# It's the Money

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## Let's Get Acquainted …

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIA, ASID, IIDA, ASHRAE,</td>
<td>A &amp; D / M, E &amp; P</td>
</tr>
<tr>
<td>BOMA, CORENET, CREW, IAMC,</td>
<td>Broker / Property Manager</td>
</tr>
<tr>
<td>IFMA, NAIOP, USGBC</td>
<td>Developer / Landlord</td>
</tr>
<tr>
<td></td>
<td>General Contractor / Sub</td>
</tr>
<tr>
<td></td>
<td>Lender</td>
</tr>
<tr>
<td></td>
<td>Tenant / Corporate</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
</tbody>
</table>

### Project Pipeline

- Upgrade or Modernization
- New Construction

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NAIOP Denver, CO - June 18, 2008  
2
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- Real Estate Experience
  - 40 Million Square Feet
    - Office
    - Industrial
    - Data Centers
    - Hotel & Resort
  - Roles
    - Asset Manager
    - Commercial Real Broker
    - Construction Manager
    - Development Manager
    - Facility Manager
    - Real Estate Consultant

- Author
  - Books, Articles & Software

Today's Program

Criteria
- Economic Benefits
- No Bleeding Edge Technology
- Clarity of Concept
  - Sustainability is not a product, it is a benefit of the process
  - Good design adds value faster than cost
  - Good enough – Isn't
  - Quality is free, doing things wrong is expensive
  - The marketplace set rents, you define your costs
  - Absent value, price becomes the key selection criteria

Agenda
1. Sustainability in Context
2. Where's The Money
3. Model Green Lease Project
4. Building Systems
   - Building Envelope
   - Lighting
   - HVAC & IAQ
   - Water
   - Commissioning
5. High Performance Building Checklist
6. Q & A
What’s a High Performance Building?

“A building that is environmentally responsible, profitable, and a healthy place to live or work.”

Sustainability in Context

What Do Tenants Want?
Top Ten Features, Amenities and Services

1. Rental Rates (Pass-through/escalations) 99% 88%
2. Comfortable Temperatures 99% 74%
3. Indoor Air Quality 99% 81%
4. Acoustics/Noise Control 99% 83%
5. Ability of Bldg. Mgmt. to Meet Tenant’s Needs 99% 89%
6. Quality Maintenance Work 99% 89%
7. Responsiveness of Bldg. Mgmt. 99% 89%
8. Effective Communications with Bldg. Mgmt. 99% 86%
9. Appearance of Building 98% 93%
10. Operating Expenses 98% 87%
14. Environmentally Friendly Materials 90% 89%
48. Operable Windows 40% 61%

Source: What Office Tenants Want - BOMA/ULI

How Well Does the Workplace Perform?

Source: CBE, IEQ Database - Occupant Satisfaction > 210 Buildings 34,000 Respondents
It's the Money

The Workplace & People - Ten Year Cost

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Rent</td>
<td>$68,973</td>
</tr>
<tr>
<td>347 SF @ $24.03 Yr *</td>
<td></td>
</tr>
<tr>
<td>Tenant Improvements</td>
<td>$8,683</td>
</tr>
<tr>
<td>347 SF @ $25.00</td>
<td></td>
</tr>
<tr>
<td>Office Furniture</td>
<td>$8,014</td>
</tr>
<tr>
<td>$6,000 + $300 Yr *</td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>$87,471</td>
</tr>
<tr>
<td>$10,000 + $10,000 Yr *</td>
<td></td>
</tr>
<tr>
<td>Salary &amp; Benefits</td>
<td>$690,356</td>
</tr>
<tr>
<td>$83,678 Yr *</td>
<td></td>
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<tr>
<td><strong>Total Costs</strong></td>
<td><strong>$863,497</strong></td>
</tr>
<tr>
<td>Present Value 10-Years</td>
<td></td>
</tr>
</tbody>
</table>

Source: BOMA, BLS, * 2.5% Annual CPI, PV @ 5.75% Discount rate

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Where's the Money?

Making the Link Between Sustainability and Value

- Payback Period & ROI
- Trends in Energy Costs & Usage
- Operating Costs & Value
- Case Study
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What’s Your Payback Period?

Payback Period in Years

Simple Payback Period = \( \frac{\text{Initial Investment}}{\text{Annual Return}} \)

Return on Investment = \( \frac{\text{Annual Return}}{\text{Initial Investment}} \)

Payback Period & Return on Investment

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Income & Expense 2005 - 1985

<table>
<thead>
<tr>
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<th></th>
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<tbody>
<tr>
<td><strong>Total Income</strong></td>
<td>$22.75</td>
<td>$24.04</td>
<td>$22.72</td>
<td>$19.33</td>
<td>$17.26</td>
<td>$14.73</td>
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<td>Cleaning</td>
<td>1.21</td>
<td>1.20</td>
<td>1.17</td>
<td>1.20</td>
<td>1.15</td>
<td>1.05</td>
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<tr>
<td>Repairs &amp; Maintenance</td>
<td>1.55</td>
<td>1.52</td>
<td>1.37</td>
<td>1.55</td>
<td>1.38</td>
<td>1.21</td>
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<tr>
<td>Utilities</td>
<td>2.00</td>
<td>1.83</td>
<td>1.86</td>
<td>1.87</td>
<td>1.84</td>
<td>1.85</td>
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<tr>
<td>Roads, Grounds &amp; Security</td>
<td>.72</td>
<td>.73</td>
<td>.68</td>
<td>.61</td>
<td>.50</td>
<td>.38</td>
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<tr>
<td>Administrative</td>
<td>1.18</td>
<td>1.22</td>
<td>1.18</td>
<td>1.12</td>
<td>.90</td>
<td>.68</td>
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<tr>
<td>Fixed Expenses</td>
<td>3.06</td>
<td>3.39</td>
<td>3.14</td>
<td>2.98</td>
<td>2.84</td>
<td>2.17</td>
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<tr>
<td><strong>Total Expenses</strong></td>
<td>$9.72</td>
<td>$9.89</td>
<td>$9.40</td>
<td>$9.33</td>
<td>$8.61</td>
<td>$7.34</td>
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<tr>
<td><strong>Net Operating Income</strong></td>
<td>$13.03</td>
<td>$14.15</td>
<td>$13.32</td>
<td>$10.00</td>
<td>$8.65</td>
<td>$7.39</td>
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</tbody>
</table>

BOMA Experience Exchange Report, All Buildings

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Commercial Electricity Prices Rising

Source: EIA – Form EIA 826

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Commercial Natural Gas Prices Rising


Energy Use
### Annual Energy Use by Building Type

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Million Btu</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family - Detached</td>
<td>108</td>
<td>31,653</td>
</tr>
<tr>
<td>Apartment - 1 to 4 Unit Building</td>
<td>78</td>
<td>22,861</td>
</tr>
<tr>
<td>Apartment - 5+ Unit Building</td>
<td>41</td>
<td>12,016</td>
</tr>
<tr>
<td>Office Building - 125,000 Sq Ft</td>
<td>11,625</td>
<td>3,406,094</td>
</tr>
</tbody>
</table>

### Btu Conversion Factors
- Electricity: kWh $\times$ 3,413
- Natural Gas: therms $\times$ 100,000 or CCF $\times$ 1,030
- Steam: 1,000 lbs $\times$ 1,000,000
- Chill Water: 1,000 tons-hrs $\times$ 3,413,000
- Fuel Oil: US Gal $\times$ 91,333

Source: EIA

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### Energy Use Intensities - Office Buildings

<table>
<thead>
<tr>
<th>LEED NC</th>
<th>K Btu per Sq Ft per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td>144</td>
</tr>
<tr>
<td>Commercial Building Consumption Survey</td>
<td>93</td>
</tr>
<tr>
<td>LEED NC Certified Avg.</td>
<td>67</td>
</tr>
<tr>
<td>LEED NC Silver Avg.</td>
<td>62</td>
</tr>
<tr>
<td>LEED NC Gold/Pt. Avg.</td>
<td>51</td>
</tr>
<tr>
<td>Wells Fargo Ctr.</td>
<td>56.6</td>
</tr>
<tr>
<td>LEED NC Lowest</td>
<td>27</td>
</tr>
</tbody>
</table>

Source: Energy Performance of LEED Buildings
Electricity Usage – Office Buildings

Source: E-Source

Operating Costs & Value
What’s a Watt Worth?

Electricity Reduction - Lighting 563,745 kWh
- 1W SF x 125,000 SF x 86.7 Hrs Week x 52 Weeks

Less Lights = Less Heat to be Removed 36 Tons
- 125,000W x 3.412 Btu / 12,000 Btu per Ton

Electricity Reduction - Cooling 129,888 kWh
- 36 Tons x 0.8 kW/ton x 4,510 Hours

Total Electricity Reduction - Lighting & Cooling 693,633 kWh

Annual Reduction in CO₂ Emissions 554.9 Tons
- 693,633 kWh x 1.6 lbs CO₂ per kWh

Savings in Annual Operating Costs $58,265
- 693,633 kWh @ $0.084/kWh = $58,265 or $0.4661 SF

\[
693,633 \text{ kWh} \times 3.412 \div 1,000 \div 125,000 = 18.94 \text{ k Btu / Sq Ft /Yr}
\]

Building Value - Income Capitalization

Per Square Foot

<table>
<thead>
<tr>
<th>Total Income</th>
<th>$ 17.42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Expenses</td>
<td>6.95</td>
</tr>
<tr>
<td>Net Operating Income</td>
<td>$ 10.47</td>
</tr>
<tr>
<td>Capitalization Rate</td>
<td>7.50%</td>
</tr>
<tr>
<td>Building Value</td>
<td>$139.60</td>
</tr>
</tbody>
</table>

Income and Expense All Buildings
BOMA Experience Exchange Report 2004
Indianapolis Suburban Buildings
## Operating Costs Effect Value

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
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</thead>
<tbody>
<tr>
<td>Total Income</td>
<td>$17.42</td>
<td>$17.42</td>
</tr>
<tr>
<td>- Total Expenses</td>
<td>6.95</td>
<td>6.48</td>
</tr>
<tr>
<td>= Net Operating Income</td>
<td>$10.47</td>
<td>$10.94</td>
</tr>
<tr>
<td>÷ Capitalization Rate</td>
<td>7.50%</td>
<td>7.50%</td>
</tr>
<tr>
<td>= Building Value</td>
<td>$139.60</td>
<td>$145.87</td>
</tr>
</tbody>
</table>

Value Created per Square Foot: $6.17  
Total Economic Value Created: $776,867.00

Income and Expense All Buildings  
BOMA Experience Exchange Report 2004  
Indianapolis Suburban Buildings

## How the Numbers Pencil Out

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Energy Savings</td>
<td>$58,265</td>
</tr>
<tr>
<td>Capitalization Rate</td>
<td>7.5%</td>
</tr>
<tr>
<td>Economic Value Added</td>
<td>$776,867</td>
</tr>
<tr>
<td>Loan to Value Ratio</td>
<td>75%</td>
</tr>
<tr>
<td>Additional Loan Amount</td>
<td>$582,650</td>
</tr>
</tbody>
</table>

Additional Cost for Lighting Upgrade: - $147,500  
Excess Loan Proceeds: $435,150  
Annual Loan Payment (25-Year Amortization @ 6.81%): $49,145  
Free Cash Flow (Energy Savings - Loan Payment): $9,120
Summary – What’s a Watt Worth

Upgrade to Lighting System
- Initial Investment $147,500
- Annual Energy Savings $58,265

• Simple Payback 2.5 Yrs
• ROI on Energy Savings 39.5 %
• ROI on Increased Building Value 526.7 %

• Increased Building Value $776,867

Case Study

Banner Bank Building – Boise
LEED CS, Platinum
Banner Bank Building - Boise, ID

- 180,000 square feet
- Office Rents
  - $19.00 - $21.50 FSG
    - CBD Market Rate
- Opened July 2006
  - 14% Leased at opening
  - Building accounted 34% of vacant space in CBD
  - Now 85%+ Leased
- Construction Costs
  - $120 sq ft
- Operating Costs
  - 37.4% Below Competitors

Design & Construction

- LEED CS Platinum
  - 50% - Less Energy Use
  - 80% - Less Water Use
- Building Features
  - Column Free Space
  - Under Floor Air Distribution
  - Moveable Wall System
  - Lighting Control
  - Low E Glass
  - Cool Roof
  - Recycled Water
    - Stormwater
  - Low Flow Plumbing Fixtures
  - Geothermal Heat
Value was Added in Four Areas

1. Spending in one area is offset by greater savings in other areas
2. Improving the quality of operations
3. Capitalize the savings in operating costs
4. Tax savings and cost of change over

Value of Building Green

<table>
<thead>
<tr>
<th>Per Square Foot</th>
<th>&quot;Market&quot; Downtown Boise</th>
<th>Banner Bank Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Income</td>
<td>$19.95</td>
<td>$19.95</td>
</tr>
<tr>
<td>- Total Expenses</td>
<td>-7.75</td>
<td>-4.85</td>
</tr>
<tr>
<td>= Net Operating Income</td>
<td>$12.20</td>
<td>$15.10</td>
</tr>
<tr>
<td>+ Capitalization Rate</td>
<td>7.5%</td>
<td>7.5%</td>
</tr>
<tr>
<td>= Building Value</td>
<td>$162.67</td>
<td>$201.33</td>
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</table>

Value Created per sq ft                   $38.66
Total Value Created                       $6,960,000
Overview of Green Lease

Landlord & Tenant Needs

Model Green Lease Project - Overview

- Rent structure and operating expenses
  - FSG with Expense Stop or Full CPI
- Energy use by tenant
  - Energy Allowance & Sub-Metering
- Operational performance
  - Defined in Lease (ASHRAE 90.1 & 62.2) & Building Hours
- Hazardous materials
  - Defined in Lease
- Recycling & Green cleaning
  - Defined in Lease & Building Rules and Regulations
- Build out of tenant spaces
  - Defined in Construction Letter & Contractor Regulations

Source: Model Green Lease Project
Building Systems

- Building Envelope
- Lighting
- HVAC & IAQ
- Water Management
- Commissioning

Typical Office Building Envelope

- Building Shell
  - Percent Glass: 40 - 50
  - Shading Coefficient: .69 - .80
  - Window U-Value: .72 - .58
  - Window R-Value: 1.39 - 1.71
  - Wall R-Value: 2.5 - 6.0
  - Roof R-Value: 9.1 - 12.6

- On a Sunny Day 95° F
  - Dark Roof: 180° F
  - Window: 120° F
  - Interior Space: 75° F

Source: DOE

National Business Park – Annapolis Junction, MD
Roofing Systems

White Roofs Are Cool

• Nearly half of US population lives or works in a heat island
  – Dark roofs cause 38% of heat island effect
• On a Sunny Day 95° F
  – Dark Roof 180° F
  – White Roof 110° F
• Energy Star Roof Criteria
  – ≥ 65% Initial Reflectance
  – ≥ 50% Reflectivity after 3-yrs.
• Roofs are 5-10% of building cost, yet account for 60-80% of litigation
## White Roofs Are Cool

![Georgia Tech – Atlanta, GA](image)

### White Roofs Are Cool Money Makers

<table>
<thead>
<tr>
<th>Office/Lab Building - 34,000 Sq. Ft.</th>
<th>Cooling Savings - Yr.</th>
<th>Increased Bldg. Value</th>
<th>Value per Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta, GA</td>
<td>$4,250</td>
<td>$56,667</td>
<td>$1.67</td>
</tr>
<tr>
<td>Baltimore, MD</td>
<td>$3,320</td>
<td>$44,267</td>
<td>$1.30</td>
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<tr>
<td>Boston, MA</td>
<td>$2,074</td>
<td>$27,653</td>
<td>$0.81</td>
</tr>
<tr>
<td>Charlotte, NC</td>
<td>$4,046</td>
<td>$53,947</td>
<td>$1.59</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>$2,312</td>
<td>$30,827</td>
<td>$0.91</td>
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<tr>
<td>Columbus, OH</td>
<td>$2,346</td>
<td>$31,280</td>
<td>$0.92</td>
</tr>
<tr>
<td>Detroit, MI</td>
<td>$1,802</td>
<td>$24,027</td>
<td>$0.71</td>
</tr>
<tr>
<td>Las Vegas, NV</td>
<td>$6,052</td>
<td>$80,693</td>
<td>$2.37</td>
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<tr>
<td>Long Beach, CA</td>
<td>$3,264</td>
<td>$43,520</td>
<td>$1.28</td>
</tr>
<tr>
<td>Sacramento, CA</td>
<td>$3,672</td>
<td>$48,960</td>
<td>$1.44</td>
</tr>
</tbody>
</table>

Source: DOE - ORNL – Cool Roof Calculator - $0.10 kWh & 7.5% Cap Rate

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NAIOP Denver, CO - June 18, 2008
Green Roofs

Ford Rouge Plant - The Challenge

- 31 inches of rain per year
  - Storm water runoff
  - Floods assembly plant
- Traditional Solution
  - Storm water treatment plant
  - Large footprint
  - Costly to build and operate
- Sustainable Solution
  - 10.4 acre green roof
  - Porous pavement
  - Underground storage basins
  - Natural wetlands & swales

Rouge Plant, Detroit - 1952
Green Roof - Benefits

- One-third the cost of storm water treatment plant and virtually no operating costs
- Maximized Land Use
- Additional Benefits
  - Cuts heating & cooling costs by up to 5%
  - Monitors & skylights allow half of the plant's lights to be turned off
  - Protects underlying roof from UV and thermal shocks - it's expected to last twice as long as a built up roof
  - Reduces heat island effect

Rouge Plant, Detroit - 2003

Do You Mow a Green Roof?

- Sedum is a drought-resistant groundcover
  - It grows to only six inches tall and spreads horizontally, crowding out weeds/plants
- Four layer blanket
  - Shale, sand, peat, compost and dolomite
  - Absorbent fleece like mat of recycle material
  - Drainage layer carries off excess water
  - Root-resistant membrane to protect the roof
- Properly insulate with non-moisture absorbing insulation
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Exterior Walls & Glazing

Thermal Efficiency - Exteriors Walls

- Brick
- Concrete
- EIFS
- Glass
- Masonary
- Stucco
- Wood

Source: DOE - ORNL
More R-Value or More HVAC?

Wall - R-Value 20, U-Factor 0.05
Window - R-Value 12.5, U-Factor 0.08

5/8” Paperless Gypsum Board
R-13 Batt Insulation
Exterior Sheathing
Water Barrier System
R-7.5 Foam Insulation
Air Space
Brick

2 Heat Mirror Films
3 krypton filled airspaces
warm edge insulated spacer bar
gas retention tape

78% Reduction in Exterior HVAC Load

<table>
<thead>
<tr>
<th></th>
<th>Winter 24°F exterior</th>
<th>Summer 99°F exterior</th>
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<tbody>
<tr>
<td></td>
<td>70°F interior</td>
<td>78°F interior</td>
</tr>
<tr>
<td>Average Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall (R-6.96 / U-1.14)</td>
<td>460,355 Btu</td>
<td>240,185 Btu</td>
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<tr>
<td>Window (R-1.96 / U-0.51)</td>
<td>815,212 Btu</td>
<td>425,328 Btu</td>
</tr>
<tr>
<td>Total</td>
<td>1,275,567 Btu</td>
<td>665,513 Btu</td>
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<tr>
<td>High Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall (R-20 / U-0.05)</td>
<td>159,355 Btu</td>
<td>83,398 Btu</td>
</tr>
<tr>
<td>Window (R-12.5 / U-0.08)</td>
<td>127,876 Btu</td>
<td>66,718 Btu</td>
</tr>
<tr>
<td>Total</td>
<td>287,231 Btu</td>
<td>150,116 Btu</td>
</tr>
</tbody>
</table>

U Value × ΔT °F × Sq Ft of Area
69,498 Sq Ft Walls
34,749 Sq Ft Windows

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Three Story Multi-Building Research Facility

- 97,000 Sq. Ft. Curtain Walls, Windows & Skylights
- Double Pane R2 Glazing System $40/Sq. Ft. $3,880,000
- Three Element R5 Glazing System $43/Sq. Ft. $4,171,000
- Incremental Investment - R2 to R5 Glazing System $291,000
- Annual Energy Savings with R5 Glazing System $42,800
- Simple Payback on R5 Glazing System 6.8 years

The Value Added Approach

Energy Savings $42,800
Capitalization Rate 7.5%
Economic Value Added $570,667
Loan to Value Ratio 75%
Loan Amount $428,000
Cost of Window Upgrade - $291,000
Excess Loan Proceeds $137,000

Annual Loan Payment (25-Year Amortization @ 6.81%) $36,100
Free Cash Flow (Energy Savings - Loan Payment) $6,700
## The Bottom Line Budget Approach

<table>
<thead>
<tr>
<th>Building System</th>
<th>Double Pane R2 Glazing</th>
<th>Three Element R5 Glazing</th>
<th>Difference</th>
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<tbody>
<tr>
<td>Glazing</td>
<td>$3,880,000</td>
<td>$4,171,000</td>
<td>$291,000</td>
</tr>
<tr>
<td>Heating</td>
<td>1,419,000</td>
<td>358,550</td>
<td>-1,050,450</td>
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<tr>
<td>Cooling/Ventilation</td>
<td>1,965,600</td>
<td>1,646,400</td>
<td>-319,200</td>
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<td>Electrical</td>
<td>410,800</td>
<td>363,800</td>
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</tr>
<tr>
<td></td>
<td><strong>$7,675,400</strong></td>
<td><strong>$6,549,750</strong></td>
<td><strong>-1,125,650</strong></td>
</tr>
</tbody>
</table>

**Energy Savings**  
PV 20 Yrs. @ 5% Discount Rate  
$0 - $533,383 - $533,383

**Net Savings**  
$7,675,400 $6,016,367 - $1,659,033

**Return on Investment**  
670%

---

## Lighting

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Climate Zone and Lighting

Climate can impact lighting’s effect on a customer’s energy bill by up to 60%

Source: Platts, SEA Analysis

How Much Light is Enough?

IESNA Suggestions:
- Weighted Average Foot Candles
  - Corridor/Transition: 10 FC
  - Restroom: 12 FC
  - Stairway: 15 FC
  - Lobby: 16 FC
  - Active Storage: 20 FC
  - Lounge/Recreation: 21 FC
  - Office: 35 FC
    - Task Lighting: 50 FC
    - Ambient Lighting: 20 FC

Variations of +/- 33% from IESNA recommended light levels can be considered as "the same" light level

Bay Networks
Lighting – Best Practices

• Control Tactics
  – Time Clocks
  – Occupancy Sensors
  – Daylighting
  – Dimming Ballasts

• Design Strategies
  – Light Colored Finishes
  – Wall Washing
  – Direct/Indirect Fixtures
  – Task/Ambient Lighting
    • Lower Ambient Light Levels
    • CRI 85-86 and 5000 K
  – Personal Lighting Control of Workstation Specific Fixtures
  – Bleeding edge .3 Watts Sq Ft

Ford Motor Company – Irvine, CA
## Fixture Layout - 8’ x 8’ on Center

<table>
<thead>
<tr>
<th></th>
<th>2’ x 4’ Prismatic</th>
<th>2’ x 4’ Parabolic</th>
<th>2’ x 4’ Parabolic</th>
<th>2’ x 4’ Parabolic</th>
<th>4” x 4’ Parabolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Lamps Type</td>
<td>T1234</td>
<td>T832</td>
<td>T832</td>
<td>T825</td>
<td>T5 HO</td>
</tr>
<tr>
<td>Lamps per Fixture</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Avg. Foot Candles</td>
<td>106.0</td>
<td>78.7</td>
<td>49.8</td>
<td>40.1</td>
<td>51.5</td>
</tr>
<tr>
<td>Watts per Fixture</td>
<td>167</td>
<td>87</td>
<td>57</td>
<td>43</td>
<td>60</td>
</tr>
<tr>
<td>Total Watts</td>
<td>3,340.8</td>
<td>1,612.8</td>
<td>1,152</td>
<td>860</td>
<td>1,152</td>
</tr>
<tr>
<td>Watts per Sq. Ft.</td>
<td>2.9</td>
<td>1.4</td>
<td>1.0</td>
<td>0.75</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Area 32’ x 36’ 1,152 SF

## Fixture Layout - 8’ x 10’ on Center

<table>
<thead>
<tr>
<th></th>
<th>2’ x 4’ Prismatic</th>
<th>2’ x 4’ Parabolic</th>
<th>2’ x 4’ Parabolic</th>
<th>2’ x 4’ Parabolic</th>
<th>4” x 4’ Parabolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Lamps Type</td>
<td>T1234</td>
<td>T832</td>
<td>T832</td>
<td>T825</td>
<td>T5 HO</td>
</tr>
<tr>
<td>Lamps per Fixture</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Avg. Foot Candles</td>
<td>85.7</td>
<td>63.5</td>
<td>40.7</td>
<td>33.1</td>
<td>41.6</td>
</tr>
<tr>
<td>Watts per Fixture</td>
<td>167</td>
<td>87</td>
<td>57</td>
<td>43</td>
<td>60</td>
</tr>
<tr>
<td>Total Watts</td>
<td>2,649.6</td>
<td>1,382.4</td>
<td>921.6</td>
<td>688</td>
<td>921.6</td>
</tr>
<tr>
<td>Watts per Sq. Ft.</td>
<td>2.3</td>
<td>1.2</td>
<td>0.8</td>
<td>0.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Area 32’ x 36’ 1,152 SF
Daylighting

Using Daylight Saves

- Existing T12 Lighting - 1.44 Watts/SF - 40 FC
- T8 Retrofit - 1.19 Watts/SF - 60 FC
- "Tuned w/ Dimming Ballasts" - 0.84 Watts/SF - 50 FC
- Day Light Harvesting - 0.65 Watts/SF Avg. - 50 FC

3100 Bristol - Costa Mesa, CA - 4.29.1999

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Occupancy Sensors

Why Light An Empty Room?

- Rest Rooms: 70%
- Meeting Rooms: 66%
- Store Room: 56%
- Single Person Office: 53%

EPA Survey of 171 Sites
## Lighting Summary

<table>
<thead>
<tr>
<th></th>
<th>2’ x 4’ Fixtures</th>
<th>2’ x 4’ Fixtures</th>
<th>2’ x 4’ Fixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 - T1234 Lamps</td>
<td>2 - T825 Lamps</td>
<td>2 - T825 Lamps</td>
</tr>
<tr>
<td></td>
<td>6’ 0” x 8’ 0” Gnd</td>
<td>6’ 0” x 8’ 0” Gnd</td>
<td>8’ 0” x 10’ 0” Gnd</td>
</tr>
<tr>
<td>Lighting Watts per Sq Ft</td>
<td>2.9</td>
<td>.75</td>
<td>.6</td>
</tr>
<tr>
<td>Building Sq Ft</td>
<td>125,000</td>
<td>125,000</td>
<td>125,000</td>
</tr>
<tr>
<td>Total Lighting Watts - Building</td>
<td>362,500</td>
<td>93,750</td>
<td>75,000</td>
</tr>
<tr>
<td>Operating Hours (87.6 Hrs x 52 Wks)</td>
<td>4,555.2</td>
<td>4,555.2</td>
<td>4,555.2</td>
</tr>
<tr>
<td>Kilowatt Hours (kWh)</td>
<td>1,651,260</td>
<td>427,050</td>
<td>341,640</td>
</tr>
<tr>
<td>Sensors, Daylighting &amp; Dimming (-30%)</td>
<td>(128,115)</td>
<td>(102,492)</td>
<td></td>
</tr>
<tr>
<td>Total Kilowatt Hours (kWh)</td>
<td>1,651,260</td>
<td>298,935</td>
<td>239,148</td>
</tr>
<tr>
<td>Energy Cost ($0.084 kWh - Phoenix)</td>
<td>$138,706</td>
<td>$25,111</td>
<td>$20,088</td>
</tr>
<tr>
<td>Energy Cost per Sq Ft</td>
<td>$1.11</td>
<td>$0.20</td>
<td>$0.16</td>
</tr>
</tbody>
</table>

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It's the Money

HVAC

HVAC 101

Outside Air

Recirculation

Exhaust Air

Filters Cool Heat Humidify Perimeter Heat

Return Air Interior Zone Perimeter Zone
Air Handling Systems Design

- Constant Volume System
  - Reheat System
  - Dual-Duct System
  - Multi-zone System
- Variable Air Volume (VAV)
  - Converting from Constant Volume to Variable Volume saves about 30% in energy costs
- Overhead Air Distribution
  - Well Mixed Room
- Under Floor Air Distribution
  - Partial Positive Displacement

Constant Air Volume System

Outside Air → Return Air

Cooling Coil → Supply Fan

70° → 55° → 55°

High Cooling Load → Moderate Cooling Load
It's the Money

Constant Air Volume System

Variable Air Volume System
Variable Air Volume System

- Cooling Coil
- Supply Fan
- Outside Air
- Return Air
- High Cooling Load
- Moderate Cooling Load
- 70°F +
- 55°F
- 55°F
- VAV Box
- 55°F
- 55°F

Air Distribution Methods

- Over Head
  - Well Mixed Room
  - 55°F supply temp.
- Under Floor
  - Partial Positive Displacement
  - 64°F supply temp.
Air Distribution Methods Impacts IAQ

Benefits of Under Floor Air Distribution

- Better IAQ & Thermal Comfort
- Lower First & Operating Costs
  - 20% Reduction in HVAC Size
    - 64°F vs. 55°F supply temp.
    - Conditioning occupied zone - not entire space
  - 30% Reduction in Energy Use
    - Smaller equipment
    - Lower fan pressure
    - More hours of outside air
- Modular Power, Voice & Data
  - Supports future technologies
  - Lower churn/change costs

Owens Corning World Headquarters – Toledo, OH
High-Efficiency Components

Cost premium is recovered < 1 year - 100+% ROI
Total cost is recovered < 5 years - 20+% ROI
Variable Speed Drives Save Energy

- VSD are an electronic device that varies the frequency of electricity to the motor to adjust its speed
- An EPA study showed VSDs provided an average energy savings of 52%
- Using VSDs can reduce total HVAC system cost
  - Smaller Pumps
  - Smaller Motors
  - Simpler Piping

The Right Chiller Saves Money Twice

500 Ton Chiller Comparison

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>R-123</th>
<th>R-134a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Load kW/ton</td>
<td>.530</td>
<td>.560</td>
</tr>
<tr>
<td>IPLV</td>
<td>.473</td>
<td>.350</td>
</tr>
<tr>
<td>Speed</td>
<td>Constant</td>
<td>Variable</td>
</tr>
<tr>
<td>kWh/ Year</td>
<td>695,164</td>
<td>527,328</td>
</tr>
<tr>
<td>Energy Savings</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td>First Cost</td>
<td>10% Less</td>
<td></td>
</tr>
</tbody>
</table>

LBNL Study: Chillers oversized 50 to 200%
Economizer Strategies

- Air Side Economizer
  - ASHRAE 90.1 & 62.1
- Water Side Economizer
- Night Time Pre-Cooling
- Run Around Energy Recovery Loop
- Air to Air Energy Recovery
  - AKA: Total Energy Wheel
  - AKA: Desiccant Wheel

70% to 90% Energy Recovery Efficiency
Indoor Air Quality

Dust & Microbial Contamination

• Findings of GSA Study
  – 70% Airborne, 63% Not Visible
  – 100 Microns of Dust on Coil Cuts Cooling Capacity 10%
  – 20-30% increase in annual energy costs

• Air Filters
  – Filter bank as large as possible
  – Use common filter size
  – Use pre-filters to extend the life of high cost filters
    • MERV 8 / MERV 14 / HEPA

• UVGI
Ultraviolet Germicidal Irradiation - UVGI

- GSA Requirement
- The germicidal wavelengths are located around 254 nanometers in the UV-C band
  - Controls fungi in HVAC systems to reduce or eliminate mold-related allergies
  - Prevents the development of Legionella and other bacteria … provides a recognized control strategy for tuberculosis
  - Predictably reduces the spread of cold and flu viruses and other airborne-transmitted diseases

UVGI is a Profit Center

- Kills mold & bacteria in HVAC system - Improves IAQ
- Cleans coils to “like new” - Cuts Maintenance Costs
- Reduces fan pressure across coils - Saves Energy
- Improves HVAC system efficiency - Downsize HVAC Equipment

AEP Saves $139,964 Per Year in Energy Costs

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Control Pollutants at the Source

• Office Equipment
  – Consolidate & Ventilate
• Use "low-emitting" materials, finishes, and furnishings that within one week of installation must contribute less than:
  – 61 µg/m³ or 0.05 ppm (50 ppb) of formaldehyde
  – 500 µg/m³ total volatile organic compounds (TVOC)
  – 50 µg/m³ of particles
  – 6 µg/m³ or 0.001 ppm (1 ppb) of 4-phenylcyclohexene (4-PC)
  – Third Party Certified

Water Management
Water Usage & Conservation Measures

Water Sewer Costs $0.11/Sq. Ft.
$2.15 per 1,000 Gallons Supply
$3.19 per 1,000 Gallons Sewer

Conservation Strategies
- Promptly Find & Repair Leaks
- Water Closets 1.1 GPF
- Waterless Urinals
- Metering Faucets w/ Aerators
- Water Efficient Landscaping
- Storm & Gray Water Recovery
- Mechanical System
  - HVAC Condensate Recovery
  - Boiler Blowdown & Tempering
  - Cooling Tower Water Treatment

Best Practices for Indoor Water Use

AWWA Research Foundation
Median Indoor Water Use
1,728,000 $9,228 19.20


<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>Daily Use</th>
<th>Gal/Yr</th>
<th>Annual Cost</th>
<th>Gal FTE Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Closet</td>
<td>1.6 GPF</td>
<td>1M + 3F</td>
<td>288,000</td>
<td></td>
</tr>
<tr>
<td>Urinal</td>
<td>1 GPF</td>
<td>2M + 0F</td>
<td>90,000</td>
<td></td>
</tr>
<tr>
<td>Faucet</td>
<td>2.5 GPM</td>
<td>.75 Min</td>
<td>168,750</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>Daily Use</th>
<th>Gal/Yr</th>
<th>Annual Cost</th>
<th>Gal FTE Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Assist Water Closet</td>
<td>1.1 GPF</td>
<td>1M + 3F</td>
<td>198,000</td>
<td></td>
</tr>
<tr>
<td>Waterless Urinal</td>
<td>0 GPF</td>
<td>2M + 0F</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Low Flow Sensor Faucet</td>
<td>.5 GPM</td>
<td>.60 Min</td>
<td>27,000</td>
<td></td>
</tr>
</tbody>
</table>

225,000 $1,202 2.50

125,000 Sq Ft Building - 360 People - 50% M 50% F - 250 Days/Year

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Commissioning Defined

- Commissioning is the systematic, quality-focused process of ensuring facilities, systems and equipment perform according to design intent and procurement contracts.
- The process assures owners and occupants that the building will meet their needs and expectations.
- Commissioning is an Audit & Risk Management Tool.
Commissioning Uncovers Hidden Problems

- Lawrence Berkeley National Laboratory studied 60 new buildings and determined that:
  - 50% had control problems
  - 40% had HVAC problems
  - 15% were missing equipment
  - 25% had malfunctioning facility management systems, economizers or drives

- Additional findings:
  - 60% of insurance claims are related to HVAC systems
  - Leading source of complaints is the HVAC system
High Performance Building Checklist

- Optimize Building Orientation
- Sustainable Landscaping
  - Native Plants
  - Permeable Paving & Bio Swales
- Optimize Structural System
- Energy Star Roof & Green Roof
- Exterior
  - Moisture Control & Air Barrier
  - High R Value Insulation
- Glazing
  - Low-E Glazed Windows
  - Thermally Enhanced Frames

High Performance Building Checklist

- Electrical System
  - Harmonic Canceling Transformers
  - Hybrid UPS
  - Micro-Turbine Back Up Power
- Lighting
  - Task Ambient Lighting
  - Wall Washers
  - Scotopic Enhanced Lighting
  - Smart Ballast
  - Daylighting
  - Occupancy Sensors
  - Time Clocks & Controls
### High Performance Building Checklist

**HVAC & Indoor Air Quality**
- Decouple Cooling & Dehumidification
- High Performance Insulation
- Under Floor Air Distribution
- Thermal Energy Storage
- Premium Efficiency Motors
- Variable Speed Drives
- Fan Wall
- Economizers
- Energy Recovery
- High Performance Air Filters
- UVGI & Electronic Air Cleaners
- Dedicated Exhaust

**Plumbing**
- Waterless Urinals
- Low Flow Plumbing Fixtures
- Rain Water Collection
- Gray Water Recovery
- UV Treatment Drinking Water
- Ozone Water Treatment

**Hand Dryers**

**Flexible Head Sprinklers**

**Building Management System**
- Sub-Metering
- Air Sampling & Monitoring

**Integrated Building Security**
High Performance Building Checklist

- Interior Fit Out
  - Modular Power/Voice/Data Cabling
  - Moveable Walls
  - Paperless Drywall
  - Carpet Tiles
  - High Performance Ceiling Tile
  - Sound Masking
  - LCD Monitors
- Smart Moves Strategies
- “Green” Cleaning Products
- Daytime Cleaning
- Recycling Program

Bank of America Tower – New York, NY

High Performance Building Checklist

- Cost Segregation Study
- Commissioning
- Computerize Preventive Maintenance System
- Ongoing Staff Training
- Web Based Tenant Service Request System
- Environmentally Responsible Products
- Benchmark Performance
- Kaizen

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