast corner of the building.
- During heavy rains, water collects in the basement mechanical room.
- The fire alarm system is aging and has experienced frequent malfunctions. Parts have been difficult to procure, which results in costly and time consuming maintenance.

Significant recent changes were noted:

- The rental office was expanded and renovated in 2003.
- New fan coils were installed in all of the apartments approximately 7 years ago.
- The fire suppression standpipe was converted from a dry to wet system.
- A portable air conditioner was installed in the elevator room.
- Roof repairs were completed over the past few years.

One planned change was noted:

- Water infiltration at the north entry vestibule must be addressed.

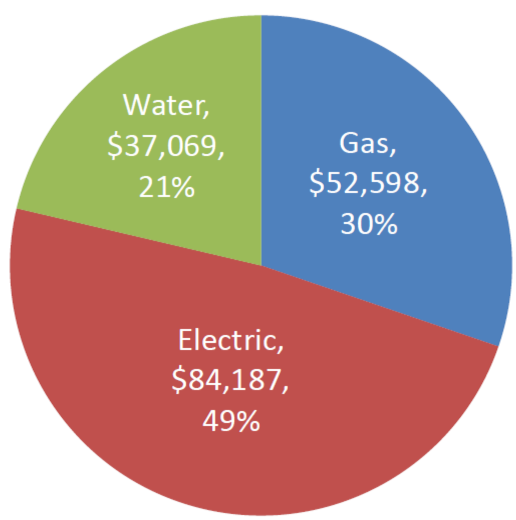
4 UTILITY BILL ANALYSIS

Utility Provider Summary:

Utility	Service Provider	Rate Structure	# Meters	Area Served	Monthly Service Charge	Billing Unit
Electricity - Common Areas	PECO	General Service – Commercial	1	Entire Building	$279.69	kilowatt hour (kWh) and kilowatt (kW)
Natural Gas	PGW	BPS Large Indirect 1	1	Entire Building – Heat & Hot Water	$51.00	hundred cubic feet (ccf)
		General Service - Commercial	2	Entire Building – Cooking & Laundry	$36.00	hundred cubic feet (ccf)
Water & Sewer	Water Revenue Bureau	C1W *with Charity Discount*	1	Entire Building	$1205.76	hundred cubic feet (ccf)

Usage data was provided for 12+ months of consumption. The annual totals are:

Utility	*Consumption*	*Cost*
Electricity	871,800 kWh	$ 84,187
Natural Gas	35,962 ccf	$ 52,598
Water & Sewer	5,687,044 gallons	$ 37,069
TOTAL		**$ 173,854**

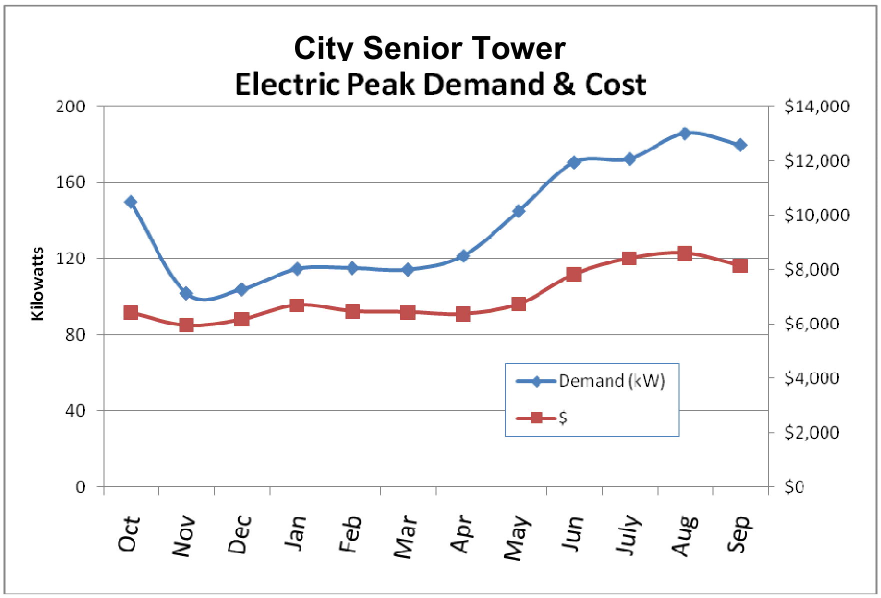


4.1 Electricity Usage

Seasonal consumption patterns are typical for a building using electricity for cooling, heating pumps, lights, and appliances.

- The lowest consumption occurs in the spring and fall, when there is no need for either heating or cooling. This corresponds to the "baseload" of lights and appliances.
- A small peak occurs during the winter months. This is attributable to heating pump and fan coil consumption, as well as increased lighting usage due to shorter days.
- A larger peak occurs during the summer. This is attributable to space cooling.

The monthly electric cost is affected by both the peak demand (kW) and consumption (kWh). The overall cost mirrors consumption more closely than demand, indicating that this is the predominant factor. However, reductions in either demand or consumption will reduce costs.



Consumption can be disaggregated as follows:

End Use	*Annual Consumption*	
Baseload	748,000 kWh	86%
Space Heating	20,200 kWh	2%
Space Cooling	103,600 kWh	12%

Average Rate: $ 0.097 / kWh

(Including Service Charges)

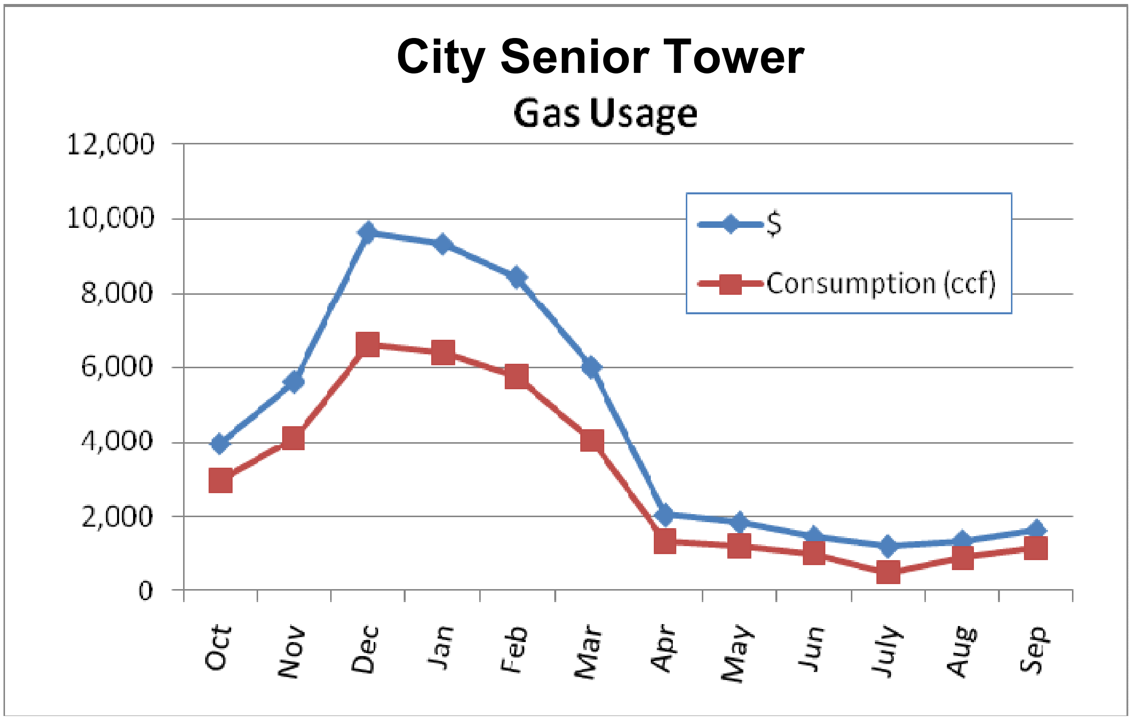
Discussion:

The overall electric cost, at $ 1.19 per square foot of building area, is very high for a building in Metropolis. Cooling consumption is typical for this type of building. The baseload accounts for most of the cost and is clearly a critical target for conservation measures.

4.2 Natural Gas Usage

Seasonal consumption patterns are typical for a building using natural gas for space heating and domestic hot water.

- Space heating consumption begins in October, peaks in January/February, and ends in April.
- Water heating consumption is steady, with a small peak in the winter, when the incoming water is colder and more heat loss occurs from pipes circulating water through the building.



End Use	Annual Consumption	
Space Heating	24,502 ccf	68%
Domestic Hot Water	11,460 ccf	32%

Average Rate: $ 1.46 / ccf

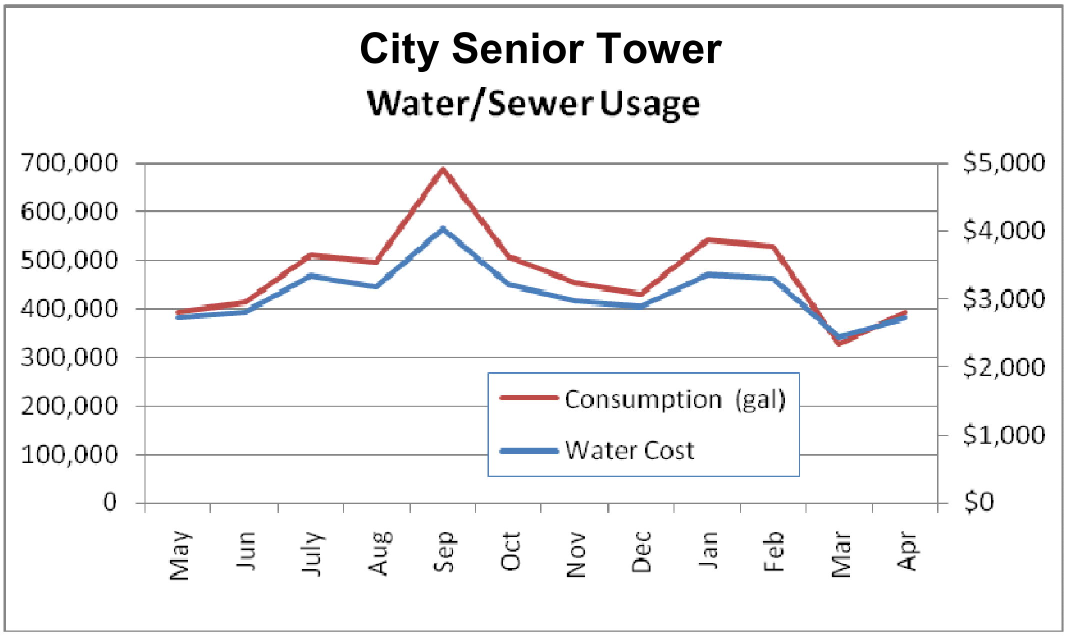
(Including Service Charges)

Discussion:

The overall gas cost, at $ 0.74 per square foot of building area, is moderate-to-high for a building in Metropolis. The proportion used for water heating is typical, indicating that there are significant gas savings opportunities related to both space heating and water heating.

4.3 Water & Sewer Usage

Seasonal consumption patterns are typical for a building with no irrigation. Consumption is fairly steady throughout the entire year, with a small peak in the summer due to increased bathing.



Average Rate: $ 6.52 / thousand gallons
(Including Service Charges)

Discussion:

The overall water cost, at $ 0.52 per square foot of building area, is average for an elderly apartment building in Metropolis. However, the consumption rate of 111 gallons per apartment per day is above average. This disconnect in these two figures is due largely to the discounted water rate received by the building. Reductions in water consumption and cost present a significant opportunity.

4.4 Benchmarking

Utility bill data was used to compare the performance of the building to other multifamily buildings of a similar age using data compiled by the U.S. Department of Housing and Urban Development.

	"Typical" Building	***City Senior Tower***	***Difference***	***Percentile[1]***
Energy Use (mmBtu/yr)	5,977	6,679	12% Worse	42 %
Water Use (1000 gals)	3,480	5,687	39% Worse	19 %

[1] The percentile score indicates the performance of the building relative to the rest of the buildings in the database. A building in the 60th percentile uses less energy than 60% of the comparison buildings and more energy than 40%.

Another common measure of building energy use is the ***Building Energy Index***. It is a calculation of the Btu's of energy consumed per square foot of building area per heating degree day. A large database of data on multifamily buildings in New York City was published in the March/April 2003 issue of Home Energy Magazine.

	Building Energy Index (Btu/sf/HDD)
Typical Building *(w/Gas Heat and DHW)*	10
City Senior Tower	19.5

Discussion:

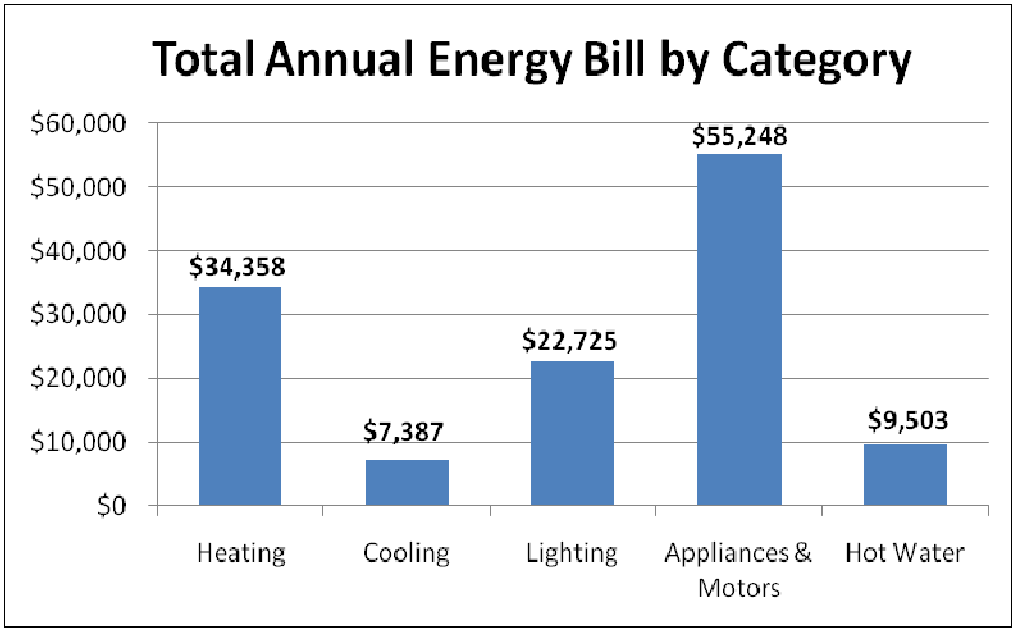
The benchmarking tools indicate that City Senior Tower uses significantly more energy and water than a typical building of its size in Metropolis.

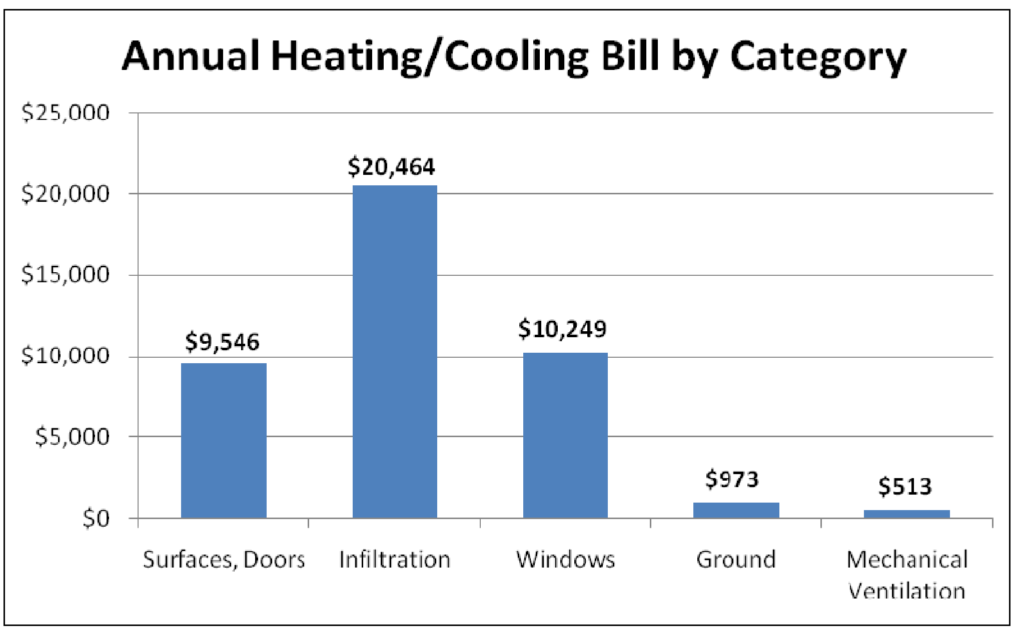
The patterns in the utility bills indicate that the biggest opportunities are in reducing the "baseload" consumption of electricity for lighting, appliance, pumps, and motors. However, there are significant opportunities to reduce gas and water consumption as well.

5 ENERGY MODELING

An energy model of the building was created using TREAT, version 3.2.5. This model is based on data from the available architectural plans and information collected at the site visit. The model inputs were adjusted to calibrate the output (estimated utility consumption) to data from the actual building utility bills.

This model estimates that the building currently consumption can be attributed as shown in the graphs below.





This energy model was used to estimate the energy consumption impact of various possible modifications to the building.

6 AS-FOUND CONDITIONS

6.1 General Description

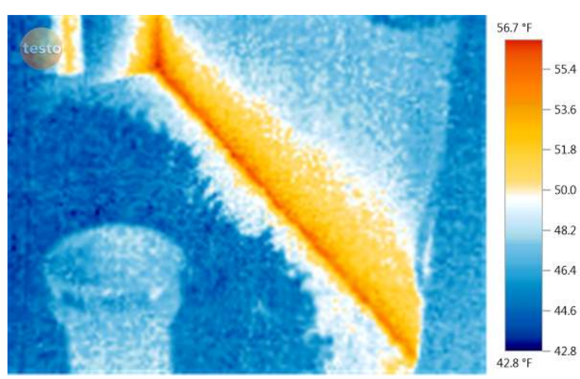
Floor	*Common Space*	*Living Units*	*Total*
Basement	Mechanical Room Electrical Room	None	1,474 sq. ft.
1	Rental Office & Lobby Community Room Kitchen/Bathroom Laundry Room Compactor Room Maintenance Room Corridors & Elevator	None	5,609 sq. ft.
2 to 11	Trash Room & Janitor Closet Corridors & Elevator	14 Units Per Floor (140 total)	6,310 sq. ft.
Roof	Elevator Room Stairwell	None	548 sq. ft.
Total		140 units	***70,731 sq. ft.***

City Senior Tower Utilization and Approximate Floor Area

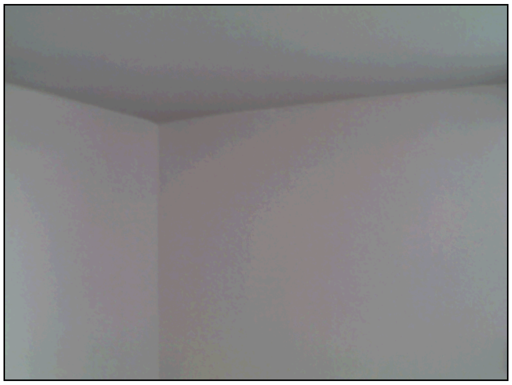
6.2 Building Envelope - Insulation

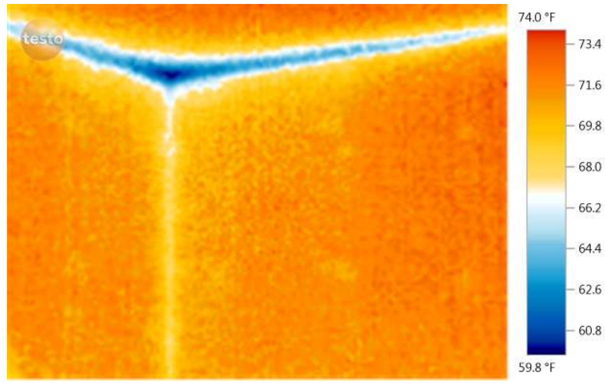
Location	*Structure*	*Insulation*	*Verification Method*
Foundation	Concrete Slab Floor Concrete Block Basement Walls	None	Visual & Thermal Imaging
Above Grade Walls	Precast Concrete Panels	Rigid Foam Sheets between Metals Studs and Concrete Panels	Visual & Thermal Imaging
Roof	Concrete Slab	Rigid Foam Under Membrane	Visual & Thermal Imaging

Thermal imaging shows significant heat loss at the first floor slab, indicating that no slab insulation is present. (Note the warm yellow/orange streak where the slab meets the landscaping.)

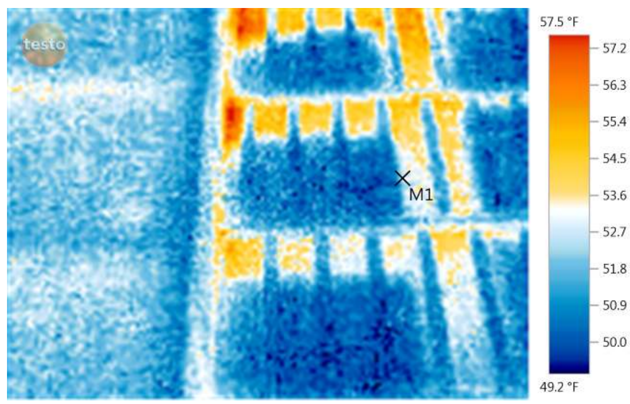


The manager noted that, during maintenance tasks, rigid insulation has been found between steel studs and the exterior concrete wall panels. This was verified during visual inspection in one apartment. Thermal imaging also confirms the presence of this insulation. The steel studs are visible as the coldest areas. The cavities between them are clearly insulated because they are warmer.

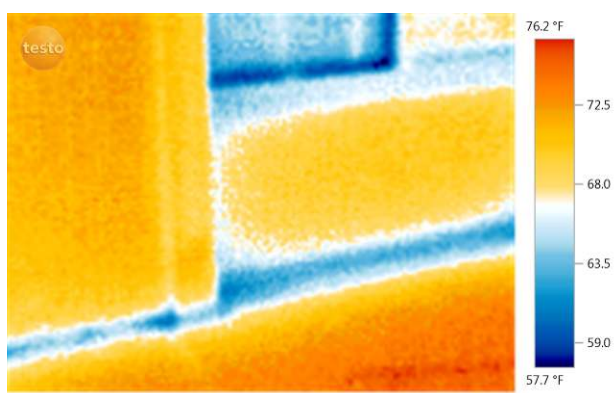




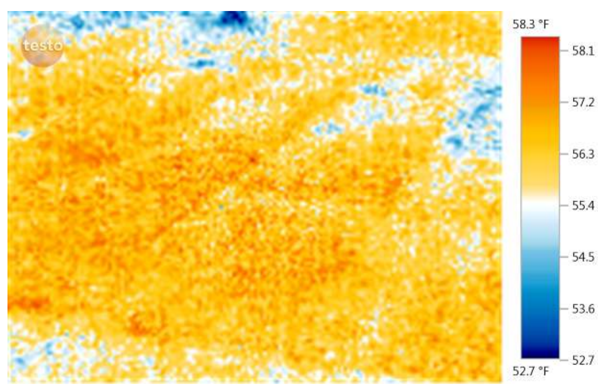
Thermal imaging on the exterior shows significant heat loss through the edges of the slabs where they protrude between the wall panels at each floor. This is also visible at the ceiling/wall junction in the interior image above.



Solid panels are located below the windows in the apartments. These appear to be 0.75 – 1.0 inch thick with metal cladding. Thermal imaging indicates that they provide insulating value comparable to the adjacent walls.



Based on visual inspection, it appears that a layer of rigid insulation was installed under the membrane when the roof was replaced. The roof membrane is 6+ inches higher than the exposed slab in the adjacent stairwell. In addition, thermal imaging shows little heat loss through the roof, supporting the conclusion that insulation is present.



Discussion:

Based on the visual inspection and thermal imaging, the building has reasonable insulation levels in most locations. Improvements to the ceiling and slab would not be cost effective. Significant heat loss is occurring through the walls. However, adding insulation would be expensive and invasive.

No changes are recommended.

6.3 Building Envelope – Windows & Doors

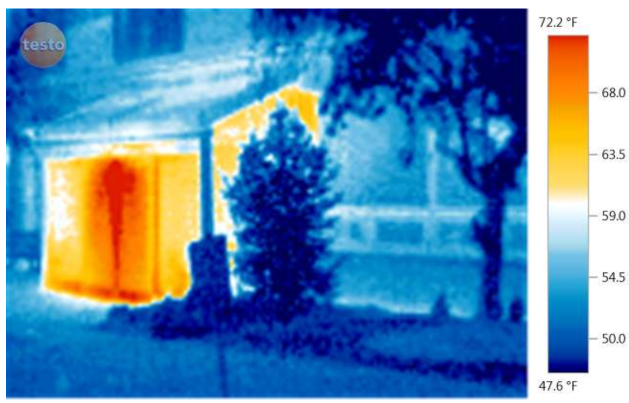
Location	***Qty***	***Type***	***Verification Method***
1st Floor Lobby	2	Aluminum Frame Single-Pane Glass	Visual
Stairwell Exits	2	Steel, Fire-Rated Small Window, Single Pane Transom and Sidelight	Visual
Community Room And Mechanical Room	2	Steel, Fire-Rated No Glass	Visual
Compactor Room	1	Roll-Up Door Uninsulated	Visual
Roof Exit	2	Steel, Fire-Rated Small Window, Single Pane	

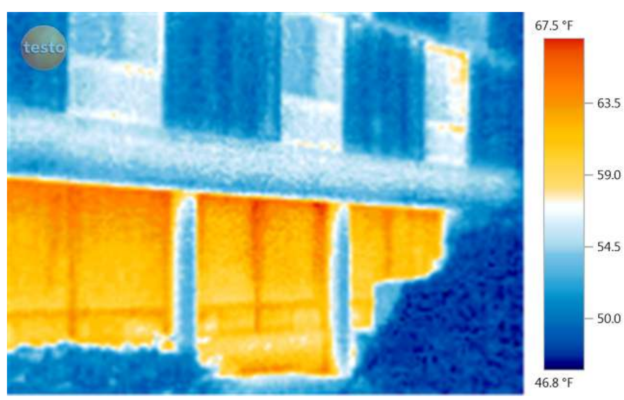
Doors

Location	***Qty***	***Type***	***Low E Coating***	***Verification Method***
Vestibules	2	Fixed, Storefront-Type Aluminum Frame Single Pane Glass	No	Visual
Lobby Community Rm. Maint. Rm.	18	Awning & Fixed, Storefront-Type Aluminum Frame Single Pane Glass	No	Visual
Rental Office	8	Awning & Fixed, Storefront-Type Aluminum Frame 2-Pane Glass, 5/8” Gap	Yes	Visual
Apartments Corridors	170	Slider Aluminum Frame w/Break 2-Pane Glass, 5/8” Gap	Yes	Visual

Windows

Thermal imaging shows significant heat loss through the single pane windows in the vestibule and community room. (Note the cooler surfaces on the double pane windows in the apartments and rental office.)





Lobby/Community Room Windows:

Apartment Windows:

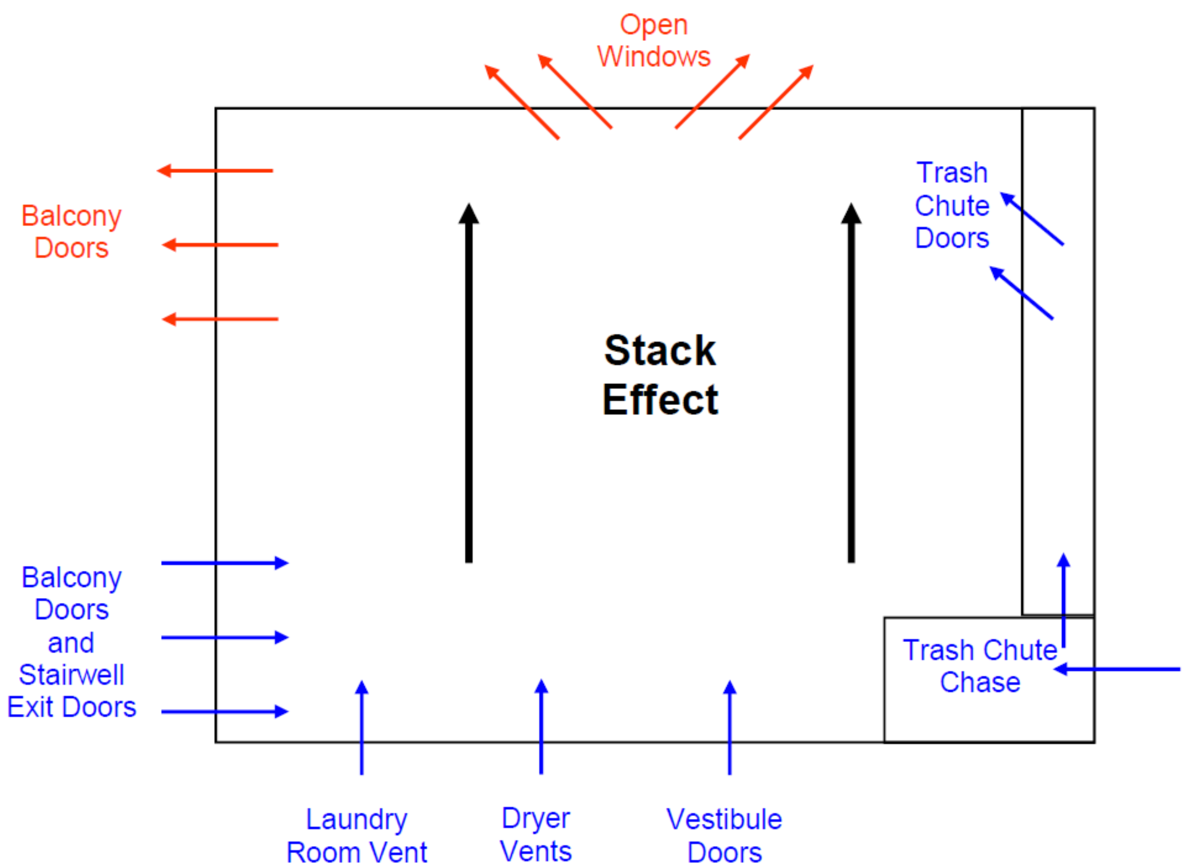
Discussion:

The windows in the apartments and rental office have double pane glass and are in good working order.

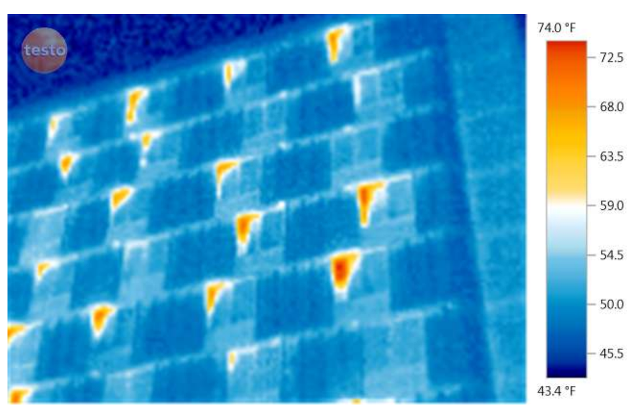
Most of the first floor windows are original single pane units. They have aluminum frames with no thermal breaks and are a significant source of heat loss. See ECM #9 for details.

Building Envelope – Air Leakage

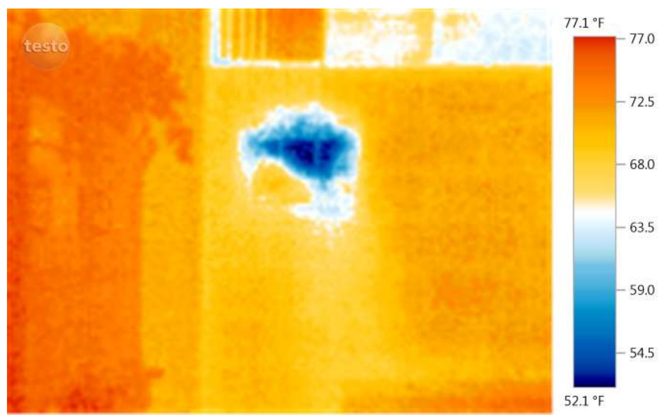
Air leaking through openings in the building shell can be one of the largest sources of heat loss in a building. Numerous significant air leakage pathways were identified. These are summarized in the diagram below:

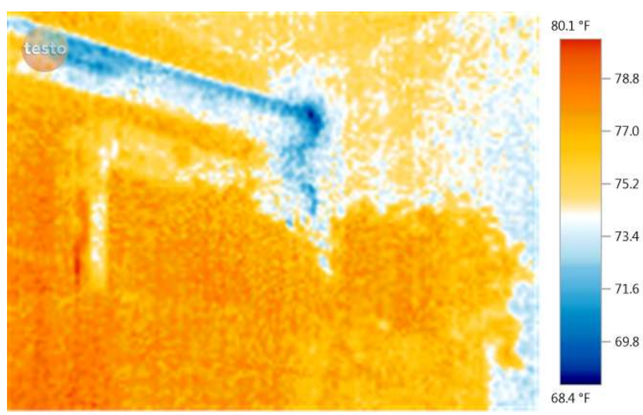


- By far the largest contribution to air leakage in the building is occupants opening windows because the spaces are warmer than desired. The thermal image below shows the pattern of open windows on a 50°F morning.

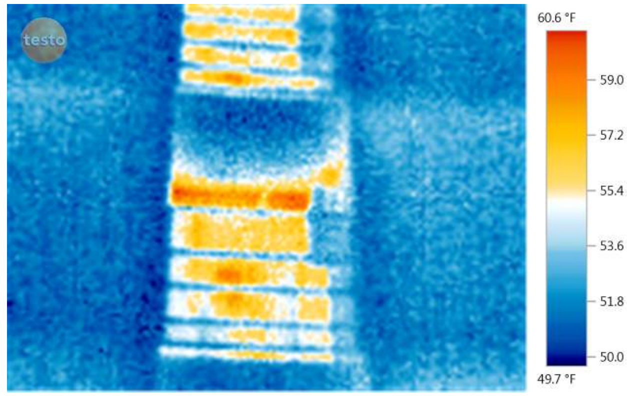


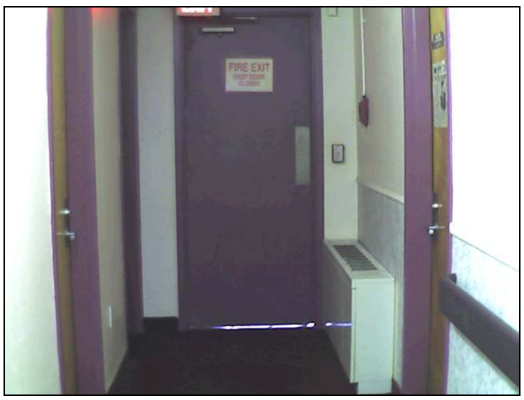
- A significant amount of outside air enters the laundry room through a ventilation opening in the wall and through the dryer outlet vents. The outlet vents are designed to be installed vertically, but are instead mounted horizontally. As a result, the integral back draft dampers do not work.

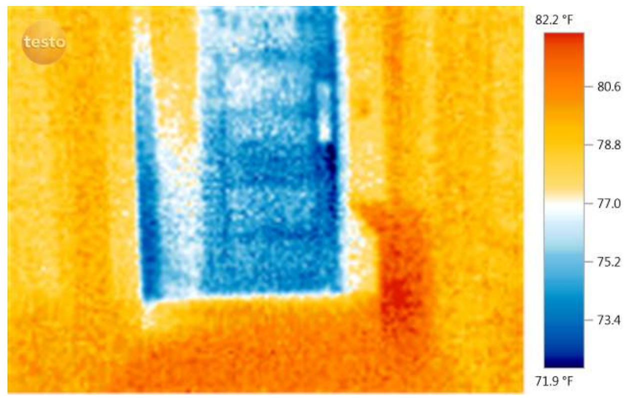




- The doors leading from the west corridors to the stairwell balconies have no weather strips or sweeps. Thermal imaging shows that they are a significant source of heat loss.



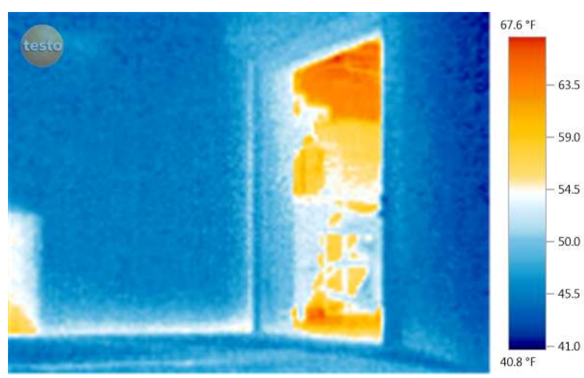




- The doors at the base of each stairwell are not sealed with weather strips or sweeps.

- The weather strips on the main entry doors are wearing and losing effectiveness.

- The trash chute is not well sealed. A large opening around the chute in the compactor room allows air to enter the building through the chase around the chute. In addition, the trash chute doors have no weather strip to stop air from flowing up from the compactor rooms into the trash rooms. This issue is exacerbated by the exterior door on this room being often left open.



Discussion:

In general, the building is reasonably well sealed. However, there is some potential for improvements.

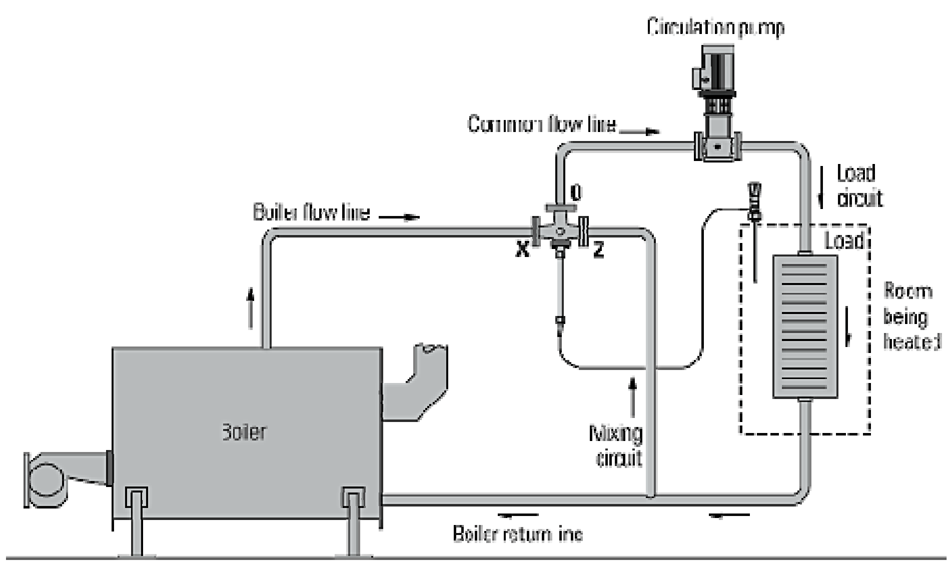
The largest concern is in reducing the overheating that is causing residents to open their windows during the heating season. See ECM #7 for recommendations.

Other air sealing recommendations are detailed in ECM #4.

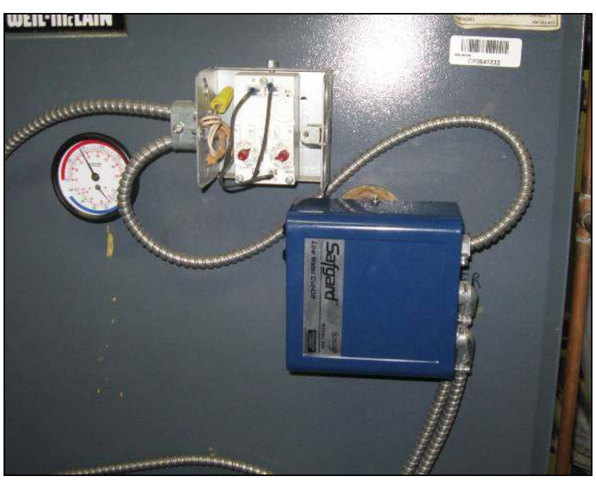
6.4 Heating Systems

The building is primarily heated by a central hot water boiler system.

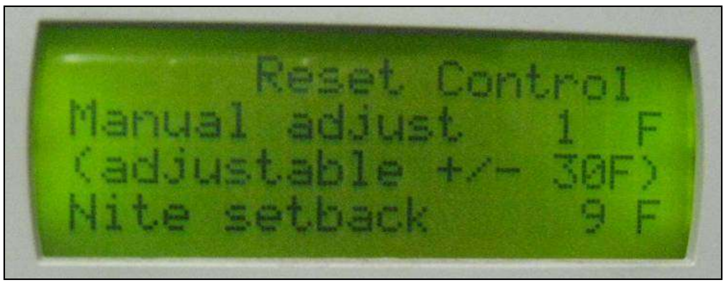
Component	***Description***	***Make & Model***	***Notes***
Boilers (Qty. = 2)	Atmospheric Vented (Fan Assisted) Natural Gas, Cast Iron Sectional Hi/Lo Modulating Burner 2,396,000 btu/hr *input* 1,904,000 btu/hr *output*	Weil-McLain 888 *(With PowerFlame WCR2-G0-20A Burner)*	• Rated at 80% Thermal Efficiency • Actual combustion efficiency measured at 83% on both boilers. • Capable of using natural gas or light oil. • Currently used with natural gas only.
Boiler Controls	Outdoor Reset Controller	t.a.c. Xenta	• Set to begin heating at 65°F outdoors. • Heating water starting temp. is 120°F. • Reset ratio: 1.3 : 1 • Integral boiler module staging control. • Night setback capability used to reduce loop temperature 9°F at night. *(See graph later in this section for comparison to recommended settings.)* *(Also controls mixing valve for domestic water heating. See Section 6.5 for details.)*
	Internal Boiler Controls	Weil-McLain	• Utilize aquastats, along with signal from t.a.c. Xenta controller, to fire and maintain set points (165 to 190°F). • Modulate firing of burners to minimize short cycling.
Loop Type	Primary/Secondary	Armstrong ¾ hp Circulators & Honeywell VGF21ES30 Mixing Valve	• Circulators move primary loop water through boilers. • Mixing valve adjusts to add boiler loop water to secondary (house) loop as needed to maintain target temperature determined by control system.



Boilers, Burner, and Internal Controls:



Outdoor Reset Controller:



Primary Loop Pumps & Mixing Valve:

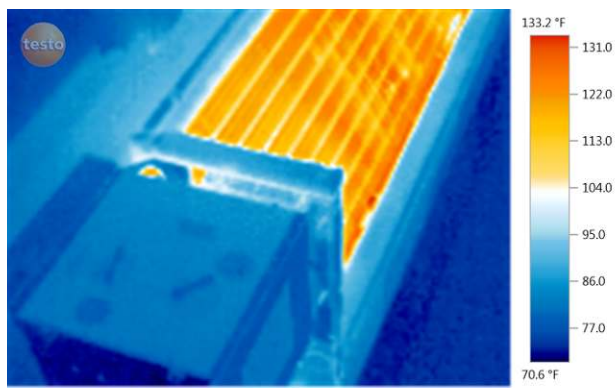
Heating loop water is pumped to terminal units in conditioned spaces around the building:

Component	***Make & Model***	***Notes***
Main Loop Pumps, 3-piece 7.5 hp (Qty = 3)	B&G 1510 BF	• Distribute heating loop water to fan coils throughout building. • Two pumps run at all times during heating season. • Third pump serves as backup.
Lobby Baseboard Pump, 3-Piece ¼ hp	Armstrong 816032-000	• Distributes heating loop water to baseboards in the lobby. • Runs at all times during heating season.
Baseboard Pump (Other Locations) ¾ hp (Qty. = 2)	Armstrong 816032-000	• Distributes heating loop water to other baseboards in the building. • One runs at all times during heating season.
Piping	Various	• Numerous sections lack insulation.
Fan Coils (in Apartment Living Rooms)	XpediAir VCA	• Vertical cabinet fan coils. • Include both fan controls and zone valves to stop water flow through the coils when thermostat set points are satisfied. • Zone valves include bypasses to ensure total loop flow remains constant. (This eliminates potential savings from adding VFD control to the heating loop pumps.) • Controlled by integral thermostats. • Zone valves (or thermostats) were not working properly in 33% of visited apartments. In most cases, they were always allowing water to flow through the coils.
Fan Coils (in Rental Office)	McQuay FTSF	• Vertical cabinet fan coils. • Controls only adjust operation of fans. • Loop water always flows through coils (no zone valves). • Controlled by integral thermostats.
Baseboards (in Lobby and Community Room)	Not Visible	• No thermostats/zone valves present.
Air Handler with Hot/Chilled Water Coil (Serving Community Room & Lobby)	McQuay CAH008GBAC with t.a.c. Xenta Controller 4 hp fan	• Located in Maintenance Office. • Includes both recirculation (return from corridor) and fresh air intake. • Fan runs at all times. • Mixing valves regulate heated/chilled water flow to maintain room temperature. • Damper in return ducts determine mix of recirculated and fresh (outside) air. • Controller allows night setback, but currently RAISES temperature at night in winter.
Fan Coil (in Compactor Rm)	Ceiling Mounted	• Running during site visits while bay door was left open.

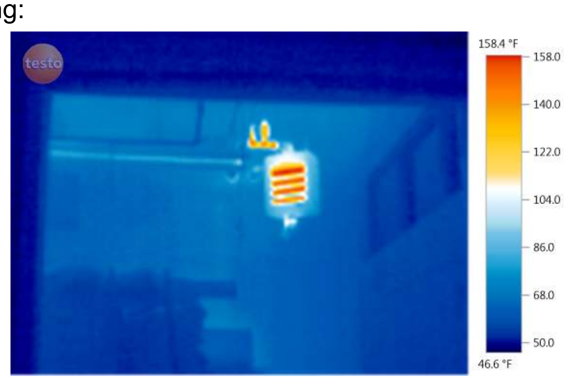
Heating Loop Pumps:

Apartment Fan Coils:

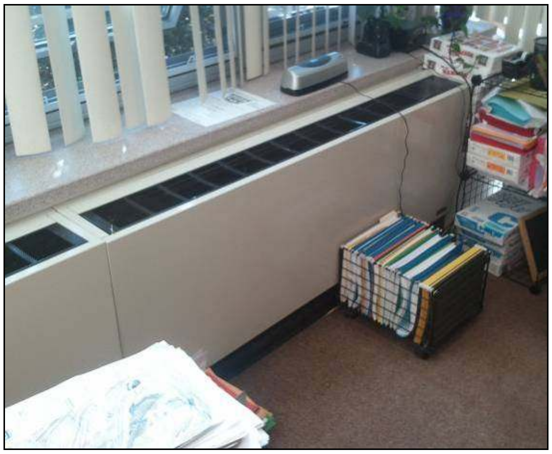
Controls Off, But Coil Hot:



Compactor Room – Door Open, Fan Coil Running:

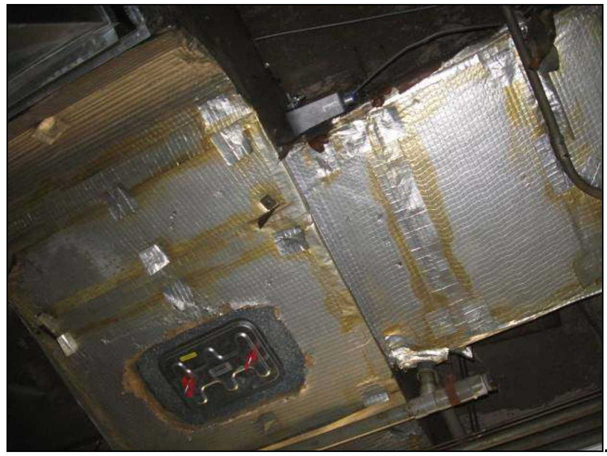


Office Fan Coils:

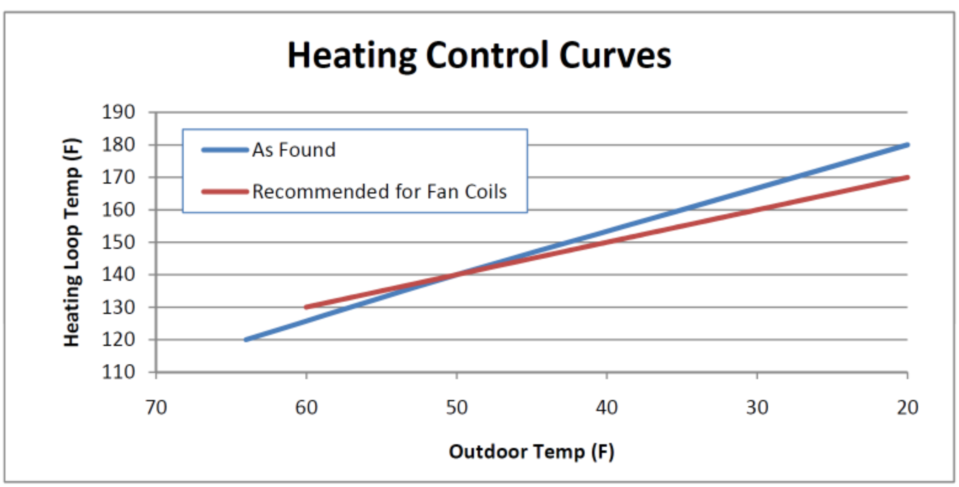


Lobby/Community Room Baseboards:

Community Room Air Handler:



The graph below shows the heating loop temperature based on the current settings in comparison to settings recommended by a leading control manufacturer (Tekmar) for fan coil distribution systems. The setings for City Senior Tower are reasonable.



Discussion:

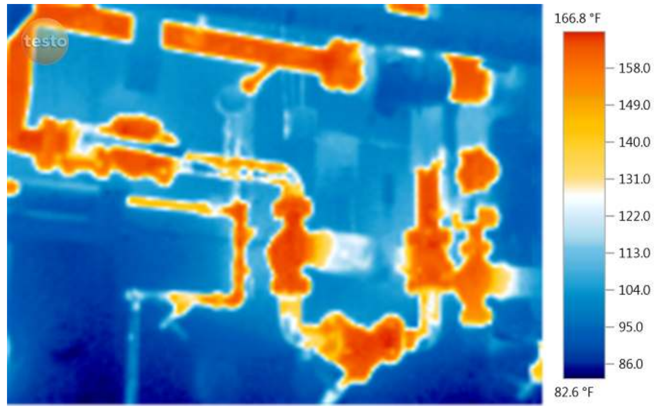
The apartment fan coils have valves to stop water from flowing through them when the thermostat temperature setting is satisfied. However some of these valves and thermostats are not functioning properly, resulting in overheating of the spaces. In addition, in numerous apartments, the residents had the fan coils operating AND the adjacent windows open.

The fan coils in the office area, as well as the baseboards in the lobby and community room, have no valves to stop water from flow through the coils. Heating (or chilled) water flows through them at all times, resulting in excessively warm temperatures in the winter.

Several ancillary components ensure the correct operation of the system:

Component	***Description***	***Notes***
Auto-Fill	Pressure Regulator & Check Valves	• Automatically fills system and maintains correct pressure.
Expansion Tank (Qty. = 2)	Original to Building	• Non-Bladder type with sight glass. • Functioning correctly at site visit.
Air Elimination	Only at Terminal Units	• Appears to be functioning properly.
Combustion Air	Wall Room Vents	• A supply vent with louvers is located in the electrical room adjacent to the boiler room. • An exhaust vent with a thermostatically controlled fan is located adjacent to the mechanical room door.

Significant heat loss was noted from hot water piping into the boiler room. Most of this heat is lost as boiler room air flows up the flue pipe and out of the building.



Other heating equipment:

Wall mounted electric resistance heaters are used to maintain the temperature in the stairwells during the heating season. A total of 6 units are installed. One is located on the 1st, 5th, and 10th floor of each stairwell. They are Dayton #5E185D models with an output capacity of 1500W. Each has an integral thermostat (set to "Low").

The vestibules are heated by Berner MK1-1-48E air curtain heaters. They have integral thermostats and are rated at 9500 watts.

Discussion:

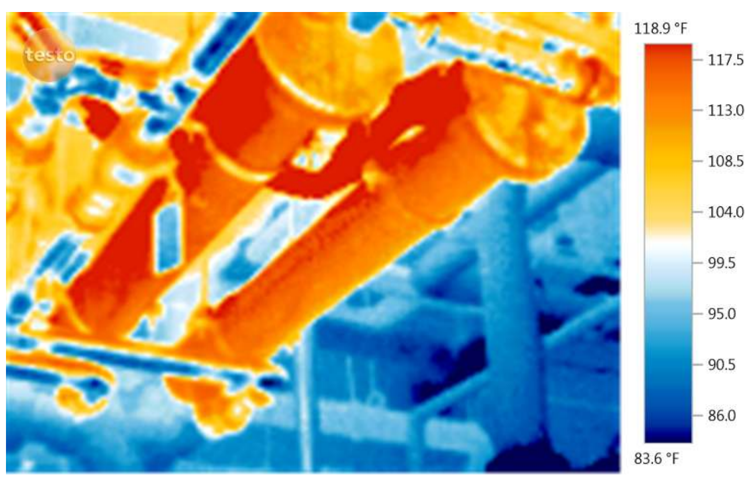
Numerous opportunities exist to improve the operation of the heating systems. See ECM's #7 & 8 for details.

6.5 Domestic Hot Water System

Domestic hot water is heated by two tankless coils connected to the central hot water boiler system:

Component	Make & Model	Notes
Boiler	See Section 6.4	• Uses space heating boiler.
Tankless Coils (Qty. = 2)	Thrush 73710	• Hung from ceiling of boiler room. • Not insulated.
Heating Water Pump	Armstrong ¾ hp	• Water from the boiler primary loop is continually recirculated through the tankless coils.
Controls	t.a.c. Xenta Controller and Honeywell VGFZ18525 Mixing Valve	• A mixing valve is used to either re-circulate the same heating water through the tankless coils, or blend in newly heated water from the boilers. • The mixing valve is adjusted to maintain the necessary proportion of recirculated heating water by the same controller used for the heating system. • Domestic hot water from the coils is delivered directly to the building (without being mixed with cold water). • Thermometers indicated the hot water leaving the tankless coils was 115-120°F at site visit. • Water to apartments averaged 117°F at site visit.
Recirculation Pump	B&G 13S J68 ½ hp	• Ensures hot water present throughout building. • Controlled by thermostat. Setting at site visit was 240°F, so it runs at all times.
Expansion Tank	None	• Should be present to moderate system pressure as water temperature changes.

Tankless Coils:



Heating Water Pump and Mixing Valve:

Recirculation Pump and Control:

Discussion:

Several opportunities exist to improve the operation of the water heating system. See ECM's #2 & 8 for details.

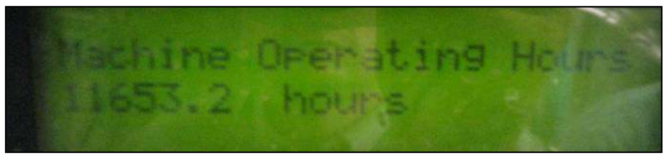
6.6 Cooling Systems

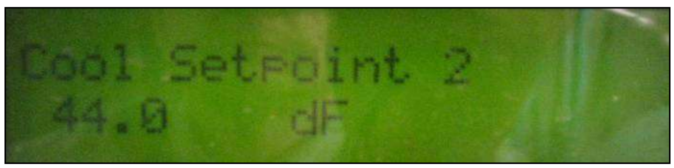
The building is cooled by a central chiller system:

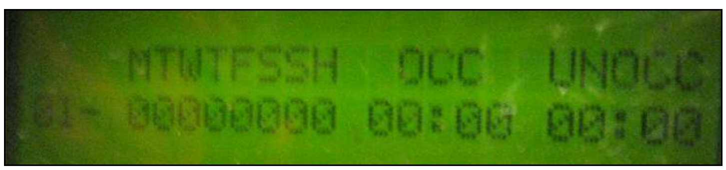
Component	Description	Make & Model	Notes
Chiller	Water Cooled, 106 Ton R134A Refrigerant	Carrier 30HXC106NY-530 *(Mfg. in 2000)*	• Hermetic Twin-Screw Compressor • Run time at site visit: 11,633 hrs • Est. efficiency = 0.55 kW/ton (IPLV value per ARI Std. 550-92. This is equivalent to an EER of 22). • All cold surfaces insulated.
Cooling Tower	Roof Mounted	Baltimore Air Coil FXT-99C	• One 7.5 hp axial fan.
Chilled Water Pump	3-Piece	B&G 1510 BF (7.5 hp)	• Runs at all times. • Heating pumps serve as backup.
Cooling Tower Pump	3-Piece	American Marsh 2.5x3-10 (10 hp)	• Runs when chiller is running.
Expansion Tank		Original to Building	• Non-Bladder type tank. • Appears to be functioning properly.
Chiller Controls		Integral	• Outdoor reset and night setback functions are available, but are not being used. • Chilled water set point fixed at 44-46°F.
Cooling Tower Controls		Integral	• Runs when chiller is on.
Distribution	Same as Heating		• See Section 6.5, except separate chilled and hot water pumps are used.

Chiller:

Chiller Control Readout:







Chilled Water and Cooling Tower Pumps:

Cooling Tower:

Discussion:

The cooling system is generally operating at high efficiency. However, utilizing the night setback function available on the chiller would reduce electric consumption. See ECM #8 for details.

6.7 Ventilation Systems

City Senior Tower has minimal ventilation:

Location Served	Type	Make & Model	Notes
Apartment Bathrooms	Ceiling Fans	ILG Model 3840	• Vented through side walls of building. • Run when bathroom lights are turned on. • See text below for measured flows. • Average flow = 14 cfm.
1st Floor Bathroom	In-Line Fan	Not Visible	• Vented through side wall of building. • Non-functional at site visit.
Community Room and Lobby	Air Handler with Fresh Air Intake	McQuay F.STF.2.506.A.A with t.a.c. Xenta Controller 4 hp fan	• Fan runs at all times. • Economizer control and damper in return ducts used to control mix of recirculated and fresh (outside) air. Therefore, no fresh air is supplied during the hottest and coldest periods. • Average fresh air flow est. 200 cfm.
Laundry Room	In-Line Fan	Not Visible	• Vented through side wall of building. • Non-functional at site visit.
Compactor Room	None	N/A	
Elevator Room	None	N/A	• Fan originally mounted in ceiling, but removed. Now only a passive vent.

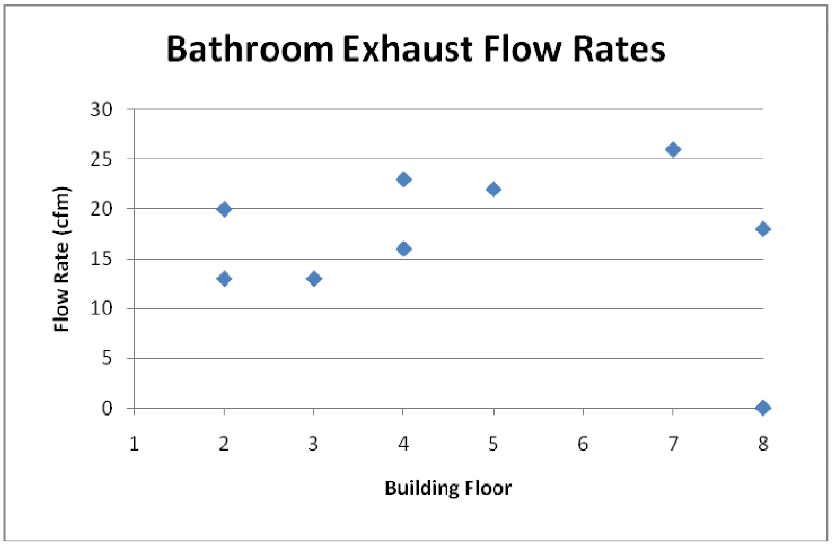
Apartment Bathroom Fans and Side Wall Vents:

Community Room Fresh Air Supply:

Laundry Room and First Floor Bathroom Fans (no longer operational):

Elevator Room Vent:

The actual bathroom and kitchen exhaust flows were measured in each visited apartment. Bathroom flows averaged 14 cfm and ranged from 0 to 26 cfm. Because of the side wall venting, little variation in flow was measured from floor to floor. Fan condition was a more significant factor. In 3 of the 14 visited apartments, the fans were non-functional. In most others, they were loud enough to deter residents from using them.



Discussion:

Ventilation plays a crucial role in the effective operation of building. Spot ventilation is necessary to remove moisture and contaminants at their source (usually kitchens and bathrooms). In addition, fresh air ventilation is required to exhaust residual contaminants and provide some outdoor air for the health of the occupants. However, ventilation has an energy penalty. Any outdoor air brought into a building must be heated or cooled from the outside temperature to the comfortable level maintained in the building. Therefore, ventilation must be carefully considered and implemented to balance these competing concerns.

The 2009 Int'l Mechanical Code requires:	Spot Ventilation in Kitchens and Bathrooms
	15 cfm - Fresh Air per Occupant in Apartments
	- (15 cfm in Efficiency, 30 cfm in 1BR)
	0.06 cfm - Fresh Air per Square Foot of Common Areas

Stephen Smith Tower has a very low ventilation rate by current standards. Bathroom fans, open windows, and air leakage through the building shell provide what minimal ventilation that does occur.

See measures H&S #1 and ECM #1, for detailed recommendations aimed at providing ventilation close to these levels while minimizing energy consumption.

6.8 Common Area Lighting

Interior common area lighting is summarized below:

Location	*Type*	*Qty. Fixtures*	*Watts per Fixture*	*Est. Hours per Day*	*Measured Intensity (fc)*	*Rec. Intensity (fc)*	*Est. Annual Consumption (kWh)*	*Control Type*
Corridors - First	Troffer, T8 Fluorescent, Electronic	4	55	24	7 to 35	5 to 10	1,927	Breaker
Corridors - First	Exit Sign, Incandescent	4	30	24			1,051	Breaker
Corridors - 2 to 8	Cove, T12, 3 ft., Magnetic	10	74	24	2 to 11	5 to 10	6,482	Breaker
Corridors - 2 to 8	Cove, T12, 6 ft., Magnetic	10	130	24	2 to 30	5 to 10	11,388	Breaker
Corridors - 2 to 8	Cove, T12, 8 ft., Magnetic	60	140	24	2 to 30	5 to 10	73,584	Breaker
Corridors - 2 to 8	Exit Sign, 2-pin CFL	20	20	24			3,504	Breaker
Stairwells	Incandescent & CFL	48	52	24	1 to 8	3 to 5	21,865	Breaker
Stairwell Exit	Exit Sign, Incandescent	2	30	24			526	Breaker
Lobby	Troffer, T12 Fluorescent, Magnetic	24	107	24	20 to 42	5 to 10	22,496	Breaker
Vestibule	Sconce, Incandescent	2	60	12		30 to 50	526	Timer
Vestibule	Sconce, CFL, Magnetic	2	15	12		30 to 50	131	Timer
Vestibule	Ceiling, CFL	1	26	12		30 to 50	114	Timer
Rental Office	Troffer, T8 Fluorescent, Electronic	6	82	10	60 to 100	30 to 50	1,796	Manual
Rental Office	Recessed, CFL, Electronic	3	36	10	60 to 100	30 to 50	394	Manual
Bathroom - 1st Fl.	Vanity, T12, 4ft, Magnetic	2	82	10		30 to 50	599	Manual
Bathroom - 1st Fl.	Vanity, T12, 18", Magnetic	1	30	10		30 to 50	110	Manual
Security Desk	Surface, T12 18", Magnetic	4	30	24		30 to 50	1,051	Breaker
Comm. Rm	Ceiling, CFL	10	28	8		30	818	Manual
Comm. Kitchen	Ceiling, T12, 4 ft, Magnetic	4	82	12		30 to 50	1,437	Manual
SS Office	Ceiling, Incandescent	3	120	8		30	1,051	Manual
SS Office	Ceiling, T12, 4 ft, Magnetic	2	164	4	50	30 to 50	479	Manual
Trash Rms	Incandescent & CFL	10	46	24		30	4,030	Manual
Laundry Rm	Ceiling, T12, 4 ft, Magnetic	3	105	20	10 to 18	30 to 50	2,300	Manual
Compactor Rm.	Ceiling, T12, 8 ft, Magnetic	1	150	10		30 to 50	548	Manual
Compactor Rm.	Sconce, CFL	2	25	10		30 to 50	183	Manual
Compactor Rm.	Bug Light, T12, 4 ft, Magnetic	1	82	24			718	Breaker
Maint Rm.	Ceiling, T12, 8 ft, Magnetic	3	150	10		30 to 50	1,643	Manual
Mechanical Rm.	Ceiling, T12, 4 ft, Magnetic	2	82	1.0		30 to 50	60	Manual
Mechanical Rm.	Ceiling, T12, 4 ft, Magnetic	1	82	24.0		30 to 50	718	Manual
Mechanical Rm.	Ceiling, T12, 8 ft, Magnetic	2	150	1.0		30 to 50	110	Manual
Mechanical Rm.	Exit Sign, Incandescent	2	30	24.0			526	Breaker
Electrical Rm	Ceiling, Incandescent	1	13	24		30 to 50	114	Manual
Cable/TV Room	Ceiling, CFL	1	13	24		30 to 50	114	Breaker
Elevator Rm	Ceiling, T12, 4 ft, Magnetic	3	82	0.5		30 to 50	45	Manual
Elevator Cars	Recessed, 2-pin CFL	8	60	24		5 to 10	4,205	Breaker

Locations with the highest usage are highlighted in yellow.

Corridor Lights:

Stairwell Lights:

Other Common Area Lighting:

Exterior Lighting is Summarized Below:

Location	Type	Qty. Fixtures	Watts per Fixture	Est. Hours per day	Annual Consumption (kwh)	Control
Flood - Large	Wall Mount, Mercury Vapor	4	175	12	3,066	Timer
Boiler Rm. Door	Wall Mount, Mercury Vapor	1	175	0.5	32	Manual
Balcony Ceiling	Surface Mount, Incandescent	11	120	0	0	Manual
Flood - Small	Sconce, High Pressure Sodium	2	50	12	438	Photo Cell
Flood - Small	Sconce, Incandescent	2	60	12	526	Photo Cell
Elevator Rm Door	Sconce, CFL	1	13	24	114	Manual

Locations with the highest usage are highlighted in yellow.

Discussion:

Common area lighting is a significant contributor to the very high electric consumption at City Senior Tower. This is the result of several circumstances:

- Lights are on 24 hours per day in locations where they don't need to be.
- Spaces are lit to higher levels than necessary for the tasks done in those areas.
- Inefficient incandescent lamps or magnetic ballasts are utilized in fixtures that are on 8 or more hours per day.
- Lights are left on in areas that are rarely occupied.

Numerous improvements are recommended. See measures H&S #4 and ECM #6 for details.

6.9 Apartment Lighting

Lighting in each apartment is summarized below:

Location	*Type*	*% Apts Found In*	*Qty. Fixtures*	*Qty. Lamps*	*Average Fixture Wattage*	*Measured Intensity (fc)*	*Rec. Intensity (fc)*
Kitchen - Ceiling	Incandescent	100%	1	2	120	6 to 47	25 to 50
Bath – Vanity	Incandescent	100%	1	1 to 2	120	12 to 30	25 to 50
Bath – IR Heater	Infrared/Incandescent	100%	1	1	250		
Hall & Closet – Ceiling	Incandescent	100%	2	4	120		

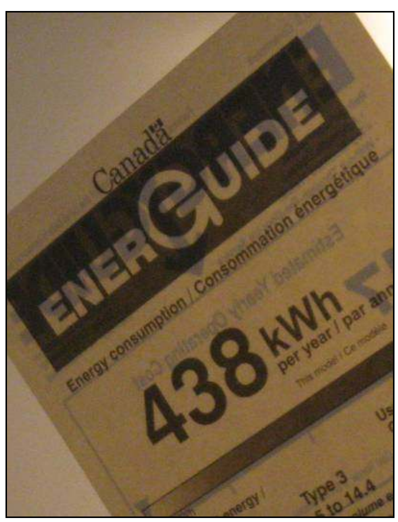
Discussion:

Apartment lighting is entirely incandescent. Compact fluorescent lamps (CFL's) can provide comparable lighting with 75% less electric consumption. See ECM #6 for details.

6.10 Appliances

Appliances in the building are summarized below:

Location	*Type*	*% Apts Found In*	*Est. Qty in Bldg*	*Notes*
Apartments	Range	100%	140	Gas
	Refrigerator (2008-2010 Models)	38%	54	Sears/Kenmore & Estate Models 438 to 443 kWh per year
	Refrigerator (2000-2005 Models)	31%	43	Sears/Kenmore Models 478 to 644 kWh per year
	Refrigerator (pre-2000 Models)	23%	32	Kenmore 253.963011 800 kWh per year
	Refrigerator (Small – 12 cu.ft. - Model)	8%	11	Kenmore 61042 331 kWh per year
Community Rm	Refrigerator		1	Frigidaire FFHT1826LS0 Energy Star Labeled 383 kWh per year
	Dishwasher		1	Not Energy Star Labeled
	Range		1	Gas
	Vending Machines		2	Soda Dispenser & Snack Machine
Laundry	Clothes Washers		3	Speed Queen SWFX61WN Energy Star Labeled
	Clothes Washers		2	Whirlpool CFM2762KQ0 Standard Eff., Top Load
	Clothes Dryers		5	Gas



Discussion:

Most of the refrigerators in the building were installed in 2000 or later and use a moderate amount of electricity. However, a few inefficient 1990's models remain. See ECM #10 for recommendations.

The laundry facilities (on each floor) have some low efficiency top-loading washers. Replacing them with Energy Star labeled models would reduce energy consumption, but it is not justified at current utility rates.

6.11 Elevators

The building utilizes two traction elevators:

Component	Description	Make & Model	Notes
Cars (Qty. = 2)	Counter Weighted	2500 lb Capacity	• Aging models. Not retrofitted in recent years.
Motors (Qty. = 2)	240V DC 15 hp, Gear Drive	Imperial 324EDH015A009	• Aging models. Not retrofitted in recent years.
System Controls (Qty. = 2)	Analog	MEC VVMC-1000-PTC	• Aging models. Not retrofitted in recent years.

Discussion:

The elevators utilize inefficient gear drives, analog controls, and DC motors. However, they use little energy relative to the cost of potential improvements.

When the elevators are overhauled for maintenance reasons, the following should be considered to attain the highest possible level of energy efficiency:

- *Install an advanced control system that utilizes usage data to determine optimum elevator positioning to minimize energy use.*
- *Install variable voltage, variable frequency motors.*
- *Install a regeneration system to convert load/counterweight imbalances into electrical energy that can be utilized in other parts of the building.*
- *Convert the drive system to non-geared operation. This can be done most simply by installing a larger sheave (there appears to be adequate space in the elevator room). Alternatively, a system like Otis Gen2 or ThyssenKrupp Synergy could be installed.*

6.12 Water Use

Apartment water fixtures are summarized below:

Location	Avg. Flow Rate	Range	Recommended Flow Rate
Kitchen Faucet	2.3 gpm	1.5 to 5.0 gpm	1.5 gpm
Bathroom Faucet	2.4 gpm	2.0 to 4.5 gpm	1.5 gpm
Showerhead	2.6 gpm	2.0 to 3.5 gpm	1.75 gpm
Toilet	1.7 gpf	1.6 to 3.5 gpf	1.6 gpf

Discussion:

Many of the water fixtures are aging. A large number of the faucet aerators and shower heads are inefficient by modern standards. Inexpensive replacements are available that will reduce both water use and water heating energy consumption. See ECM #5 for details.

Booster Pumps:

The building uses two 7.5 hp pumps to boost the domestic cold water pressure so that it is adequate to reach the top floors. Both run at full speed at all times.

Discussion:

These pumps are a significant contributor to the high electric consumption at City Senior Tower.

Variable frequency drives (VFD's) can be used to modulate the input power of pumps, providing minimal boost when demand is low and more during periods of peak demand. This provides more consistent water pressure and significantly reduces pump energy consumption.

See ECM #3 for details.

6.13 Health & Safety

Carbon Monoxide:

- No measurable ambient carbon monoxide was detected at any locations in the building.
- Smoke detectors are installed in each apartment, but no carbon monoxide detectors were noted in the building.
- The central boilers were tested and found to be generating carbon monoxide at levels lower than the 25 ppm action level specified by the Building Performance Institute.
- Ranges in several apartments were tested and found to be generating carbon monoxide at safe levels (lower than the 100 ppm action level specified by the Building Performance Institute).

Discussion:

Carbon monoxide is a significant health hazard in buildings that utilize combustion appliances. Current building codes require a carbon monoxide detector in each apartment. In addition, ranges should be tested periodically to ensure they are not generating significant levels of carbon monoxide. This is particularly important in buildings with no kitchen spot ventilation.

See measure H&S #2 for details.

Radon:

- No radon abatement system is installed, but the building is located in an area (Metropolis County) with low radon presence.

Moisture:

- Some intrusion of water has been experienced in the apartments at the northeast corner of the building. No clear entry point was noted. However, it appears most likely that it is occurring at either the window frames or the junctions between the wall panels and floor planks.
- Significant water intrusion occurs regularly at the north entry vestibule. The landscaping in this area is graded towards the vesibule. Drain troughs have been installed in the adjacent sidewalks, but they are not adequate to handle the flow during heavy rains.




- Dryers are poperly vented to outdoors.
- Bathrooms are vented to outdoors with ceiling fans vented through channels in the floor planks, but the fans are aging. They are loud and remove an small volume of air. (See Section 6.7.)
- Kitchens are not ventilated.
- The site is graded to effectively move water away from the building.

Discussion:

Repairs are necessary to minimize bulk water intrusion into the building. See measure H&S #3 for details.

The apartment bathroom fans are the primary means of removing humidity from the building. However, their effectiveness has diminished as they have aged. In numerous apartments, they have been disabled due to high noise levels. They should be replaced. See measure H&S #1 for details.

7 Disclaimer

The energy conservation opportunities contained in this report have been reviewed for technical accuracy.

Savings estimates reflect experience with similar and/or past projects and results provided by industry-standard software. However, because energy savings ultimately depend on the lifestyle of the residents, the weather, and many other factors that cannot be controlled, Bone Energy Services does not guarantee the savings estimated in this report. Bone Energy Services shall not, in any event or circumstance, be held liable should the actual energy savings vary from estimated savings.

The recommended modifications to building components and operation are intended as a starting point for the implementation of changes. Significant modifications to a building or its components should be reviewed and certified by a licensed architect or engineer. Compliance with all applicable national, state, and local codes and best practices is essential to realizing expected savings. Applicable codes supersede any recommendations in this report. Bone Energy Services may suggest certain contractors or products that will help attain the necessary energy savings. These entities and/or products are chosen based on experience and/or expertise, Bone Energy Services neither provides compensation, nor is it provided compensation, for any recommended products or services.

APPENDIX:

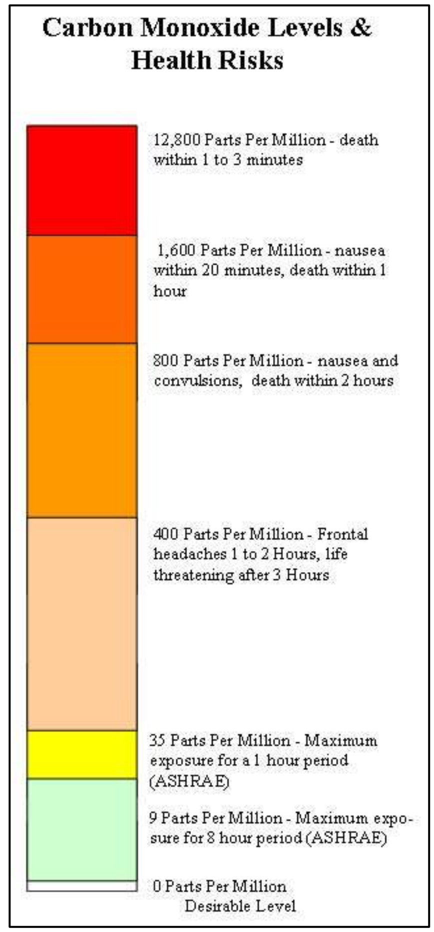
Detailed Descriptions of Recommended Measures

Health and Safety Measures:

_H&S #1_	**_Apartment Bath Fan Replacement_**
Rationale:	The apartments are currently under-ventilated according to the 2009 International Mechanical Code, which requires 15 cfm of continuous fresh air *per occupant*. This fresh air can be provided by bathroom fans which remove stale air and draw in fresh air from the corridors and through leaks in the building envelope. However, the existing fans are aging. They remove an average of only 14 cfm per apartment when powered, which would not be an adequate ventilation rate even if they were run continuously.  Bathroom fans are available that will provide a continuous low level of ventilation air flow, and higher level of flow when necessary to remove moisture and odors from the space. The installation of Energy Star labeled fans will assure consistent flow, low noise, low energy consumption, and long service life.
Proposed Implementation Method:	1. Replace the existing ceiling-mounted fan in each apartment with an Energy Star labeled fan that allows continuous low speed operation and a high speed boost when the bathroom is occupied. 2. Adjust the fan to provide 15 cfm per apartment occupant of continuous flow. 3. Provide a high speed boost of at least 50 cfm that is activated (by the light switch or a motion sensor) when the bathroom is occupied. Leave the fan in boost mode for a preset period (approximately 15-20 minutes) after the occupant leaves the room. One suitable example is the Panasonic WhisperGreen series, which allows the continuous flow rate to be set by a dial on the fan, and the boost to be activated by either a wall switch or an integral occupancy sensor.  Another option is to use a different model of Energy Star labeled fan with a switch designed for ventilation applications, such as the AirCycler SmartExhaust or Tamarack Airetrak CD. After installation, building management can adjust the fan “on-time” or speed to suit the needs of the residents.

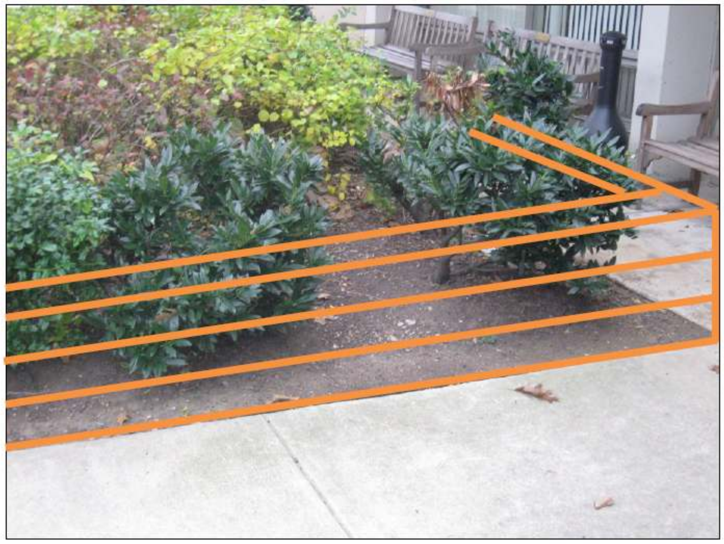
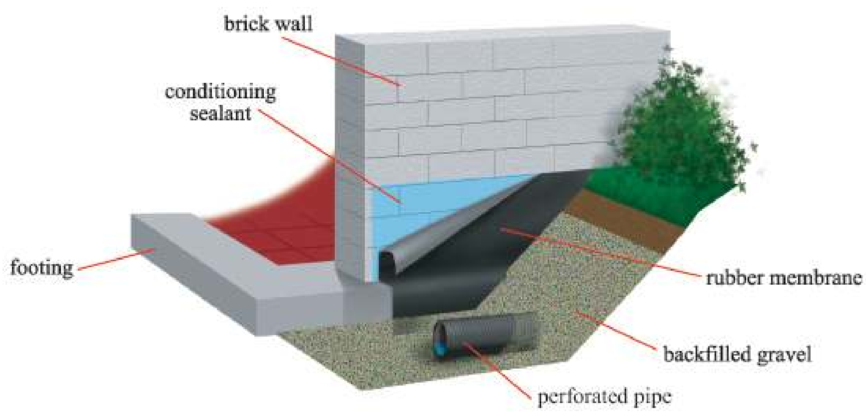
Estimated Implementation Cost:	$ 51,869
Estimated Annual Energy Savings:	**$ -7,611**

H&S #2	Carbon Monoxide Detectors in Apartments/Boiler Rm
Rationale:	The potential exists for significant quantities of carbon monoxide to be generated by the heating boilers or the ranges in the apartments. The building occupants should be protected by detectors which provide an audible warning if the ambient carbon monoxide concentration reaches an unsafe level. A detector should be present in each apartment, as well as in the mechanical room.



Proposed Implementation Method:	Replace the hard-wired smoke detector in each apartment and boiler room with a hard-wired combination smoke & carbon monoxide detector.
Estimated Implementation Cost:	$ 17,400
Estimated Annual Energy Savings:	None

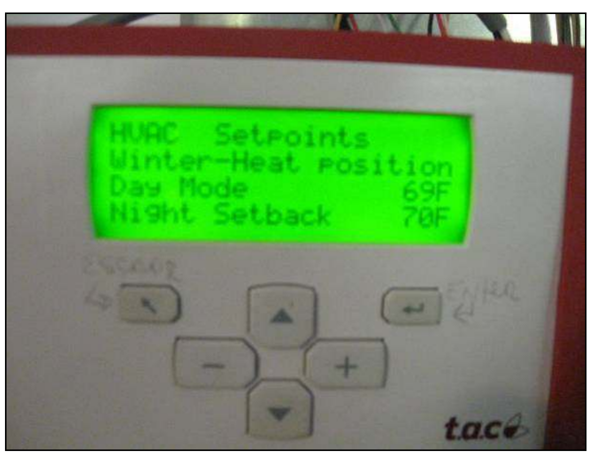
H&S #3	Drainage Improvements – Entry Bathroom Area
Rationale:	Water consistently enters the north entry vestibule during heavy rains. The landscaping in this area is graded towards the vestibule. Drain troughs have been installed in the adjacent sidewalks, but they are not adequate to handle the flow during heavy rains.  
Proposed Implementation Method:	Numerous approaches are possible to alleviate the movement of significant storm water runoff towards the vestibule. The use of a retaining wall and/or swale to divert this water onto a permeable lawn is one potential solution. It is detailed below. *However, any solution implemented to resolve this issue should be designed and approved by a licensed landscape professional.* 1. Build a retaining wall along the line of the existing sidewalk to divert water around the vestibule. 

	2. Ensure that the retaining wall is at least 12" above grade.  3. Ensure that the uphill side of the retaining wall is constructed to properly absorb and divert the volume of water directed towards it. This should include a perforated drain pipe (directing water towards a storm drain or large permeable surface), gravel backfill, and transplanted landscaping. The construction would be similar to the waterproofing scheme typically used against a building foundation wall. 

Estimated Implementation Cost:	$ 12,000
Estimated Annual Energy Savings:	None

H&S #4	***Astronomic Timer for Outdoor Lights***
Rationale:	A timer is used to control some of the exterior lighting. The settings on this mechanical timer require constant adjustment due to changes in sunrise/sunset times. If these adjustments are not done, the lighting may be on during daylight hours, or there may be unlit areas during dark hours. This situation was noted during the site visit at City Senior Tower.  
Proposed Implementation Method:	Replace the existing mechanical timers for the exterior lighting with astronomical timers that automatically adjust for changes in sunrise and sunset times. One suitable model is the Intermatic ET8015C. This will provide more safe (and possibly more energy efficient) operation. 
Estimated Implementation Cost:	$ 408
Estimated Annual Energy Savings:	None

Energy Conservation Measures:

ECM #1	***First Floor HVAC Controls***
Rationale:	The first floor lobby, corridor, and community room are heated and cooled by a McQuay CAH008GBAC air handler located in the maintenance room. It utilizes hot and chilled water from the central boiler and chiller systems, and it has the capability to blend both outside fresh air and recirculated room air into the return stream.  This air handler is controlled by a t.a.c. Xenta control system. The fan operates continuously and t.a.c. mixing valves modulate the flow of hot/cooled water to the coils to moderate the room temperature. The exact operation of the outdoor air damper was unclear but it appeared to be closed at the time of the site visit, and most likely only opens when outdoor air is cool and dry enough to be useful in the conditioning the building. 

<table>
<tr><td></td><td>

The operational scheme results in excessive electrical consumption due to the continuous operation of the 4 hp air handler fan. This is especially true in the winter, when first floor heating is also provided by baseboards, so minimal heating is required from this air handler. In addition, the fresh air intake does not appear to be providing adequate fresh air to the first floor, based on the requirements specified in the 2009 International Mechanical Code.
Finally, the control system has the facility to modify the night temperature set points to reduce energy consumption, but it is only currently programmed for a 1°F INCREASE in the heating temperature and a 1°F increase in the cooling temperature.
</td></tr>
<tr><td>Proposed Implementation Method:</td><td>
Note: HVAC control system design and specification should be completed by a licensed mechanical engineer.
Modify the programming of the t.a.c. Xenta controller to operate the system as follows.

Program the thermostat to decrease the heating temperature and increase the cooling temperature at least 3°F during the overnight hours.
Only run the air handler fan when temperatures in the occupied spaces require heating or cooling OR as necessary to provide fresh air ventilation (see #3). This may require using the existing hot/chilled water mixing valves for on/off flow control, rather than metering.
Measure the air flow into the fresh air intake when the fan is on and the damper is open, then program the system to turn the fan on and open the damper the appropriate number of minutes out of each hour to provide an average fresh air rate of approximately 300 cfm. This will provide the 0.06 cfm per square foot of fresh air required by the 2009 IMC.
Program the system to take advantage of outdoor air for cooling when the room is warm enough to require cooling and the outdoor air is at a suitable temperature and humidity level to provide that cooling.

</td></tr>
</table>

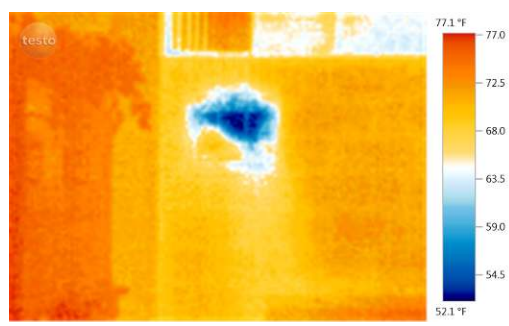
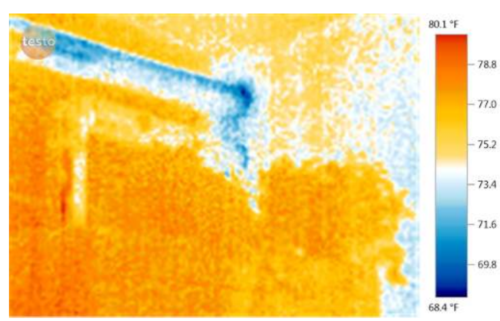
Estimated Implementation Cost:	$ 1,088
Estimated Annual Energy Savings:	$ 1,222

ECM #2	Hot Water Recirculation Control – Adjust Setting
Rationale:	A B&G ½ hp pump re-circulates domestic hot water through the building to maintain the loop temperature and keep hot water close to each apartment. A thermostat is installed that can shut this pump off until the water cools enough to require recirculation. This saves pump energy and heat loss from the circulating water when demand is negligible. At the time of the site visit this thermostat was set at 240°F. Therefore, the pump never shuts off. Studies have shown that a set point of 110°F is optimal for most buildings, minimizing energy usage while maintaining water at an adequate temperature in the loop. 
Proposed Implementation Method:	1. Adjust the thermostat so the domestic hot water recirculation pump shuts down when the loop temperature is above 110°F. 2. Fine tune the set point based on tenant feedback to ensure hot water is adequately maintained in the loop.

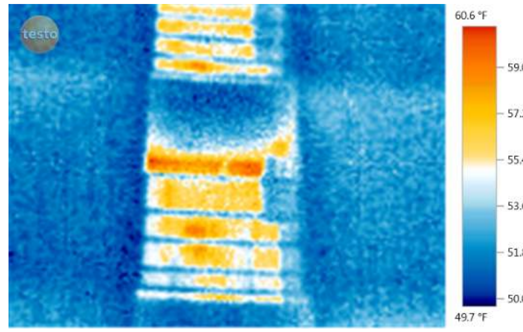
Estimated Implementation Cost:	$ 119
Estimated Annual Energy Savings:	$ 208

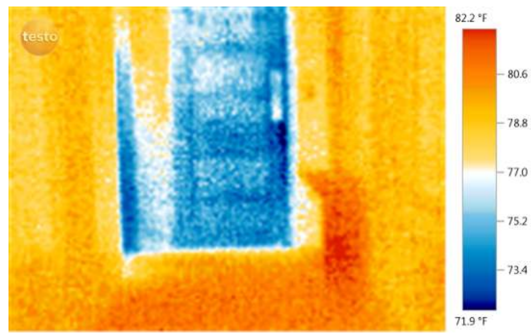
ECM #3	***Variable Frequency Drives – Domestic Cold Water Booster Pumps***
Rationale:	The building uses two 7.5 hp pumps to boost the domestic cold water pressure so that it is adequate to reach the top floors. Based on site observations and discussion with the maintenance staff, both of these pumps run at all times. There is no apparent means to adjust the power of these pumps based on the varying demand for water in the building. As a result, they appear to be over pressurizing the water supply most of the time in order to meet peak demand during a few small periods.  Variable frequency drives (VFD's) can be used to modulate the input power to pumps, providing minimal boost when demand is low and more during periods of peak demand. This provides more consistent water pressure and significantly reduces pump energy consumption.
Proposed Implementation Method:	Install a pressure sensor in the main supply line and a variable frequency drive (VFD) on each pump. Use the variable frequency drives to modulate the power to the pumps to maintain the minimum pressure in the line to provide adequate pressure to the top floor.

Estimated Implementation Cost:	$ 5,540
Estimated Annual Energy Savings:	$ 5,008

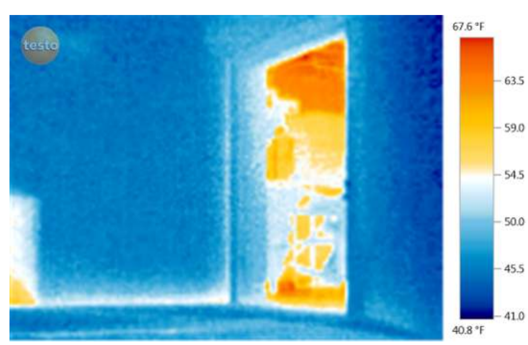
ECM #4	***Air Sealing Package***
Rationale:	Air leaking through openings in the building shell can be one of the largest sources of heat loss in a building. Several significant air leakage pathways were identified. • A significant amount of outside air enters the laundry room through a ventilation opening in the wall and through the dryer outlet vents. The outlet vents are designed to be installed vertically, but are instead mounted horizontally. As a result, the integral back draft dampers do not work.      

- The doors leading from the west corridors to the stairwell balconies have no weather strips or sweeps. Thermal imaging shows that they are a significant source of heat loss.





- The doors at the base of each stairwell are not sealed with weather strips or sweeps.

	• The weather strips on the main entry doors are wearing and losing effectiveness.   • The trash chute is not well sealed. A large opening around the chute in the compactor room allows air to enter the building through the chase around the chute. In addition, the trash chute doors have no weather strip to stop air from flowing up from the compactor rooms into the trash rooms. This issue is exacerbated by the exterior door on this room being often left open.    

Proposed Implementation Method:	***Note: Compliance of each measure with local fire codes should be verified by a licensed mechanical engineer before these recommendations are implemented.*** 1. Install a fan with an integral back draft damper on the ventilation opening in the laundry room wall. Install a thermostat (such as the LuxPro LV3) that only activates the fan when temperature in the space exceeds a comfortable level.   2. Replace the dryer vents with heavy duty models that include functional back draft dampers and ensure that the dampers are oriented so they close when the dryers are not running. 3. Install heavy duty sweeps and weather strips on the west balcony doors and the exit doors at the bottom of each stairwell. 4. Install new heavy duty sweeps, astragal seals, and perimeter weather strips on the main entry doors.  5. Seal the chase around the trash chute in the compactor room with a suitable air barrier (e.g. drywall or plywood) and spray foam. 6. Install a weather strip on the trash chute door on each floor. 7. Encourage the building staff to close the compactor room door when this space is not in use.

Estimated Implementation Cost:	$ 4,438
Estimated Annual Energy Savings:	$ 2,191

ECM #5	**_Low Flow Showerheads and Faucet Aerators_**
Rationale:	Much of the water used in a multifamily building flows through showerheads and faucet aerators. The current federal mandate for these devices is a maximum flow rate of 2.5 gallons per minute (gpm). Most of the faucet aerators in the building are 2.0 and 2.2 gpm models. Showerheads range from 2.0 to 3.5 gpm models. High efficiency models are available that can reduce this flow well below even the current federally mandated maximum levels. This will reduce both water consumption and water heating energy use.  
Proposed Implementation Method:	1. Replace all shower heads with 1.75 gpm versions. One suitable model is the Niagara Conservation Earth Massage N2917CH, which provides a variable spray pattern and reliable performance at a reasonable cost. 2. Replace all faucet aerators with 1.5 gpm versions.  

Estimated Implementation Cost:	$ 5,230
Estimated Annual Energy/Water Savings:	$ 3,750

ECM #6	Lighting Upgrade Package
Rationale:	Much of the lighting at City Senior Tower is aging and consumes more electricity than necessary. • The vast majority of the stairwell landings are lit with inefficient incandescent lamps. Because these fixtures are on 24 hours a day, they are a significant source of electric consumption.  • Fixtures in the entry vestibules and trash rooms also use incandescent lamps. • The 2nd to 11th floor corridors are lit cove fixtures that absorb much of the output of the lamps, rather than directing it out at the occupied space. In addition, these fixtures utilize T-12 lamps with inefficient magnetic ballasts. These fixtures are also lit 24 hours a day.  • The exit signs on 2nd to 11th floor corridors use 2-pin compact fluorescent lamps with very inefficient magnetic ballasts. (Although the lamps are rated at 5 watts each, the total fixture draw is over 20W.) 

	• The exit signs on the first floor and in the mechanical room and stairwells use incandescent lamps. LED exit signs use far less energy.  • The light levels in the lobby sitting area are higher than necessary when 4 lamps are installed in each fixture.  • The offices are lit to a brighter level than is necessary, particular for staff members who primarily work at computer screens. • The laundry room lights are currently powered most of time, although there are significant time periods when the room is unoccupied.  • The mechanical room has two circuits of T12, magnetic ballast fluorescent lights. One appears to be left on very often because the switches are located at the base of the stairwell, rather than at the door where the room is typically exited.

- Every fixture observed in the apartment kitchens, halls, closets, and bathroom vanities is lit with incandescent lamps. Compact fluorescent lamps (CFL's) use far less electricity to provide comparable lighting.


- Lights were observed to be nearly always left on in the trash rooms and compactor room, as well as the 1st floor bathroom. These could be frequently turned off with occupancy or vacancy sensors.

- The elevator cars are lit with recessed 2-pin compact fluorescent fixtures that utilize very inefficient magnetic ballasts. (Although the 2 lamps in each fixture are lamps are rated at 13W each, the total fixture draw is close to 60W.)
- The small flood lamps on the exterior of the building are designed to use high output, high pressure sodium (HPS) lamps, standard incandescent lamps are installed in some of them. These provide far less light output for the same energy consumption. In addition, some of the photo cells are damaged.


Proposed Implementation Method:

1. Install light fixtures on the 2nd to 11th floor corridors that use fluorescent lamps with high efficiency electronic ballasts. One configuration that is very effective at providing good light distribution with low electric consumption is the use of 1-lamp, 28W, 4 ft. T8ES fixtures with electronic ballasts, mounted perpendicular to the corridor.

2. Replace the incandescent lamps in the stairwells, entry vestibules, and trash rooms with 13 watt screw-in (medium base) compact fluorescent lamps (CFL's).
3. Install CFL's in the kitchen, hall, closet, and bathroom fixtures in each apartment. 13W lamps are suitable in the hallways. The kitchens and bathroom vanities would benefit from the increased output of 23W lamps.
4. Provide 2 or 3 additional CFL's to each resident for use in plug-in lamps.

LIGHT OUTPUT EQUIVALENCY

To determine which ENERGY STAR qualified light bulbs will provide the same amount of light as your current incandescent light bulbs, consult the following chart:

INCANDESCENT LIGHT BULBS	MINIMUM LIGHT OUTPUT	COMMON ENERGY STAR QUALIFIED LIGHT BULBS
WATTS	LUMENS	WATTS
40	450	9-13
60	800	13-15
75	1,100	18-25
100	1,600	23-30
150	2,600	30-52

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5. Replace all of the existing fluorescent exit signs in the 2nd to 11th floor corridors with new LED exit signs.
6. Replace the incandescent lamps in the exit signs on the first floor and in the stairwells and mechanical room with LED replacement lamps.

7. Remove one ballast and two lamp clips from each of the 4-lamp troffer light fixtures in the lobby sitting area. Also, repeat this procedure on the 1st floor corridor fixtures if the building management agrees that the reduced light levels are acceptable. (Although these fixtures use magnetic ballasts, power readings indicate that they are reasonably efficient and replacement is not justified.)
8. Remove one lamp from each of the 3-lamp troffer light fixtures in the office and install a label inside the fixture instructing maintenance staff to continue installing only two lamps in these fixtures for energy saving operation. (The ballasts in these fixtures are designed for either 2 or 3-lamp use.)
9. Install switch-mounted occupancy sensors for the lighting in the trash rooms and first floor bathroom. These will automatically turn on the lights when someone enters the spaces and turn them off after sensing that occupants are no longer present.

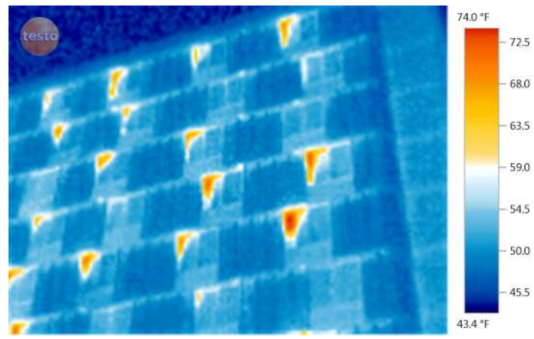
10. Install an occupancy sensor on the light fixture in the mechanical room at the base of the west stairwell.
11. Install switch-mounted vacancy sensors for the lights in the laundry room and compactor room. These will require an occupant to activate them to turn on the lights. They will then turn off when occupants are no longer present. This will prevent lights from being activated when daylight is adequate in these spaces. One suitable model is the Lutron Maestro MS-VP600M.
12. Replace the recessed light fixtures in the elevator cars with “Air Tight” fixtures that use standard “medium-base” lamps. Install a 23W Energy Star-labeled compact fluorescent lamp in each fixture.
13. Replace the malfunctioning photo cells on the small exterior flood light fixtures and install the correct high pressure sodium lamps in each. 35W lamps should provide adequate light levels in these locations.

Estimated Implementation Cost:	$ 42,043
Estimated Annual Energy Savings:	$ 11,913

ECM #7	Fan Coil Improvement Package

Rationale:

Many building occupants were observed with both windows open and their heat running during cold mid/late November days. This is possible because residents have full control over the fan coil thermostats. So they can be set high enough to overcome the heat loss associated with open windows.



The fan coils serving the apartments are equipped with both thermostats and "OFF/HI/MED/LOW" switches. But thermostats only turn off water flow to the coils. The fans run at all times unless the units are switched "OFF". This results in considerable electric consumption to run the 1/6 hp fans even when no heating or cooling is required in the apartments.

The fan coils serving the office areas (and one end of the 11th floor) are McQuay models that only include a fan control. There is no means for stopping water flow through the coil. Therefore, heat is always added to these spaces, even if the temperature is already warmer than desired by the occupants.

The baseboards serving the first floor community room and lobby also lack zone control valves.

<table>
<tr><td></td><td>Several of the water flow control valve actuators on the apartment fan coils were found to be non-functional. When they fail “Open”, apartments are overheated or overcooled. When they fail “Closed”, tenants are likely to be uncomfortable.
</td></tr>
<tr><td>Proposed Implementation Method:</td><td>1. Install locks on the doors covering the controls on the fan coils in the apartments. Allow only the building staff to adjust the settings and encourage residents to first close windows if they are not comfortable.

2. Modify the wiring in each fan coil so that when the room temperature satisfies the thermostat set point, the flow control valve is closed AND the fan is turned off.

3. Install flow control valves in the fan coils serving the office. Wire them to open only when each thermostat calls for heating or cooling. Continue using the thermostats to also control the operation of the fans. One possible valve option is the Honeywell V4044 series, which is available for line voltage or low voltage applications.
4. Install a TRV with thermostatic control dial on each baseboard radiator serving the first floor. Adjust the settings to attain comfortable temperatures.
 </td></tr>
</table>

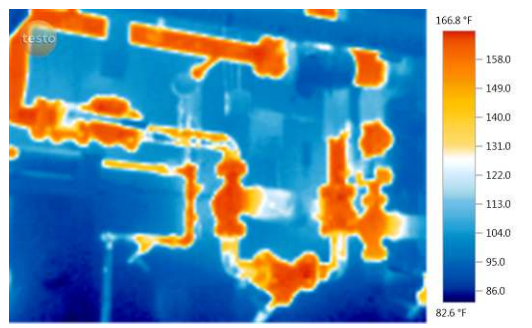
Estimated Implementation Cost:	$ 51,961
Estimated Annual Energy Savings:	$ 9,994

ECM #8	Boiler Replacement for Heating & DHW, plus HVAC Control Changes

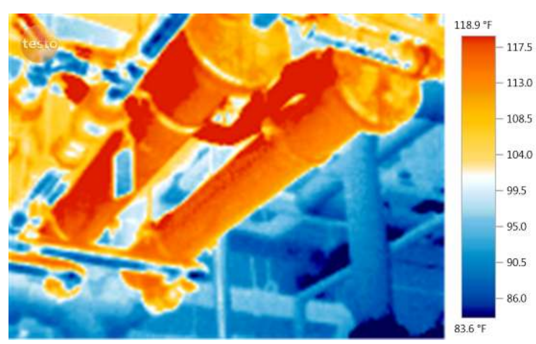
Rationale:

The building is currently heated using two atmospheric-vented cast iron sectional boilers. They have a relatively low estimated annual fuel utilization efficiency (AFUE) of 77%. Replacing these boilers with a high-efficiency condensing boiler system (Thermal Efficiency = 93+%) will significantly reduce heating gas consumption.

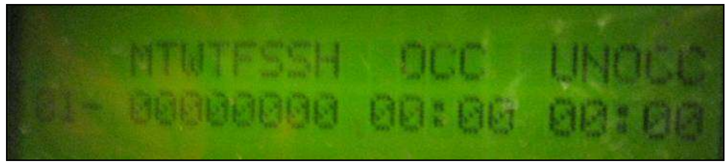
Many of the heating system pipes in the boiler room are not insulated. These pipes are very hot and lose a significant amount of heat to the surrounding space. The boiler room is intentionally vented to provide combustion air to the boilers. Therefore, much of the heat from the steam pipes is wasted warming air that flows into the room, through the boilers, up the chimney, and out of the building.



Domestic hot water is generated using the heating boilers and two tankless coil heat exchangers. Because they must have a continual flow of boiler water to generate instantaneous hot water for any building demand, the tankless coils require that a ¾ hp pump run constantly to supply them. This results in significant electric consumption, as well as considerable heat loss because many of the pipes and the tankless coils are not insulated.



The chiller has a control system capable of night setback, which would allow the set point to be raised during the overnight hours. It is not currently being used.



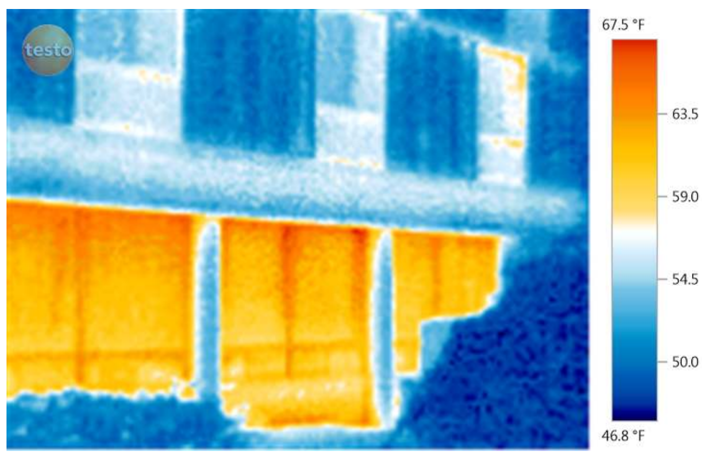
Proposed Implementation Method:

Note: Heating system design and specification should be completed by a licensed mechanical engineer. Sizing should be completed in accordance with ACCA Manual J or N.

1. Replace the current boilers with a high efficiency condensing boiler system. Energy modeling indicates a peak heating load of about 1,450,000 btu/hr (after all ECM's have been implemented). Additional capacity is needed for generation of domestic hot water. Therefore, two units with an input capacity of 1,000,000 btu/hour each should be adequate. One suitable model is the Lochinvar SYNC, which has an integral control system with outdoor reset and night setback capabilities. It also has integral controls that allow it to be used simultaneously for heating and generation of domestic hot water.

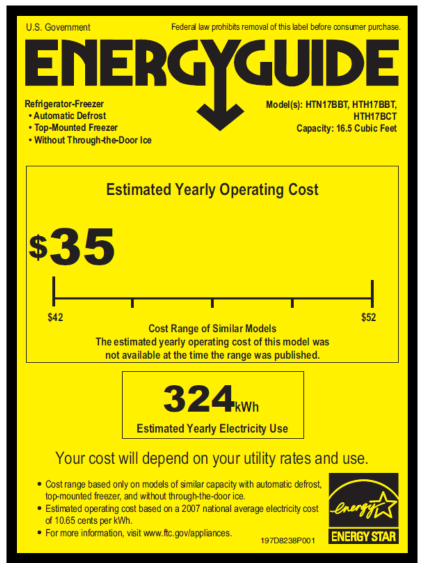
2. Install domestic hot water storage tanks designed to be heated indirectly by a hot water boiler. Generally, models manufactured by the same company as the boiler will be easiest to integrate into the system. One suitable model is the Lochinvar EGS120.
3. Install all valves, circulating pumps and electrical controls necessary to control the flow of water between the boilers and tanks. Do not circulate water continuously between the boiler and tanks. Instead, install an aquastat in each tank and configure the system so the boiler and circulator pump only run when the temperature in the tank falls below the set point (approximately 125°F).
4. Install a bladder-type expansion tank in the domestic hot water system to protect the storage tanks and distribution piping from pressure increases that can occur when the heating water expands as it increases in temperature. One suitable option is the Amtrol Extrol SX series.
5. Install R-5 fiberglass insulation on all heating and domestic hot water lines in the boiler room. It should cover all straight sections, elbows, and tees.
6. Program the chiller controls to increase the temperature of the chilled water loop be 2°F to 4°F from 11PM to 5AM.
7. Seal all combustion air openings into the mechanical room, since they will no longer be necessary with the condensing boilers.

Estimated Implementation Cost:	$ 96,400
Estimated Annual Energy Savings:	$ 9,621

ECM #9	***Replace All Original Single-Pane Windows***
Rationale:	Most of the windows on the first floor of the building are original, aluminum-framed, single-pane units. (The only exception is the windows that were installed during the 2003 expansion and renovation of the office area.) They don't offer the resistance to heat loss that modern energy efficient windows do.  
Proposed Implementation Method:	1. Replace each original single-pane window with double-pane, argon filled replacement unit that includes a heat-reflective low-e coating. The new windows should have a rated U-value of 0.40 or lower. 2. Ensure that the window frames are properly flashed and sealed to eliminate infiltration of water and air.

Estimated Implementation Cost:	$ 48,455
Estimated Annual Energy Savings:	$ 3,679

<table>
<tr><th>ECM #10</th><th>Refrigerators - Replace Pre-2000 Units</th></tr>
<tr><td>Rationale:</td><td>Based on sampling at the site visits, nearly 25% of the refrigerators in the building are Kenmore models that were installed before 2000. Accounting for component wear, these refrigerators each consume approximately 800 kilowatt hours (kWh) of electricity per year. New Energy Star labeled refrigerators of a similar size can be economically purchased and use far less energy. One example is the Hotpoint HTH17CBTWW, which is rated to consume 324 kWh/yr.


</td></tr>
<tr><td>Proposed Implementation Method:</td><td>1. Inspect the refrigerator in each apartment and determine its approximate annual consumption. One useful resource is: http://www.homeenergy.org/consumerinfo/refrigeration2/refmods.php.
2. Replace any refrigerators that consume more than 700 kWh/yr with new Energy Star labeled models that are rated for no more than 350 kwh/yr consumption. (The estimates below assume replacement of 30 refrigerators.)</td></tr>
<tr><td>Estimated Implementation Cost:</td><td>$ 16,050</td></tr>
<tr><td>Estimated Annual Energy Savings:</td><td>$ 933</td></tr>
</table>