The Empire State Building
Repositioning an Icon as a Model of Energy Efficient Investment

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The Empire State Building
Demonstrate the business case for cost effective energy efficient retrofits through verifiable operating costs reductions and payback analysis

102 stories and 2.8 million square feet

3.8 million visitors per year

$11 million in annual energy costs

Peak electric demand of 9.5 MW down from 11.6 (3.8 W/sqft, inc HVAC)

88 kBtu per sq ft per yr for the office building

CO₂ emissions of 25,000 tons per yr (22 lbs/sqft)
PROJECT DEVELOPMENT PROCESS

1) Five key groups and contributors used a collaborative and iterative approach.

The project development process, which the team focused on, is the first step towards executing and verifying the success of a retrofit.
2) A 4-phase project development process helped guide progress.

Project activities (audits, workshops, presentations, analyses, reports, etc.) were divided into 4 phases.

<table>
<thead>
<tr>
<th>Phase I: Inventory &amp; Programming</th>
<th>Phase II: Design Development</th>
<th>Phase III: Design Documentation</th>
<th>Phase IV: Final Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities:</td>
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<tr>
<td>• April 14th kick-off meeting</td>
<td>• June 18th Theoretical Minimum workshop</td>
<td>• July 30th Tenant Focus workshop</td>
<td>• Sept. 10th workshop</td>
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<td>• May 7th/May 14th team workshops</td>
<td>• July 2nd workshop</td>
<td>• August 13th eQUEST workshop</td>
<td>• Sept 29th Presentation to Ownership</td>
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<tr>
<td>• June 2nd Presentation to Ownership</td>
<td>• July 15th Presentation to ownership</td>
<td>• August 27th Presentation to Ownership</td>
<td>• October 6-8th Finance workshop (Boulder)</td>
</tr>
<tr>
<td>Outputs:</td>
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<td>Outputs:</td>
<td>Outputs:</td>
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<tr>
<td>• Baseline Capital Projects Report</td>
<td>• Baseline Energy Benchmark Report</td>
<td>• Tenant Initiatives (prebuiltts, design guidelines, energy management) Report</td>
<td>• Model (eQUEST, financial, GHG) outputs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tuned eQUEST model</td>
<td>• Integrated Sustainability Master Plan Report (inc. Energy Master Plan)</td>
</tr>
</tbody>
</table>
Industry standard and newly developed design tools, decision-making tools, and rating tools helped to evaluate and benchmark existing and future performance.
Determining the optimal package of retrofit projects involved identifying opportunities, modeling individual measures, and modeling packages of measures.

**PROJECT DEVELOPMENT PROCESS**

A 4-phase project development process helped guide progress.

1. **Identify Opportunities**
2. **Model Individual Measures**
3. **Create Packages of Measures**
4. **Model Iteratively**

**Outcome:** Package of measures with best economic & environmental benefits
Balance financial return & carbon reduction
ESB can achieve a high level of CO₂ and energy reduction cost-effectively

A solution that balances CO₂ reductions and financial returns is in this range.

There are diminishing (and expensive) returns for greater efficiency.
LESSONS LEARNED

2) At a certain point, there is tension between CO2 savings and business value.

Maximizing business value leaves considerable CO2 on the table.
Achieving an energy reduction greater than 38% appears to be cost-prohibitive.

**KEY FINDINGS**

1) Eight interactive levers ranging from base building measures to tenant engagement deliver these results.

The average cost per ton of carbon dioxide saved for the first 90% of the savings is **-$200/ton** while the average cost per ton for the last 10% is **over $300 per ton**.
LESSONS LEARNED

At a certain point, CO2 savings and business value become polarities.

Attempting to save CO2 faster may be cost prohibitive.

15-Year NPV of Package versus Cumulative CO2 Savings

- Acceleration reduces the NPV as projects become out of sync with replacement cycles.
LESSONS LEARNED
Several approaches help maximize cost-effective savings.

Projects are most cost-effective when coordinated with equipment replacement cycles.

15-Year NPV of Package versus Cumulative CO2 Savings

Incremental CapEx

Absolute CapEx

Cumulative metric tons of CO2 saved over 15 years
LESSONS LEARNED
At a certain point, CO2 savings and business value become polarities.

Anticipated CO2 regulation in the U.S. doesn’t change the solution set … though European levels of regulation would.

15-Yr NPV and Cumulative CO2 Savings at Fluctuating Carbon Costs

- No Regulation
- 1.34% RGGI
- 8.8% CA: EU OTC
- .33% CA: Low Carbon Economy Act
- 2% CA: Lieberman Warner
Implementing recommended measures
Eight interactive levers ranging from base building measures to tenant engagement deliver these results

Annual Energy Savings by Measure

- Baseline
- Balance of DDC
- Tenant Day/lighting/Plugs
- VAV AHU's
- Retrofit Chiller Plant
- Building windows
- Tenant Energy Mgmt
- Radiative barrier
- Tenant DCV
- Energy Use

38% Reduction
IV. IMPLEMENTATION

1) Three stakeholders, with different implementation mechanisms, will deliver the savings.

Johnson Controls, the Empire State Building, and Tenants are each responsible for delivering some of the total savings.

Energy Savings by Implementation Stakeholder

- Adjusted Baseline: 61%
- JCI: 22%
- ESB: 17%
- Tenant
- NPV Mid
Business case through verifiable operating costs reductions and payback analysis

With a $550 million capital improvement program underway, ownership decided to re-evaluate certain projects with cost-effective energy efficiency and sustainability opportunities in mind.

Capital Budget Adjustments for Energy Efficiency Projects

- **2008 Capital Budget for Energy-Related Projects =** $93m + 0% Energy Savings
- **Sum of adds / changes / deletes =** +$13m
- **3.1 year payback on incremental cost**
- **New Capital Budget w/ Efficiency Projects =** $106m + 38% Energy Savings
III. KEY FINDINGS

1) Eight interactive levers ranging from base building measures to tenant engagement deliver these results.

Though it is more informative to look at financials for the package of measures, capital costs and energy savings were determined for each individual measure.

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Projected Capital Cost</th>
<th>2008 Capital Budget</th>
<th>Incremental Cost</th>
<th>Estimated Annual Energy Savings*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows</td>
<td>$4.5m</td>
<td>$455k</td>
<td>$4m</td>
<td>$410k</td>
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<tr>
<td>Radiative Barrier</td>
<td>$2.7m</td>
<td>$0</td>
<td>$2.7m</td>
<td>$190k</td>
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<tr>
<td>DDC Controls</td>
<td>$7.6m</td>
<td>$2m</td>
<td>$5.6m</td>
<td>$741k</td>
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<tr>
<td>Demand Control Vent</td>
<td>Inc. above</td>
<td>$0</td>
<td>Inc. above</td>
<td>$117k</td>
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<tr>
<td>Chiller Plant Retrofit</td>
<td>$5.1m</td>
<td>$22.4m</td>
<td>-$17.3m</td>
<td>$675k</td>
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<tr>
<td>VAV AHUs</td>
<td>$47.2m</td>
<td>$44.8m</td>
<td>$2.4m</td>
<td>$702k</td>
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<tr>
<td>Tenant Day/Lighting/Plugs</td>
<td>$24.5m</td>
<td>$16.1m</td>
<td>$8.4m</td>
<td>$941k</td>
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<tr>
<td>Tenant Energy Mgmt.</td>
<td>$365k</td>
<td>$0</td>
<td>$365k</td>
<td>$396k</td>
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<tr>
<td>Power Generation (optional)</td>
<td>$15m</td>
<td>$7.8m</td>
<td>$7m</td>
<td>$320k</td>
</tr>
<tr>
<td>TOTAL (ex. Power Gen)</td>
<td>$106.9m</td>
<td>$93.7m</td>
<td>$13.2m</td>
<td>$4.4m</td>
</tr>
</tbody>
</table>

*Note that energy savings are also incremental to the original capital budget.
Limited internal capital is greatest barrier

What is the top barrier to capturing potential energy savings for your organization?

- Lack of capital budget: 28%
- Insufficient payback/ROI: 18%
- Uncertainty of savings/ROI: 18%
- Technical expertise: 12%
- Landlord/tenant split incentives: 6%
- Buy-in from senior leaders: 6%
- Dedicated attention, ownership: 4%
- Inability to finance (credit rating, collateral, balance sheet): 4%
- Other (specify): 3%

3.1
Average maximum payback period for energy efficiency
48% require a 3 year payback or less
Internal capital budgets is primary funding source

Which options will your organization consider to pay for energy efficiency and renewable energy projects over the next 12 months? (Select all that apply)?

- Facilities capital budget: 42%
- Energy savings performance contract: 25%
- Energy or climate set-asides in capital budget: 19%
- Grants or tax credits: 18%
- Power purchase agreement (PPA): 15%
- Shared savings agreement: 15%
- Traditional debt financing: 13%

N = 2872
VI. INDUSTRY NEEDS

a) Select the right buildings for whole-systems retrofits

Retrofitting the right buildings in the right order can reduce the societal cost ($/metric ton) for carbon abatement.
VI. INDUSTRY NEEDS

b) Develop solutions for small to mid-range commercial buildings.

Most retrofit or energy service companies only address large commercial buildings or residential buildings. Yet 95% of the U.S. building stock is small to mid-sized buildings that consume 44% of total energy use.

Source: EIA data
www.esbsustainability.com