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**

- **Building ID:** 12345
- **For Period Ending:** January 31, 2004
- **Date SEP Generated:** March 30, 2004

<table>
<thead>
<tr>
<th>Facility Space Use Summary</th>
<th>Area (sq ft)</th>
<th>Number of Stacks</th>
<th>Number of PCs</th>
<th>Cooling Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Data Center</td>
<td>134</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>K-12 Schools</td>
<td>313,221</td>
<td>1,21</td>
<td>459</td>
<td>160</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Energy Use Summary</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity (kWh)</td>
<td>5,045,891</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propane (kWh)</td>
<td>320,419</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas (kWh)</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Energy (kWh)</td>
<td>5,949,329</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Results**

<table>
<thead>
<tr>
<th>Energy Performance Rating (1-100)</th>
<th>94</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Intensity</td>
<td>17</td>
</tr>
<tr>
<td>Source (kWh/ft²-yr)</td>
<td>48.4</td>
</tr>
</tbody>
</table>

**Foundation**

- **Owner:** John Doe
- **Contact:** 311 Main St, Suite 500
  Arlington, VA 22203
  Phone: 703-123-4567

**Environmental Information**

- **CO₂ (100 lb/yr):** 6,701
- **SO₂ (100 lb/yr):** 305
- **NOₓ (100 lb/yr):** 21

**Notes**

1. Application for ENERGY STAR must be submitted to EIA within 6 months of the final audit date. Award of ENERGY STAR is not final until approval is received from EPA.
2. The energy performance rating of this facility is the minimum annual cooling rating to be certified eligible for ENERGY STAR.

**Tracking Number:** SEP064005000011644542
### Benchmarking: Online Tools

#### All Developments

<table>
<thead>
<tr>
<th>Name</th>
<th>Full-Year Sum</th>
<th>Detailed Data per Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myrtle Ave</td>
<td>59,840</td>
<td></td>
</tr>
<tr>
<td>MLK</td>
<td>55,574</td>
<td></td>
</tr>
<tr>
<td>Dunn Rockaway</td>
<td>46,672</td>
<td></td>
</tr>
<tr>
<td>Dunn Atlantic</td>
<td>38,798</td>
<td></td>
</tr>
<tr>
<td>The Andrew</td>
<td>31,027</td>
<td></td>
</tr>
<tr>
<td>Eltona Apartments</td>
<td>30,571</td>
<td></td>
</tr>
<tr>
<td>Executive Towers</td>
<td>4,776</td>
<td></td>
</tr>
<tr>
<td>585 Sixth Ave.</td>
<td>Not tracking gas</td>
<td></td>
</tr>
<tr>
<td>Hughes Gardens</td>
<td>No data available</td>
<td></td>
</tr>
<tr>
<td>El Jardin de Selene</td>
<td>Less than 1 year of data</td>
<td></td>
</tr>
<tr>
<td>Fortune Society</td>
<td>Less than 1 year of data</td>
<td></td>
</tr>
<tr>
<td>Liberty Apartments</td>
<td>Less than 1 year of data</td>
<td></td>
</tr>
</tbody>
</table>
Benchmarking: DIY

A Top 10 Owner of Multifamily Building in NYC
## Benchmark Targets

<table>
<thead>
<tr>
<th>Category</th>
<th>Target</th>
<th>Critical Action Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>&lt;10 BTU/FT2/HDD</td>
<td>&gt;15 BTU/FT2/HDD</td>
</tr>
<tr>
<td>Electric Use</td>
<td>&lt;4-5 kWh/FT2/YR</td>
<td></td>
</tr>
<tr>
<td>Water Use</td>
<td>&lt;50 gal/person/day OR &lt; 100 gal/bedroom/day</td>
<td>&gt;65 gallons/person/day</td>
</tr>
<tr>
<td>Hot Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resident Complaints</td>
<td>No quantitative target</td>
<td>You’ll know it</td>
</tr>
</tbody>
</table>
Scoping Before the Audit

• Interviews – Property Mgmt, Operators
  o Goals of audit and how they related to operations
  o O&M issues > Energy issues

• Benchmarking Complete
  o Repair bills can further justify improvements

• Scoping Audit
  o Building a plan for testing and diagnostics
  o Retrieve blueprints/plans if possible
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

Install door sweep
### Envelope: Blower Door Testing

#### Test Details

<table>
<thead>
<tr>
<th>Test Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>S8</td>
</tr>
<tr>
<td>Floor Area (sq. ft.)</td>
<td>924</td>
</tr>
<tr>
<td>Surface Area (sq. ft.)</td>
<td>2928</td>
</tr>
<tr>
<td>Volume (cu. ft.)</td>
<td>3316</td>
</tr>
<tr>
<td>Outdoor Temp (F)</td>
<td>45</td>
</tr>
<tr>
<td>Indoor Temp (F)</td>
<td>60</td>
</tr>
<tr>
<td>Fan Position</td>
<td>Depress</td>
</tr>
<tr>
<td>Wind Condition</td>
<td>Baseline</td>
</tr>
<tr>
<td>Baseline Pressure</td>
<td>0 Pa</td>
</tr>
</tbody>
</table>

#### Test Results

<table>
<thead>
<tr>
<th>Test Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>House Pressure (Pa)</td>
<td>47.4</td>
</tr>
<tr>
<td>Fan Pressure (Pa)</td>
<td>156.7</td>
</tr>
<tr>
<td>Flow Rate (cfm)</td>
<td>518.5</td>
</tr>
<tr>
<td>Temp Corr Flow (cfm)</td>
<td>526.1</td>
</tr>
<tr>
<td>Log (House Pressure)</td>
<td>1.676</td>
</tr>
<tr>
<td>Log (Flow Rate)</td>
<td>2.721</td>
</tr>
</tbody>
</table>

#### Graph:

![Graph showing the relationship between log of house pressure and log of CFM](image)

### Calculations

- **Slope:** 0.5811
- **Intercept:** 1.7491
- **R^2:** 0.9872

#### Calculated Values

- **CFM:** 545
- **ACH:** 3.93
- **ACH_{25}:** 0.23
- **ELA:** 36.6 in² (4 Pa)
- **EqLA:** 62.9 in² (10 Pa)
- **Leakage Ratio:** 0.186109439
- **ELA (in²)/100 ft²:** 1.22
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
High Priorities

• Weatherstripping

• Airsealing (Energy/O&M/H&S)
  – Stairwell Venting
  – AC Covers
  – Penetrations

• Roof/cavity Insulation
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

Exhaust CFM at Each Floor of a 9-story Building

- Over-ventilation (energy waste)
- Under-ventilation (Potential indoor air quality problems)

30 CFM = SWA Recommended Ventilation Rate

Floor of Building

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

Questions?

Ryan Merkin
rmerkin@swinter.com
212-564-5800 ext.116