COMMUNITY PLANNING & DEVELOPMENT

Measurement & Verification

Ryan Merkin, M.S., LEED AP

Steven Winter Associates, Inc.

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Building Systems Consultants - Founded 1972

- Energy Efficiency
- Advanced Building Systems
- Indoor Environmental Quality (IEQ)
- Systems Engineering and Optimization

Integrated "Whole Building" Approach

Session Overview

- The Audit Process
- Benchmarking and Metrics
- Envelope
- Heating
- Domestic Hot Water
- Lighting
- Payback Analysis

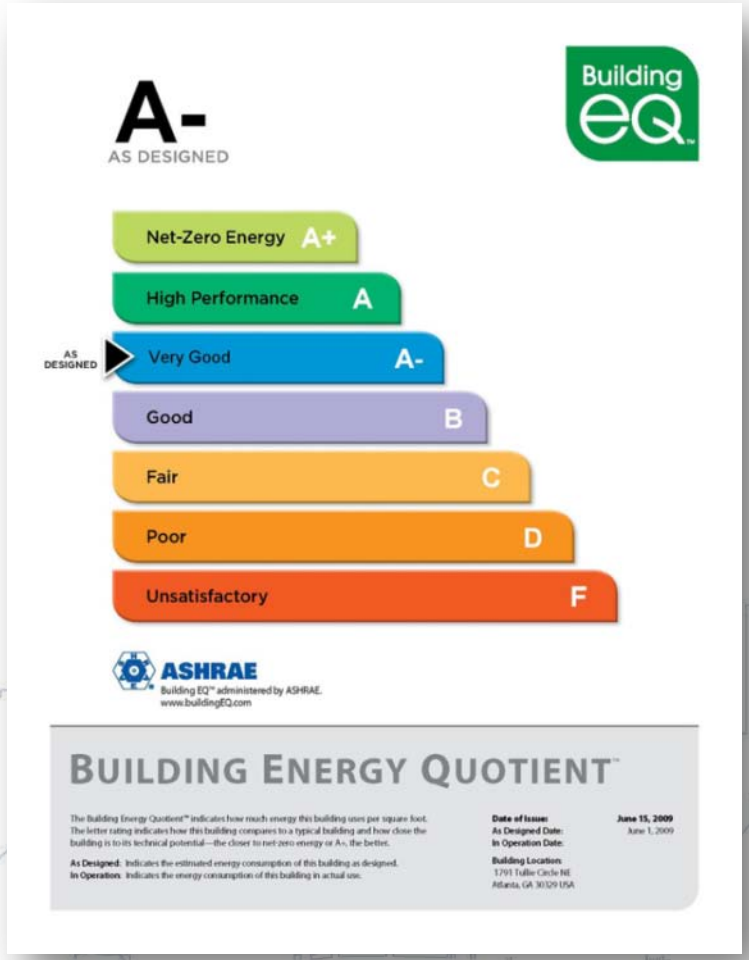
Which Building is Most Efficient?

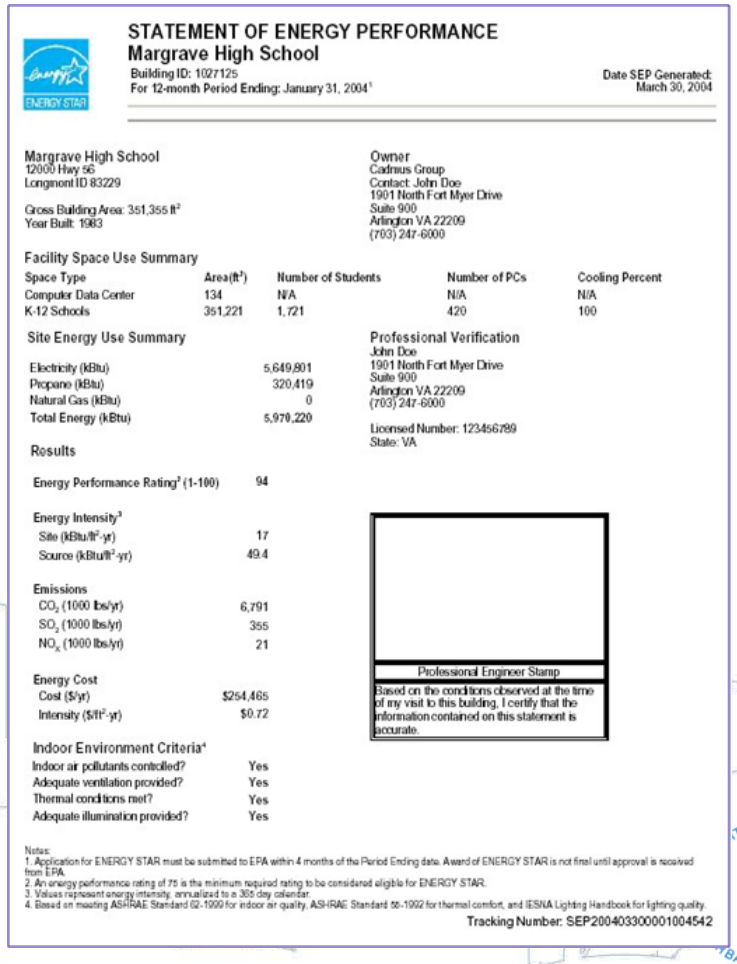
First
ES MF
Bldg→

First
LEED
MF in
←US

1972
MF
Milwaukee
WI →

Before the Audit: Benchmarking





STATEMENT OF ENERGY PERFORMANCE
Margrave High School

Building ID: 1027125
For 12-month Period Ending: January 31, 2004[1]

Date SEP Generated: March 30, 2004

Margrave High School
12000 Hwy 56
Longmont ID 83229

Gross Building Area: 351,355 ft²
Year Built: 1983

Owner
Cadmus Group
Contact: John Doe
1901 North Fort Myer Drive
Suite 900
Arlington VA 22209
(703) 247-6000

Facility Space Use Summary

Space Type	Area(ft²)	Number of Students	Number of PCs	Cooling Percent
Computer Data Center	134	N/A	N/A	N/A
K-12 Schools	351,221	1,721	420	100

Site Energy Use Summary

Electricity (kBtu)	5,649,801
Propane (kBtu)	320,419
Natural Gas (kBtu)	0
Total Energy (kBtu)	5,970,220

Professional Verification
John Doe
1901 North Fort Myer Drive
Suite 900
Arlington VA 22209
(703) 247-6000

Licensed Number: 123456789
State: VA

Results

Energy Performance Rating[2] (1-100)	94
Energy Intensity[3]	
Site (kBtu/ft²-yr)	17
Source (kBtu/ft²-yr)	49.4
Emissions	
CO_2 (1000 lbs/yr)	6,791
SO_2 (1000 lbs/yr)	355
NO_x (1000 lbs/yr)	21
Energy Cost	
Cost ($/yr)	$254,465
Intensity ($/ft²-yr)	$0.72

Professional Engineer Stamp

Based on the conditions observed at the time of my visit to this building, I certify that the information contained on this statement is accurate.

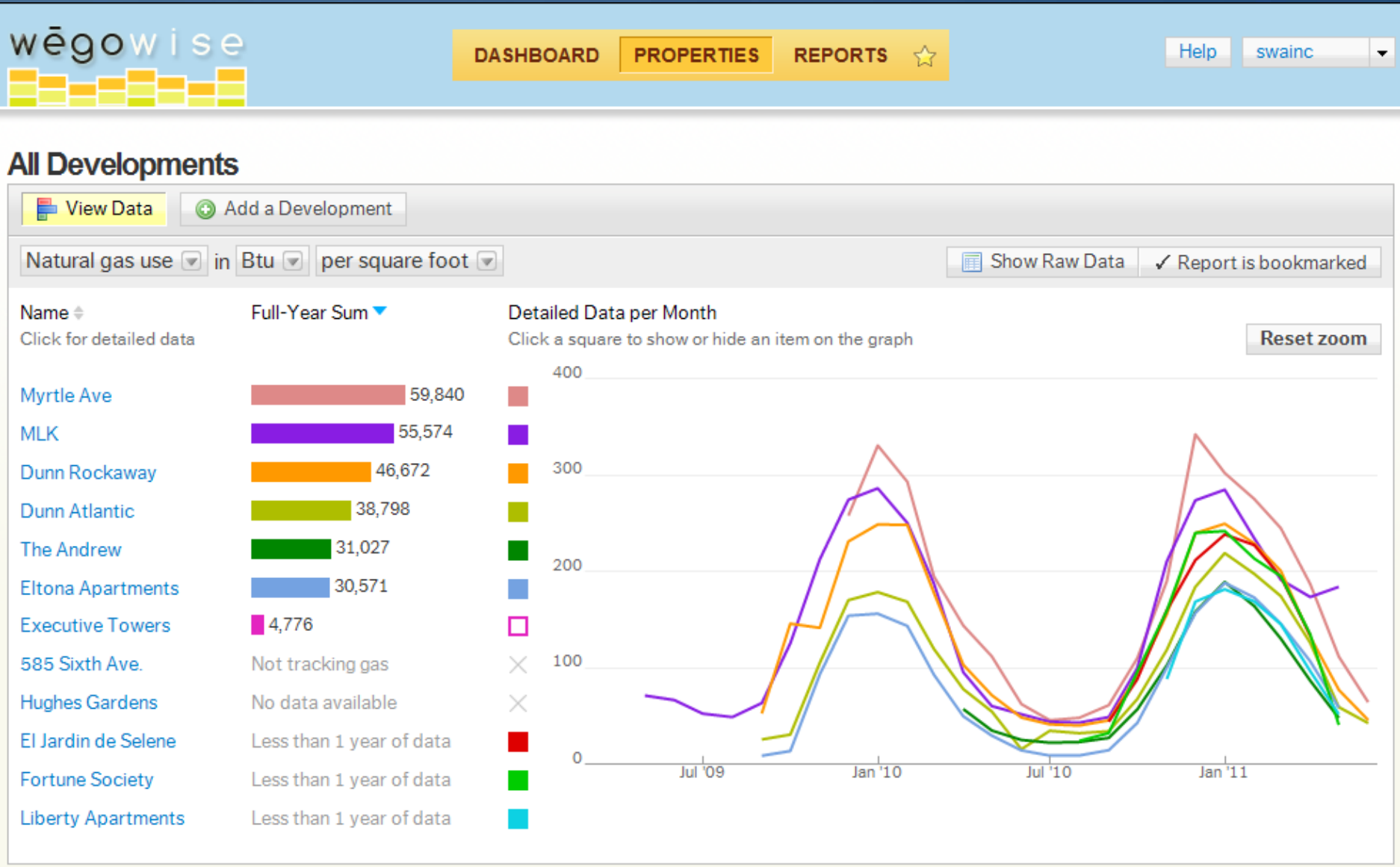
Indoor Environment Criteria[4]

Indoor air pollutants controlled?	Yes
Adequate ventilation provided?	Yes
Thermal conditions met?	Yes
Adequate illumination provided?	Yes

Notes:
1. Application for ENERGY STAR must be submitted to EPA within 4 months of the Period Ending date. Award of ENERGY STAR is not final until approval is received from EPA.
2. An energy performance rating of 75 is the minimum required rating to be considered eligible for ENERGY STAR.
3. Values represent energy intensity, annualized to a 365 day calendar.
4. Based on meeting ASHRAE Standard 62-1999 for indoor air quality, ASHRAE Standard 55-1992 for thermal comfort, and IESNA Lighting Handbook for lighting quality.

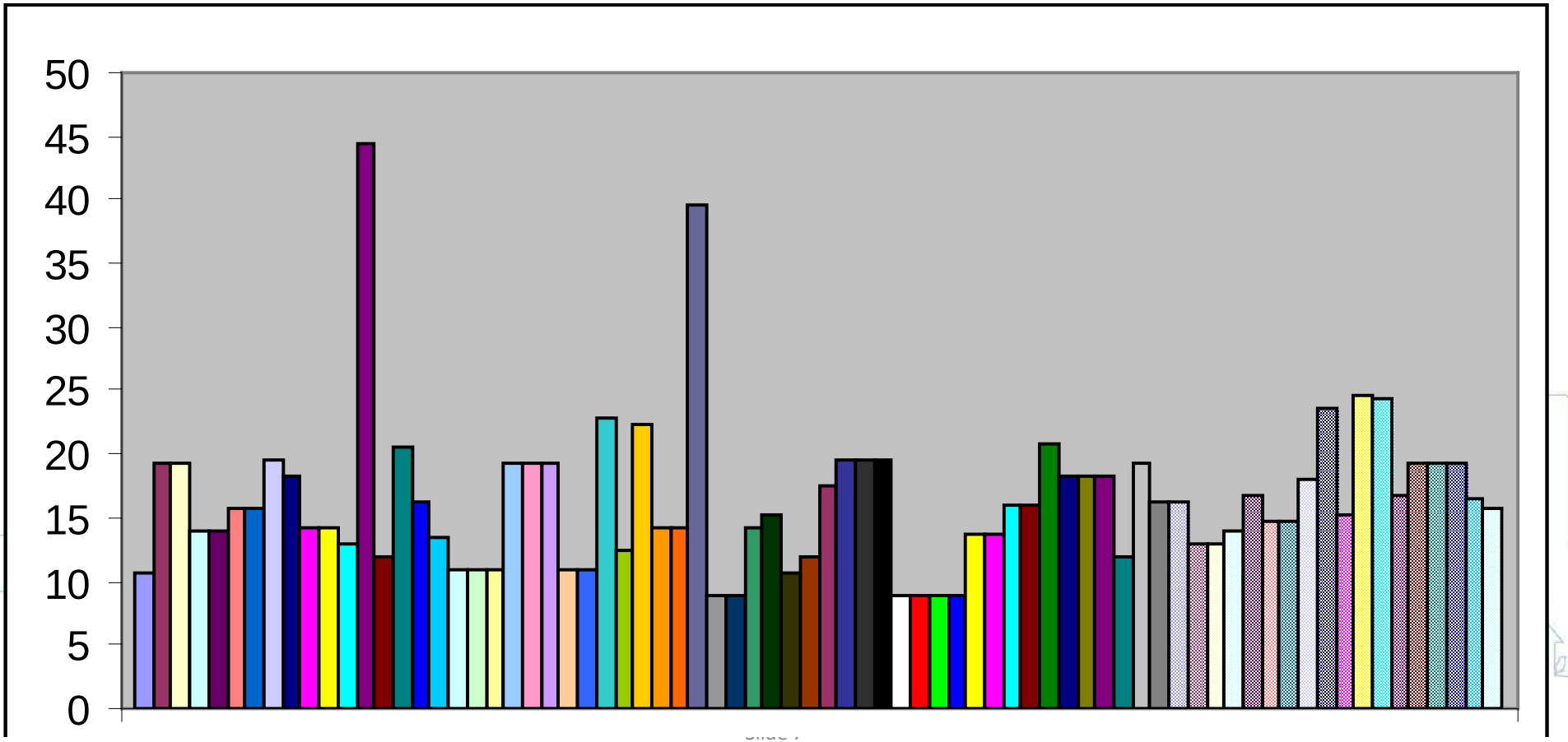
Tracking Number: SEP20040330000001004542

Benchmarking: Online Tools



Benchmarking: DIY

A Top 10 Owner of Multifamily Building in NYC



Benchmark Targets

Category	Target	Critical Action Needed
Space Heating	<10 BTU/FT2/HDD	>15 BTU/FT2/HDD
Electric Use	<4-5 kWh/FT2/YR	
Water Use	<50 gal/person/day OR < 100 gal/bedroom/day	>65 gallons/person/day
Hot Water		
Resident Complaints	No quantitative target	You'll know it

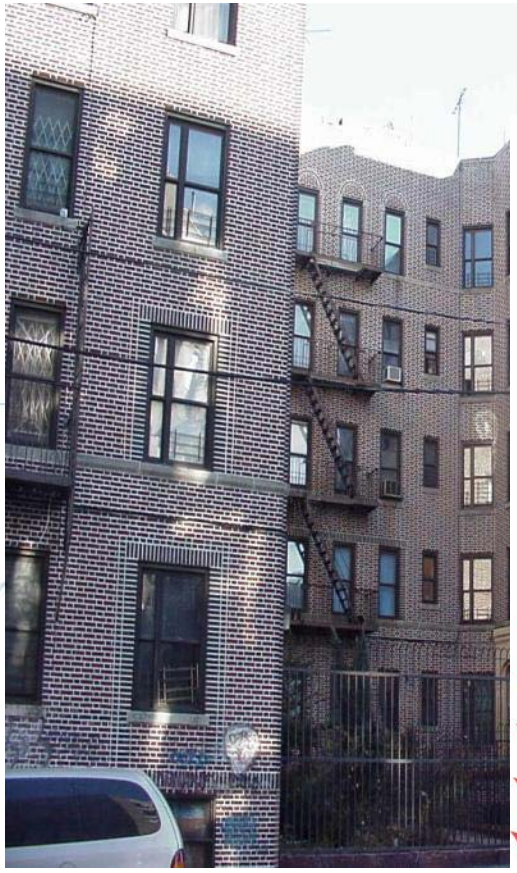
Scoping Before the Audit

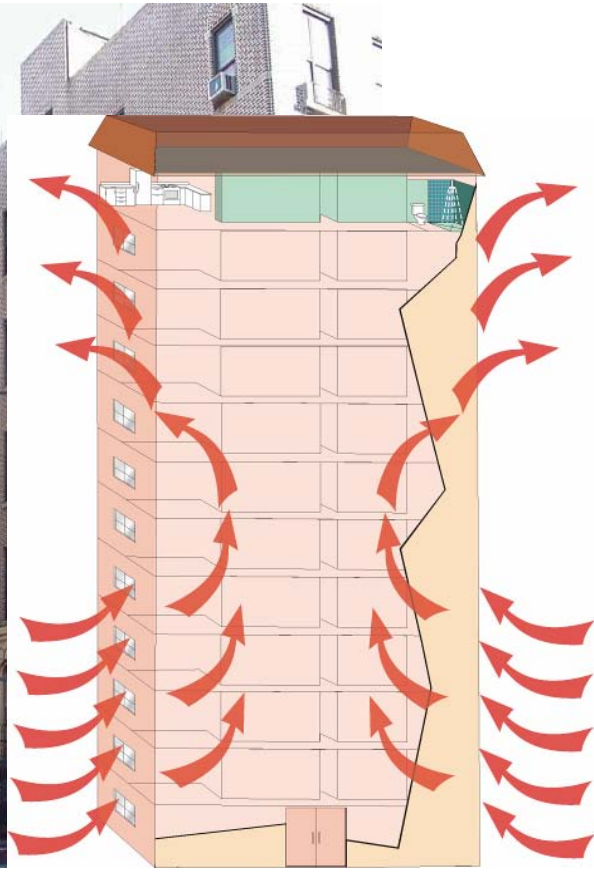
- Interviews – Property Mgmt, Operators
  - Goals of audit and how they related to operations
  - O&M issues > Energy issues
- Benchmarking Complete
  - Repair bills can further justify improvements
- Scoping Audit
  - Building a plan for testing and diagnostics
  - Retrieve blueprints/plans if possible

The Audit: Exterior Envelope

Before we step foot in a building:

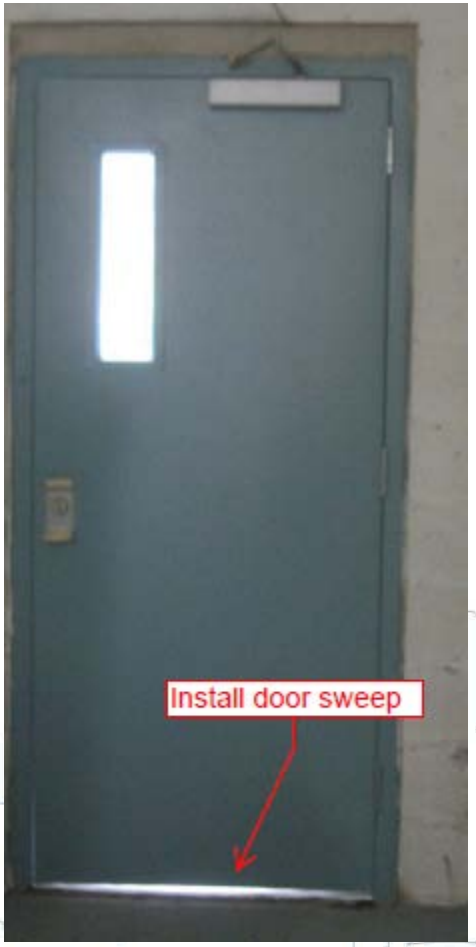
- Open Windows in Winter
- Window conditions
- Air conditioners
- Façade conditions
- Exterior lighting
- Cleanliness
- Exterior doors
- Trash chute vent





The Audit: Envelope Diagnostics

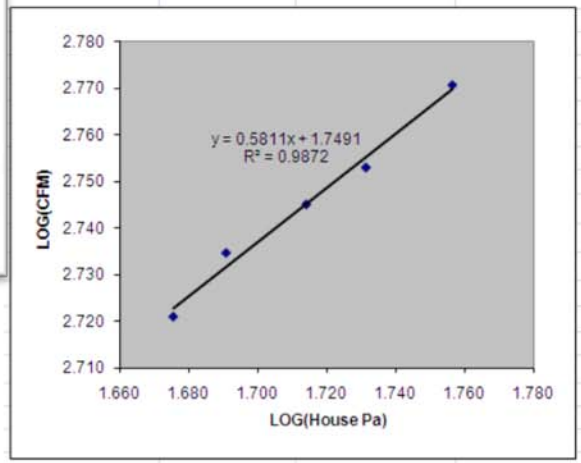
- Use Your Eyeballs
  - Weatherstripping
  - Caulking
  - A/C Covers
- Blower Door Testing
- Infrared Scan (seasonal)
- Low-e checker



Envelope: Blower Door Testing

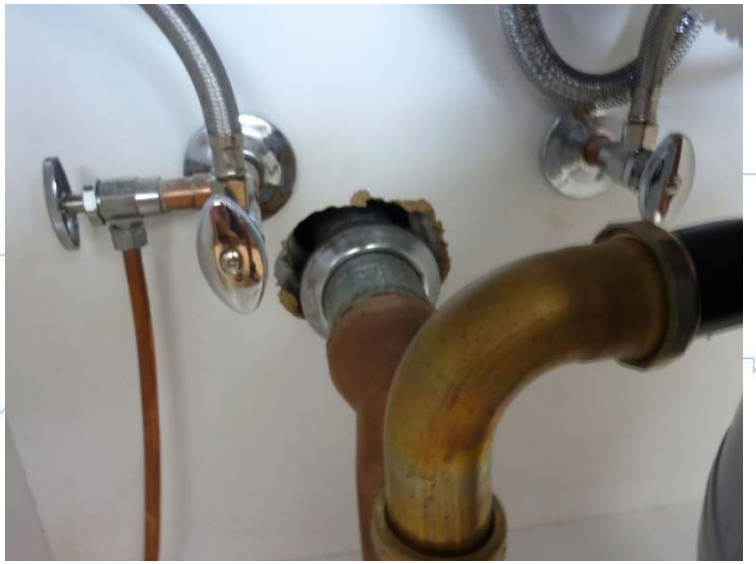
Project Name:	xxxxxxxx				
Apartment	8B			Sherman Corr. Factor	
Location:	xxxxxxxx		Climate Factor, C	17	Function of Temperature and Wind, See Cl
Floor Area in sq.ft.:	924		Height Factor, H	1	1 Story = 1.0, 1.5 Stories = 0.9, 2 Stories =
Surface Ar in sq.ft.:	2928		Shielding Factor, S	1	Well-Shielded = 1.2, Normal = 1.0, Expose
Volume in cu.ft.:	8316		Type of Holes, L	1	Small Cracks = 1.4, Normal = 1.0, Large H
Outdoor Temp (F):	45		Correlation Factor, N	17	N = C*H*S*L
Indoor Temp (F):	60				
Fan Position:	Depress				
Wind Condition:			Fan Baseline		
Baseline Pressure	0	Pa	0.4		

House Pressure (Pa)	Fan Pressure (Pa)	Plate Position	Flow Rate (cfm)	Temp Corc Flo (cfm)	Log (HousePress)	Log (Flowrate)
47.4	156.7	1	518.5	526.1	1.676	2.721
49.1	166.9	1	535.1	543.0	1.691	2.735
51.8	175.1	1	548.1	556.2	1.714	2.745
53.9	181.6	1	558.2	566.4	1.732	2.753
57.1	197	1	581.4	589.9	1.757	2.771
					#NUM!	



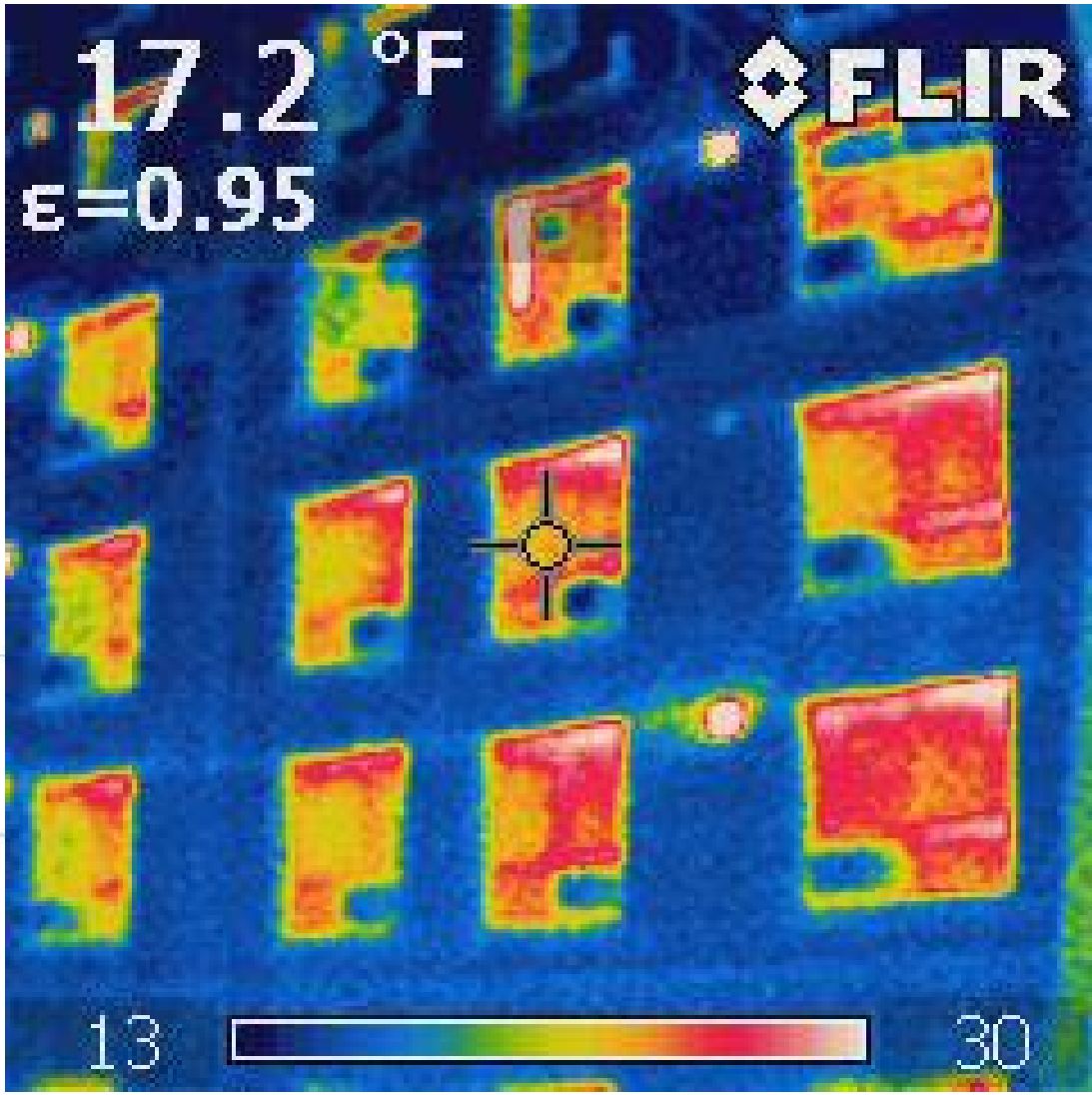
Slope:	0.5811	
Intercept:	1.7491	
C:	56.11238873	
n:	0.5811	
R:	0.9872	
From Regression:		
CFM_{50}:	545	
ACH_{50}:	3.93	
ACH_{nat}:	0.23	(ACH_{50}/N)
ELA:	35.6	in^2 (4 Pa)
EqLA:	62.9	in^2 (10 Pa) - Canada
Leakage Ratio:	0.186109439	CFM_{50}/ft^2 surface area
ELA(in2)/100ft2	1.22	

Blower Door Diagnostics



Infrared Diagnostics

- Diagnose and confirm insulation issues/installation



The Audit: Roof

- Open louvers at top of stairwell
- Elevator room venting
- Compactor Shaft
- Roof surface
- Roof cavity insulation
- Roof cavity venting
- Parapet condition
- Drainage

Envelope Recommendations

High Priorities

- Weatherstripping
- Airsealing (Energy/O&M/H&S)
  - Stairwell Venting
  - AC Covers
  - Penetrations
- Roof/cavity Insulation

Envelope Recommendations

Low Priorities

- Wall Insulation
  - 1-2” of cellulose or foam can go a long way
- New Windows
  - Typically makes sense after 20+ years
  - New units should NFRC rating
    - U-value < 0.5 for aluminum frame
    - U-value < 0.32 (ENERGY STAR) for other types
    - SHGC vary by region

The Audit: Rooftop Fans

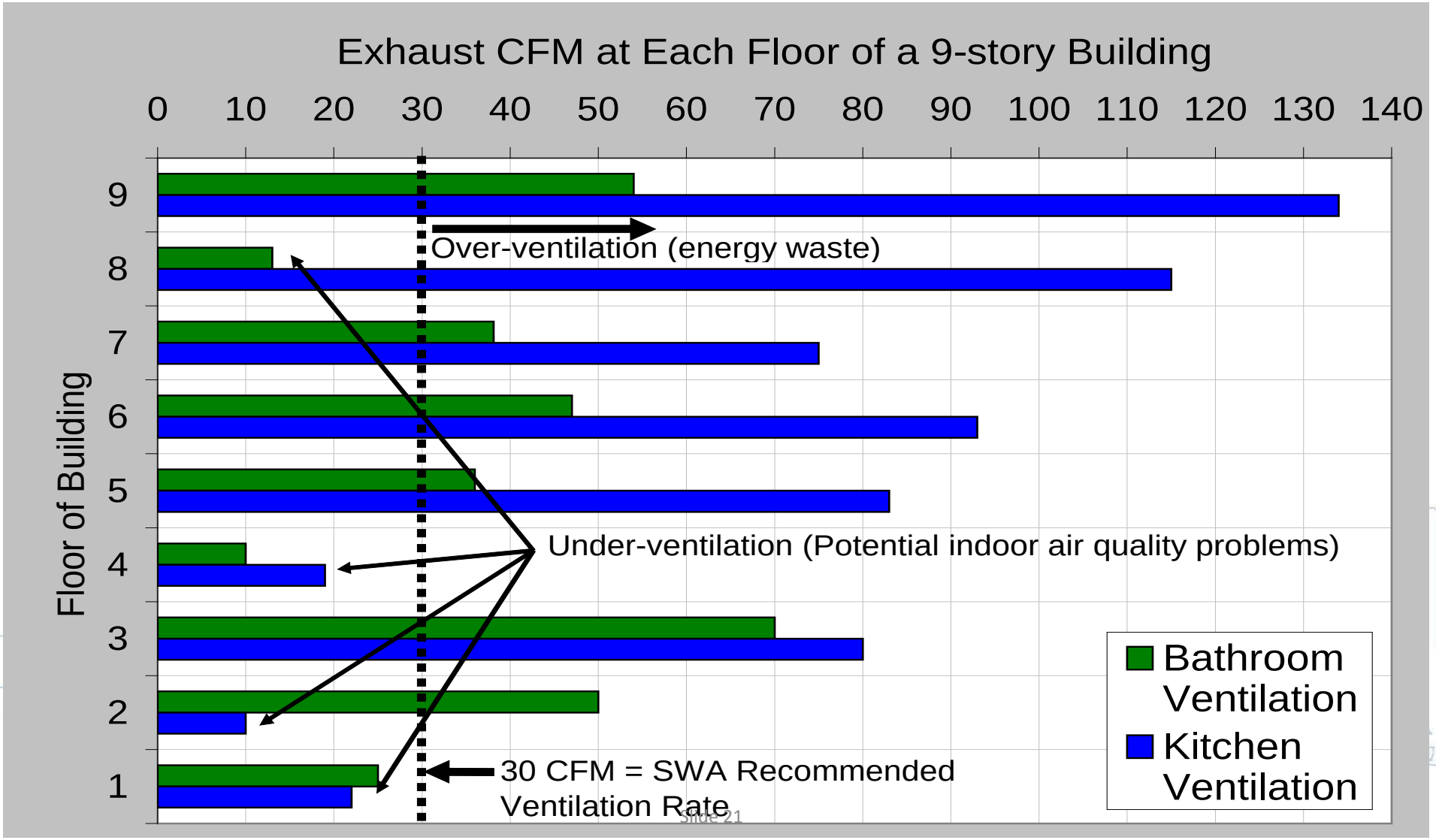
Can be big savings opportunity

- What function do they serve
- Continuous operation
- Are they running?

- Fanflow testing
- Shaft construction
- Register condition

Ventilation: Beware the Gap

Ventilation: What Actually Happens

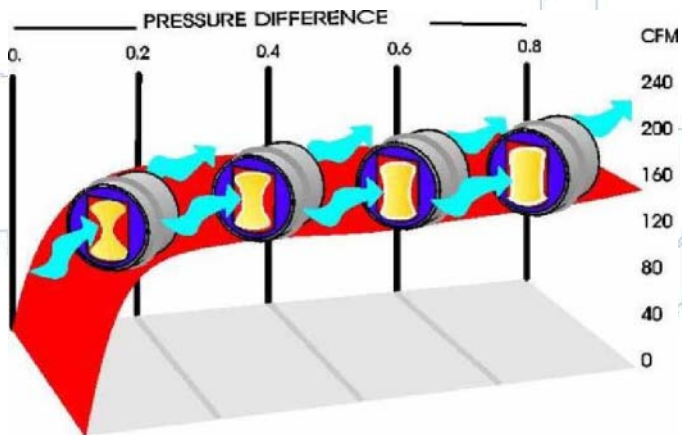


Advanced Measures: IAQ

The Central Ventilation Retrofit

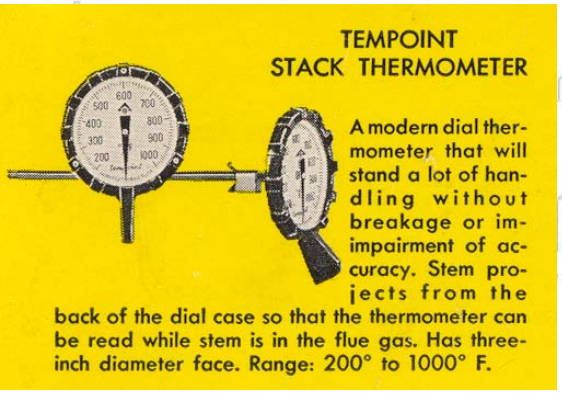
- Test flows
- Clean shaft
- Seal shaft
- Seal registers at sheetrock
- CAR Dampers (auto balancing)
- New direct-drive fans (less maintenance)

Ventilation: Solutions



The Audit: Heating Systems

- If atmospheric, look to replace
  - **Condensing units do not retrofit well**
- Combustion Efficiency Test to quantify
  - Does not capture standby losses
- Boiler Controls
  - Steam settings
  - Burner modulation



The Audit: Heating Systems

Atmospheric = Inefficient

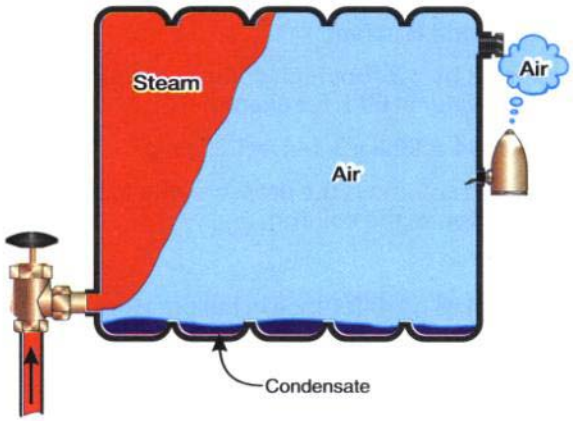
Solution = Sealed Combustion Boilers

The Audit: Heating Controls

- Heating Controls
  - Working Clock
  - Outdoor Reset
    - Know your heating season and regulations
  - Lead/Lag

The Audit: Heating Distribution

- Insulation
- Steam Venting
- Leaks, Buried Returns?
  - Water meter on boiler feed
- Radiator Conditions
  - Pitch
  - Air vents
  - Orifice plate retrofit?
- Baseboard Conditions
  - Heat output
  - Thermostatic Control and Valve



Heating Recommendations

Low-Cost

- Insulate bare pipes
- Set controls
- Address distribution (venting, TRV's, pitching)
- Water meter on boiler feed
- Temperature gauge on flue

Investment-Grade

- New Boilers
- New Controls with wireless sensors
- VFD Control

The Audit: Domestic Hot Water

- Combustion Efficiency Test
  - Same rules apply: Atmospheric vs. Sealed Combustion
- Types of Systems
  - Tankless Coil
  - Standalone
  - Indirect

The Audit: Why Not Atmospheric?

Advantages

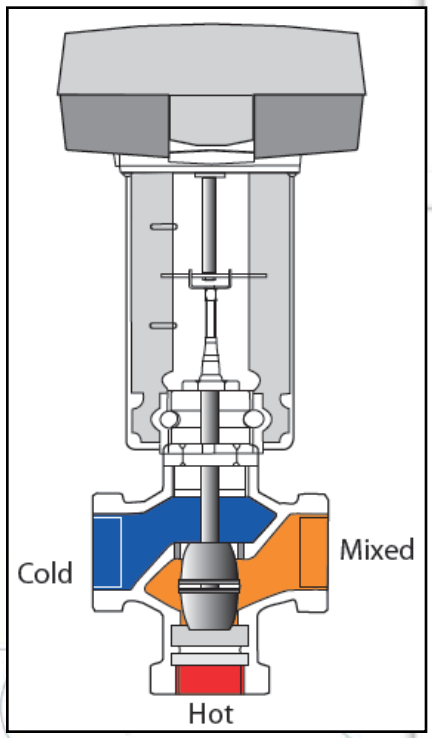
- Cheap.
- Cheap.
- Cheap.

Disadvantages

- Very inefficient.
- High standby losses when off due to open combustion chamber.
- Poor draft control.
- Many models have open pilot light.

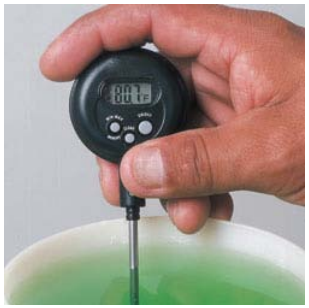
The Audit: Domestic Hot Water

- Mixing Valve
  - Upgrade to electronic
  - Temperature gauge at outlet
  - Thermostatic mixing valves fail in the HOT position; electronic mixing valves fail in the COLD position.
- Setpoint
  - Aim for 115 - 120°F



The Audit: Domestic Water

- Toilets
  1.3 gpf or less



- Showerheads
  1.75 gpm

- Faucet Aerators
  1.5 gpm Kitchen | 1.0 gpm lavatories
  Look for EPA's Watersense® Label

DHW: Recommendations

Low-Cost

- Insulate bare pipes
- Set controls
- Low-flow fixtures
- Temperature gauge on flue
- Upgrade mixing valve

Investment-Grade

- New Boilers

The Audit: Lighting

- Incandescents are no longer affordable
- Federal legislation phases out
- CFL's replace all

- T8 Tubes &CFL's
- LED Replacements
- Controls: Occupancy, Photosensor
- Some fixtures have controls built in!

Cost/Benefit of Lighting Retrofit

T12 Lamp Replacement

40W x 24/7/365	=	350 kWh
At $0.15/kWh	=	$52.56

LED

15W x 24/7/365	=	131 kWh
At $0.15/kWh	=	$19.71

Savings = $32.85

At $100 installed: Payback = 3.0 years | SIR = 1.7

Cost/Benefit of Lighting Retrofit

T12 – 2 Lamp Replacement

86W x 24/7/365	=	753 kWh
At $0.15/kWh	=	$113.00

T8 Bi-level Fixture

62W x 4/7/365	=	90.5 kWh
19W x 20/7/365	=	138.7 kWh
At $0.15/kWh	=	$34.38

Savings = $78.62

At $300 installed: Payback = 3.8 years

Putting It All Together

The Cost/Benefit Analysis

- Payback
  - How long a measure takes to payback in years.
- S.I.R.
  - How many times does measure payback over lifespan.
- LCC
  - Provides net present value of investment.
- TRC
  - Includes total project, design, & program costs.

Putting It All Together

Energy Savings Opportunities						
Measure	**Installed Cost**	**kWh Savings**	**Therm Savings**	**Annual Savings**	**Payback (yrs)**	**SIR**
High Priority						
1. Apartment Low Flow Showerheads & Aerators	$ 9,030	0	22,247	$ 19,800	0.5	13.7
2. Common Area Lighting & Controls	$ 7,600	20,308	N/A	$ 2,640	2.9	1.6
Medium Priority						
1. Mechanical Rooftop Exhaust System Upgrade	$ 130,050	62,330	31,796	$ 36,401	3.6	2.4
2. Cogeneration	$ 235,000	550,977	-27,646	$ 47,022	5.0	3.0
3. Domestic Hot Water System Upgrade	$ 148,000	0	15,710	$ 13,982	10.6	1.6
Total	**$ 529,680**	**633,615**	**42,107**	**$ 119,845**	**4.4**	**2.6**

Thank You!

Questions?

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