# Empire State Building Case Study

## Cost-Effective Greenhouse Gas Reductions via Whole-Building Retrofits:
## *Process, Outcomes, and What is Needed Next*

For more information, please visit www.esbsustainability.com

Jones Lang LaSalle®
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Clinton Foundation | Clinton Climate Initiative

Rocky Mountain Institute

Johnson Controls

# OVERARCHING MESSAGE

There is a compelling need as well as an economic case for reducing greenhouse gas emissions in existing buildings. The Empire State Building case study provides an example of how this can be done. However, significant challenges remain that must be addressed in order to quickly and cost-effectively capture the full greenhouse gas reduction opportunity for building retrofits on a widespread basis.

# PRESENTATION OVERVIEW

I. **Motivation:** The retrofit of the Empire State Building was motivated by the owners desire to reduce greenhouse gas emissions, to demonstrate how to retrofit large commercial buildings cost effectively, and to demonstrate that such work makes good business sense.

II. **Project Development Process:** Using ESB as a convening point, a collaborative team was formed to develop the optimal retrofit solution through an iterative process that involved experience, energy and financial modeling, ratings, metrics, and robust debate.

III. **Key Findings:** At current energy costs, ESB can cost-effectively reduce energy use by 38% and save (a minimum of) 105,000 metric tons of $CO_2$ over the next 15 years.

IV. **Implementation:** Three different stakeholders will implement the 8 savings measures over a 5-year period using various implementation mechanisms.

V. **Key Lessons:** Key lessons relate to strategies to maximize cost-effective savings, balancing $CO_2$ savings with economics, and streamlining the project development process.

VI. **Industry Needs:** Challenges in each stage of the retrofit process are hindering the achievement of long-term goals.

# I. MOTIVATION

The retrofit of the Empire State Building was motivated by the building ownership's desire to:

1) Prove or disprove the economic viability of whole-building energy efficiency retrofits.

2) Create a replicable model for whole-building retrofits.

3) Reduce greenhouse gas emissions.

# I. MOTIVATION

## 1) Prove or disprove the economic viability of whole-building energy efficiency retrofits.

Prior to 2008, the Empire State Building's performance was average compared to most U.S. office buildings.


***Annual utility costs:***

- $11 million ($4/sq. ft.)

***Annual CO2 emissions:***

- 25,000 metric tons (22 lbs/sq. ft.)

***Annual energy use:***

- 88 kBtu/sq. ft.

***Peak electric demand:***

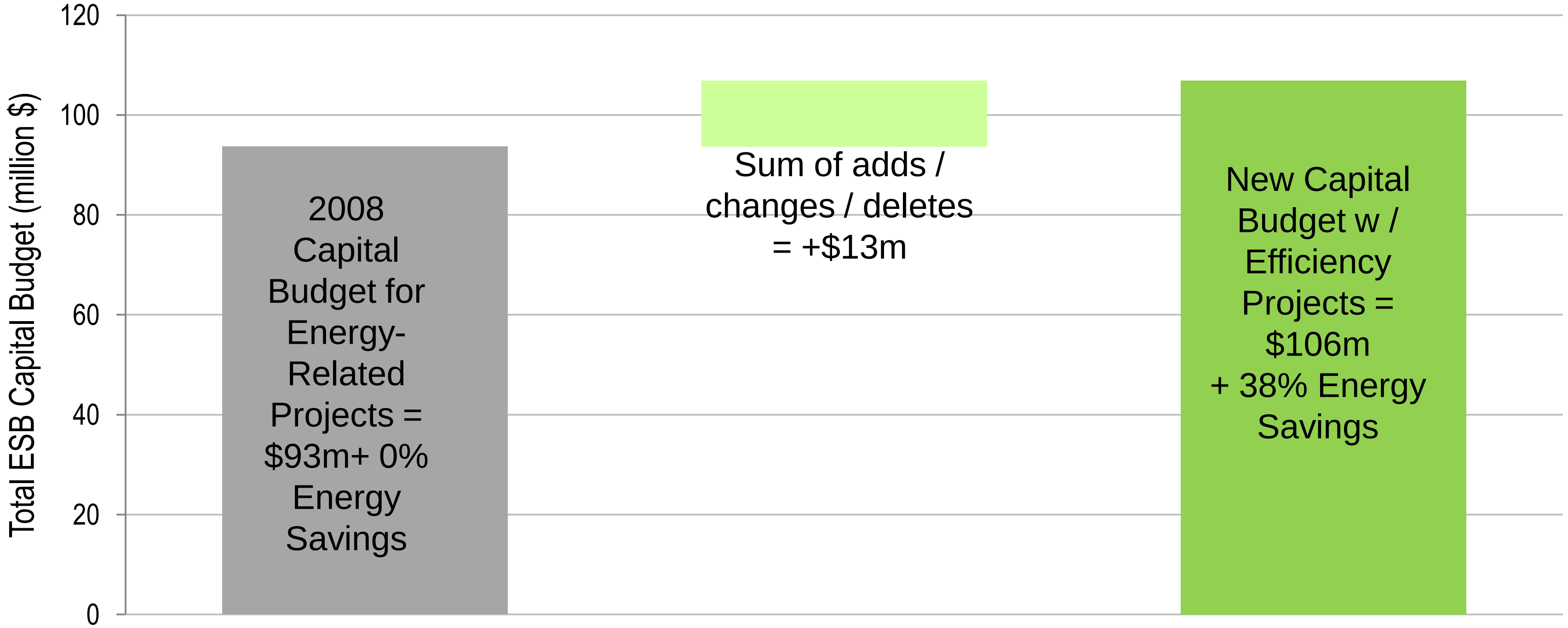
- 9.5 MW (3.8 W/sq. ft. inc. HVAC)

# I. MOTIVATION

## 1) Prove or disprove the economic viability of whole-building energy efficiency retrofits.

With a $500 million capital improvement program underway, ownership decided to re-evaluate certain projects with cost-effective energy efficiency and sustainability opportunities in mind.

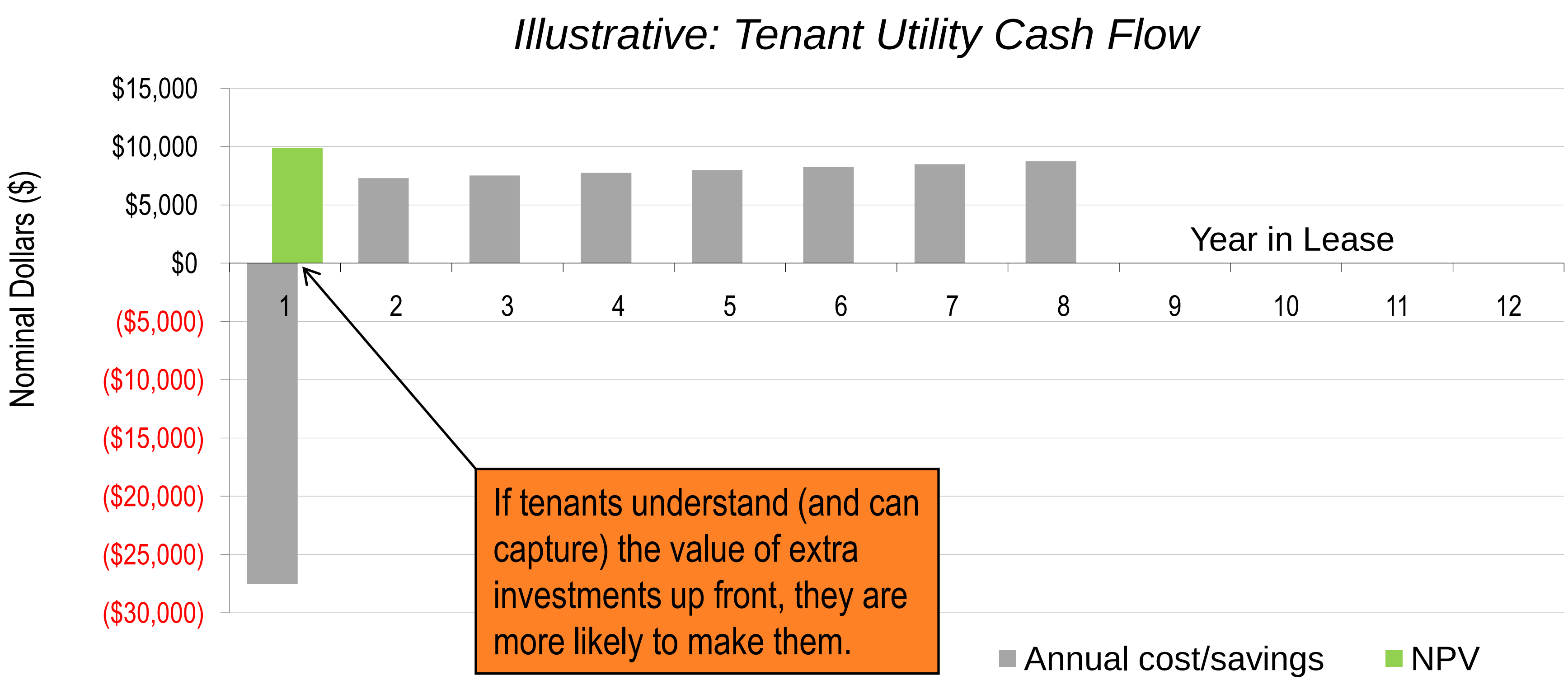
*Capital Budget Adjustments for Energy Efficiency Projects*



# I. MOTIVATION

## 1) Prove or disprove the economic viability of whole-building energy efficiency retrofits.

Energy efficiency and sustainability provide amenities (lower energy costs, easier carbon reporting, daylighting, etc.) that set the building apart from surrounding tenant space.



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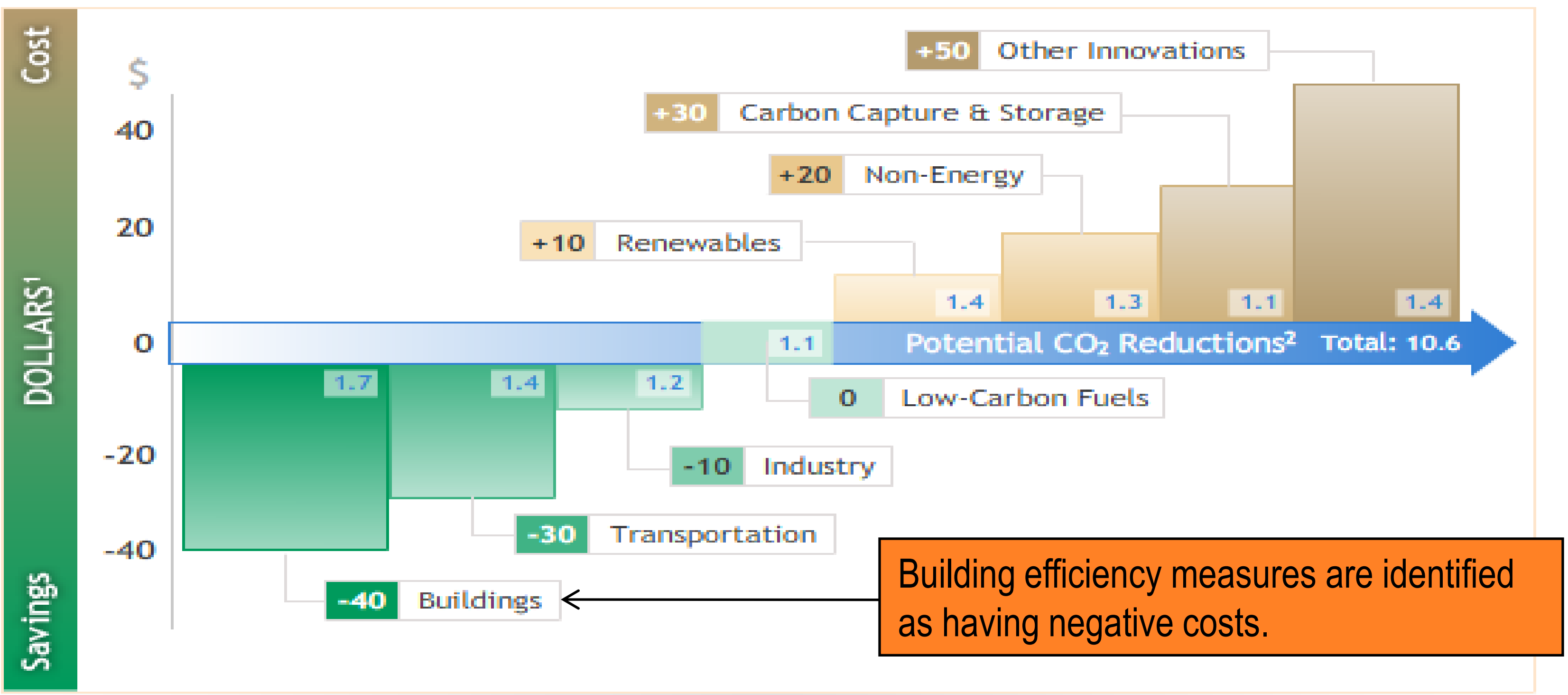
3) Reduce greenhouse gas emissions.

# I. MOTIVATION

## 2) Create a replicable model for whole-building retrofits.

There are known opportunities to cost-effectively reduce greenhouse gas emissions, yet few owners are pursuing them.

*Cutting U.S. Global Warming Pollution 80% by 2050: Cost & Payoff by Sector*




Source: NRDC - http://www.nrdc.org/globalwarming/blueprint/default.asp

# I. MOTIVATION

## 2) Create a replicable model for whole-building retrofits.

ESB ownership wants to demonstrate how to cost-effectively retrofit a large multi-tenant office building to inspire others to embark on whole-building retrofits.

### 1 Identify opportunities

- 60+ energy efficiency ideas were narrowed to 8 implementable projects
- Team estimated theoretical minimum energy use
- Developed eQUEST energy model

### 2 Evaluate measures

- Net present value
- Greenhouse gas savings
- Dollar to metric ton of carbon reduced
- Calculated for each measure

### 3 Create packages

- Maximize net present value
- Balance net present value and $CO_2$ savings
- Maximize $CO_2$ savings for a zero net present value
- Maximize $CO_2$ savings

### 4 Model iteratively

- Iterative energy and financial modeling process to identify final eighht recommendations

# I. MOTIVATION

The retrofit of the Empire State Building was motivated by the building ownership's desire to:

1) Prove or disprove the economic viability of whole-building energy efficiency retrofits.

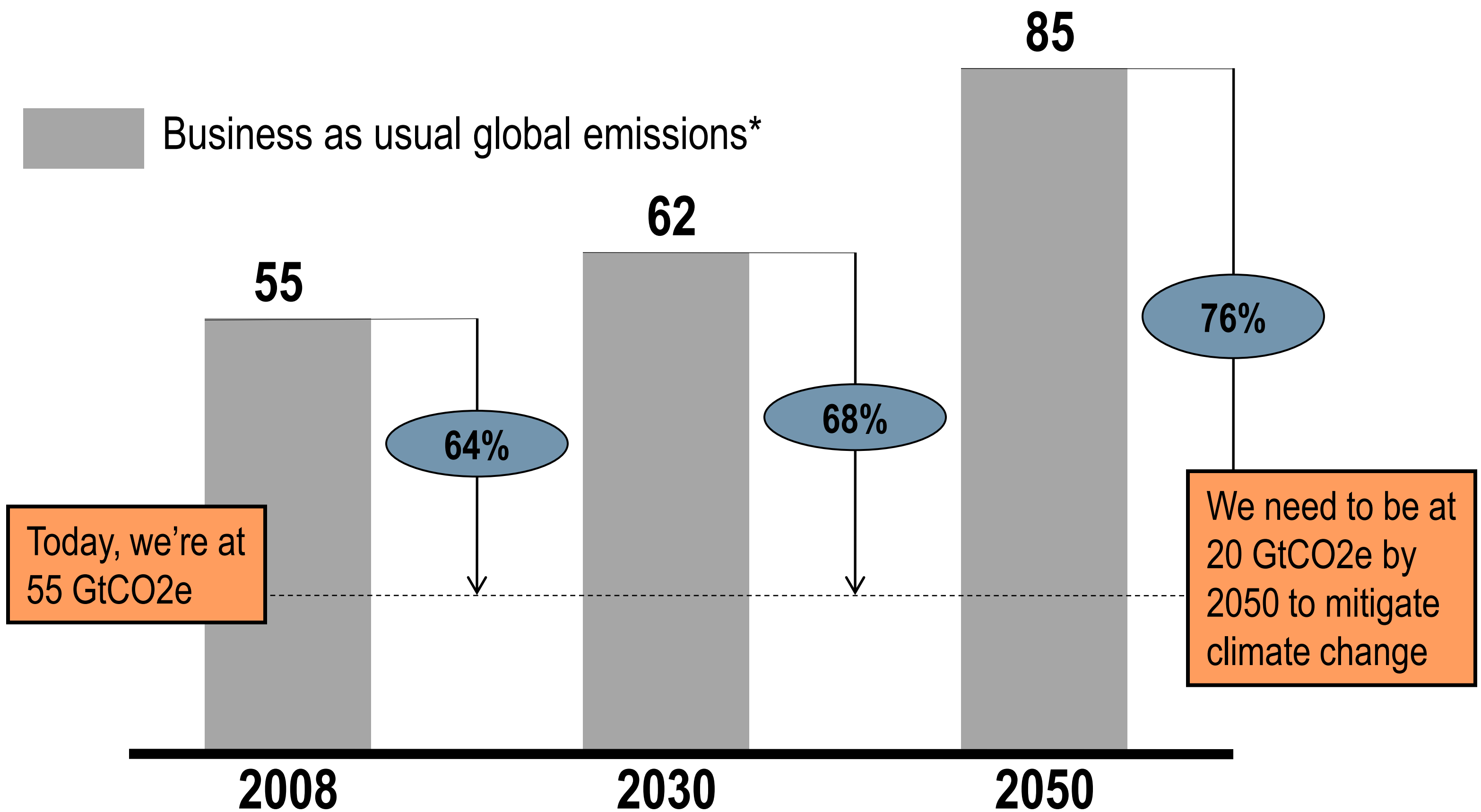
2) Create a replicable model for whole-building retrofits.

3) Reduce greenhouse gas emissions cost-effectively.

# I. MOTIVATION

## 3) Reduce Greenhouse Gas Emissions

We need to reduce greenhouse gas emissions by 75% by 2050 to stabilize the climate.

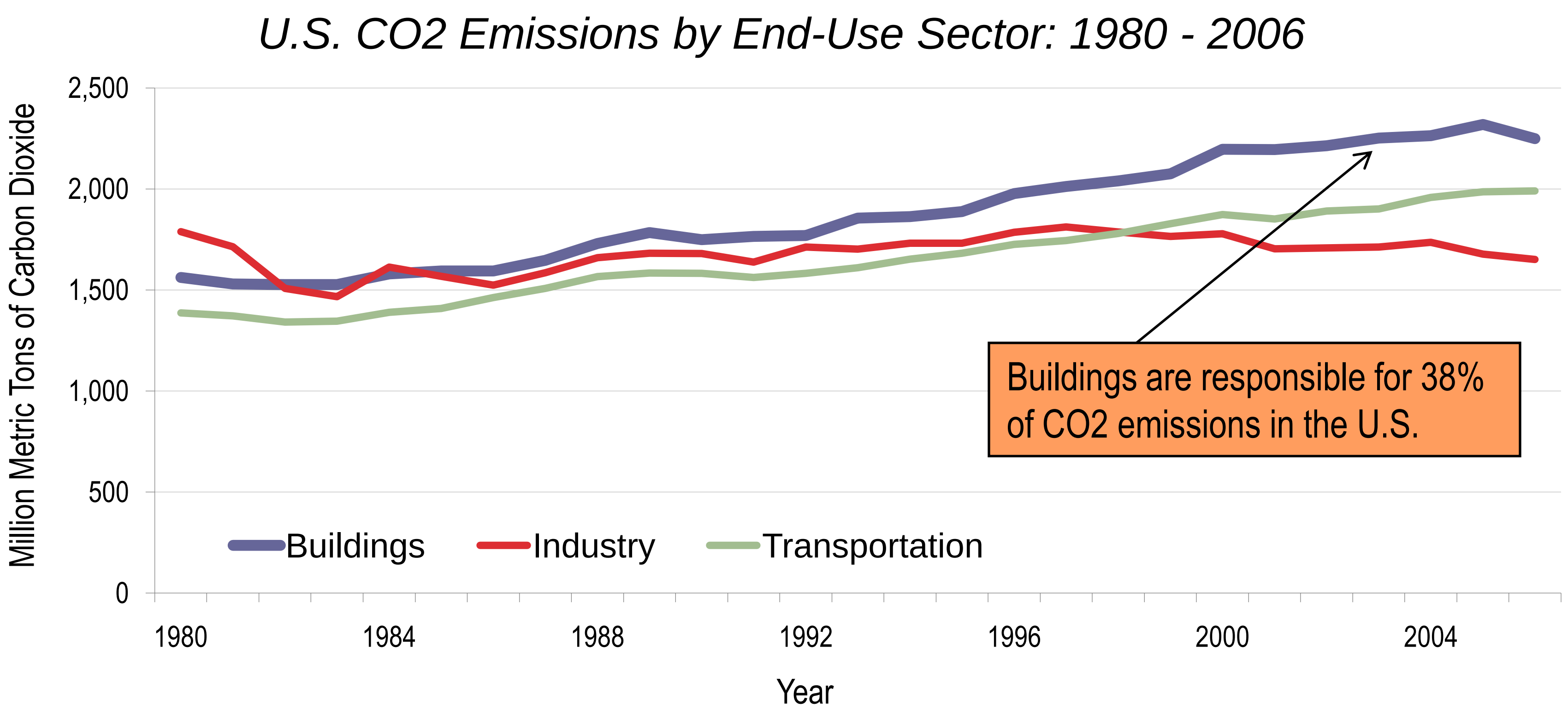



*Source: McKinsey Analysis, IPCC, Stern Review (2006)

# I. MOTIVATION

## 3) Reduce Greenhouse Gas Emissions

The building sector must be a large part of the solution as it is the largest contributor to U.S. greenhouse gas emissions.



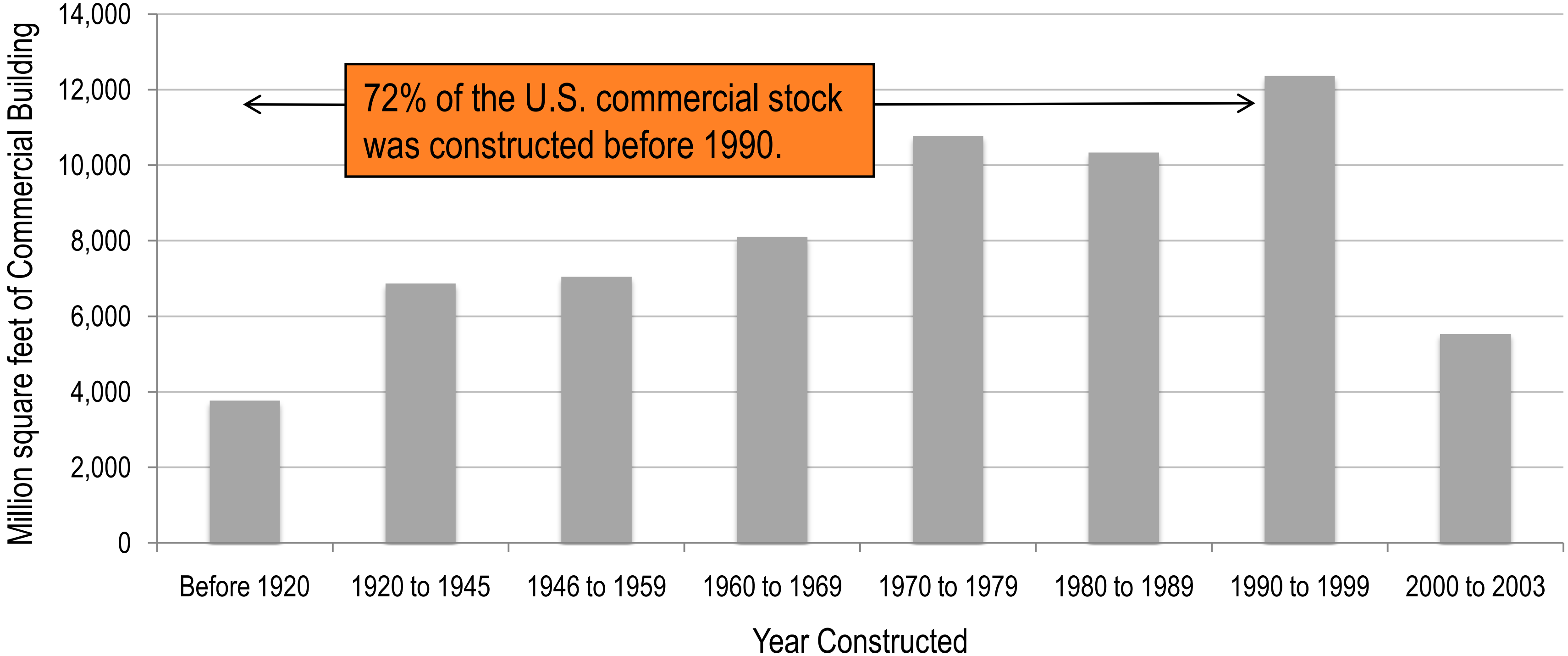

**Source: EIA data - Table 12.2: http://www.eia.doe.gov/emeu/aer/envir.html**

# I. MOTIVATION

## 3) Reduce Greenhouse Gas Emissions

Nearly 75% of U.S. commercial buildings are over 20 years old (and thus ready for retrofit). Retrofitting existing buildings must be part of the solution.

*U.S. Commercial Building Space by Age*




**Source: EIA data - Table 12.2: http://www.eia.doe.gov/emeu/aer/envir.html**

# I. MOTIVATION

*"The goal with ESB has been to define intelligent choices which will either save money, spend the same money more efficiently, or spend additional sums for which there is reasonable payback through savings. Addressing these investments correctly will create a competitive advantage for ownership through lower costs and better work environment for tenants. Succeeding in these efforts will make a replicable model for others to follow."*

*- Anthony E. Malkin*

# II. PROJECT DEVELOPMENT PROCESS

Using ESB as a convening point, a collaborative team was formed to develop the optimal solution through a rigorous and iterative process that involved experience, energy and financial modeling, ratings systems, technical advice, and robust debate. Key points include:

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

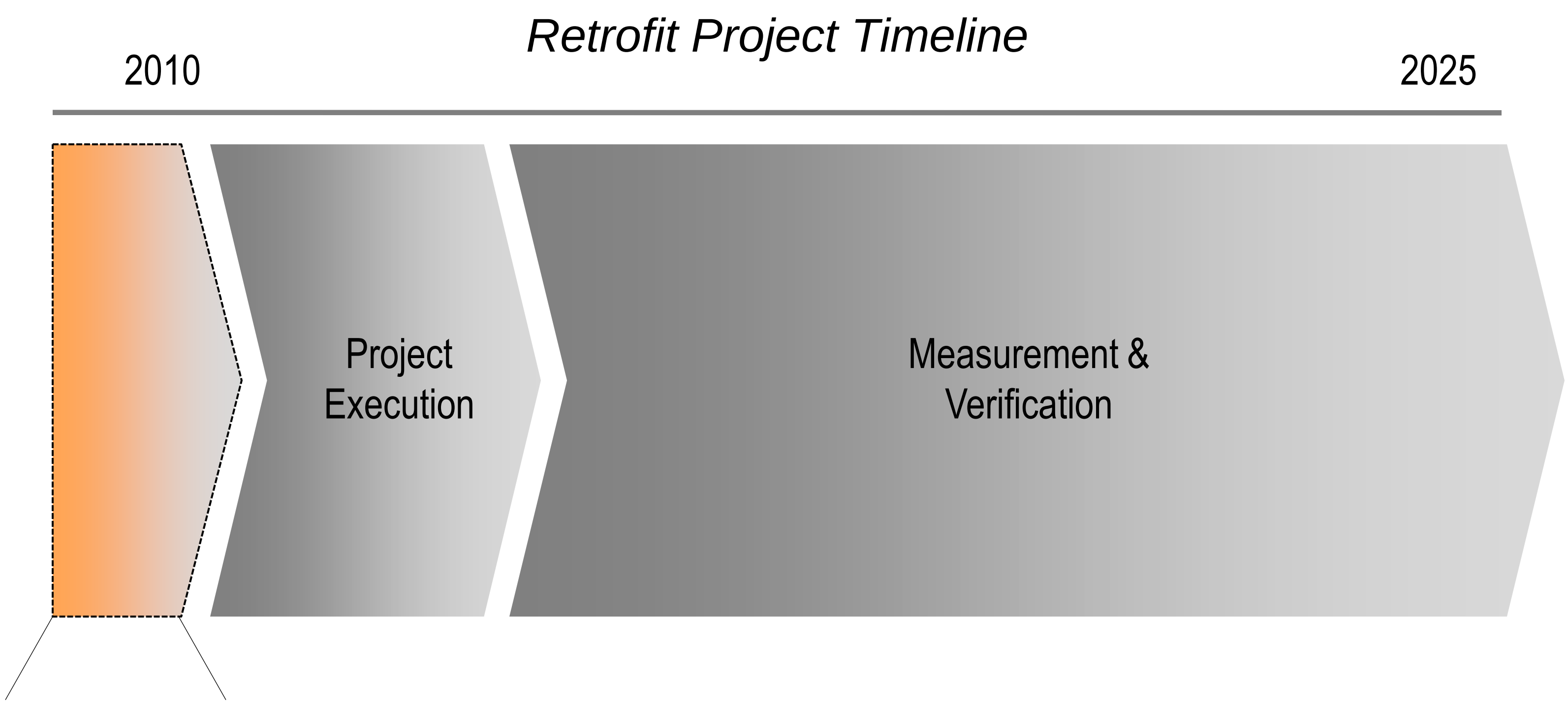
2) A 4-phase project development process helped guide progress.

3) A variety of complementary tools were used and developed to triangulate to the best answer.

# II. 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.



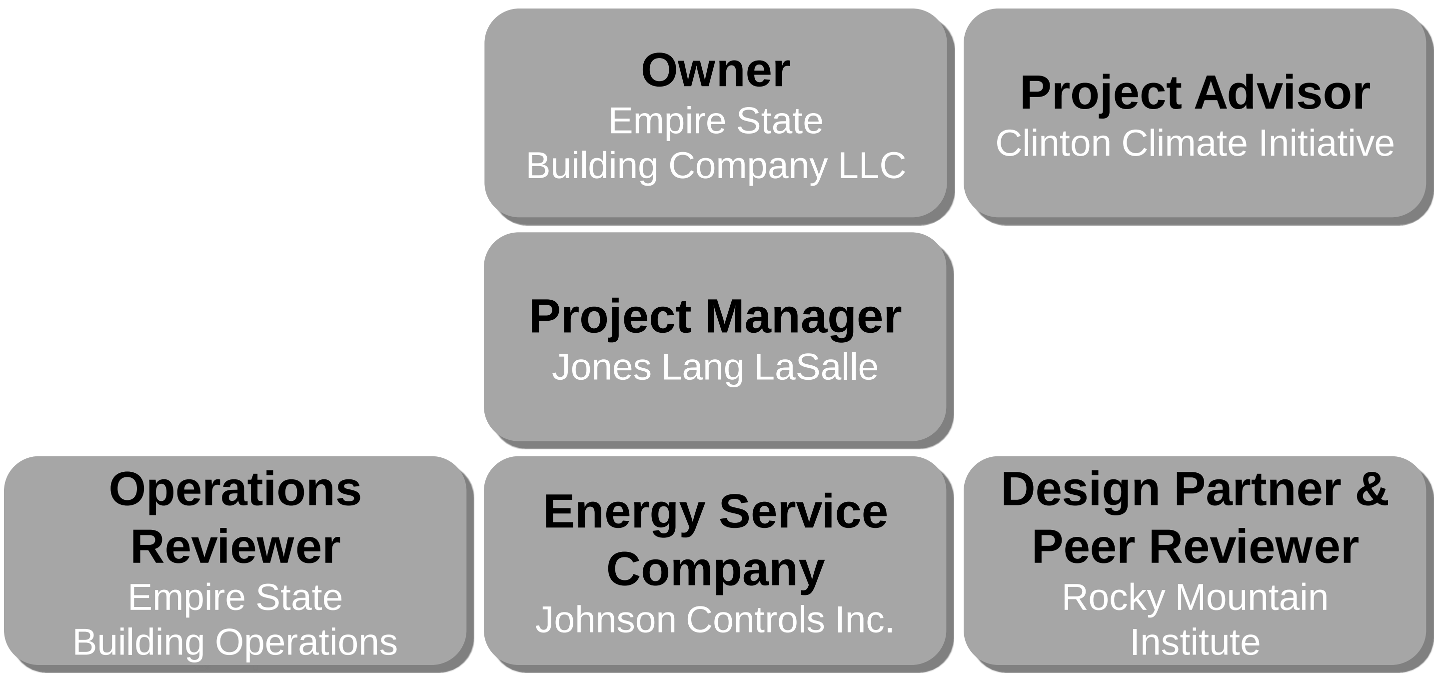

Project development is focused on understanding current performance, analyzing opportunities, and determining which projects to implement.

# II. PROJECT DEVELOPMENT PROCESS

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

Core team members for the project development process included the Clinton Climate Initiative (CCI), Johnson Controls Inc. (JCI), Jones Lang LaSalle (JLL), Rocky Mountain Institute (RMI), and the Empire State Building (ESB).

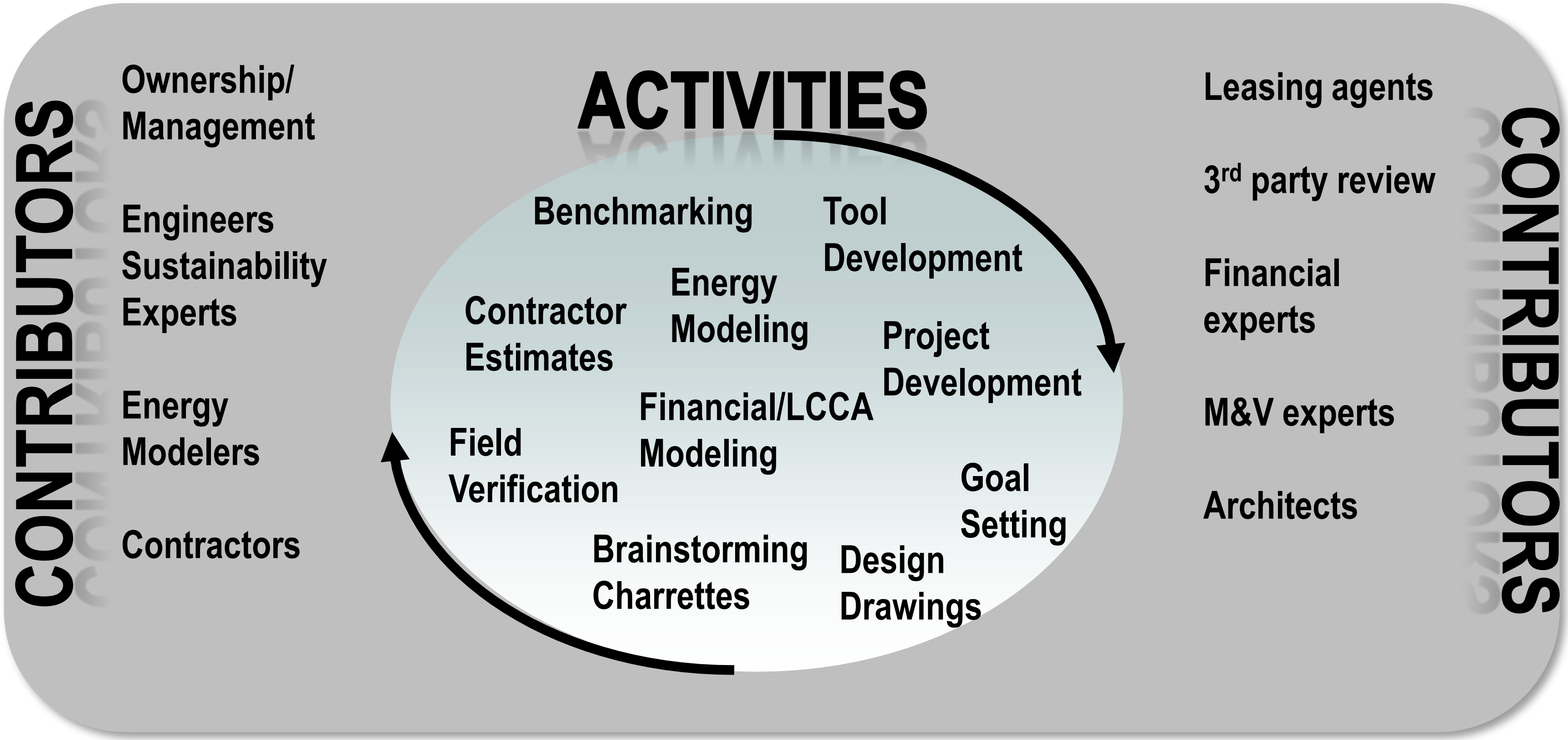
*Team Organization Chart*



# II. PROJECT DEVELOPMENT PROCESS

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

Many other contributors, in addition to the core team, provided additional expertise to fully explore all opportunities.



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Using ESB as a convening point, a collaborative team was formed to develop the optimal energy efficiency retrofit solution through a rigorous and iterative process that involved experience, energy and financial modeling, ratings systems, technical advice, and robust debate. Key points include:

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

2) A 4-phase project development process helped guide progress.

3) A variety of complementary tools were used and developed to triangulate to the best answer.

# II. PROJECT DEVELOPMENT PROCESS

## 2) A 4-phase project development process helped guide progress.

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

| | *Phase I: Inventory & Programming* | *Phase II: Design Development* | *Phase III: Design Documentation* | *Phase IV: Final Documentation* |
|---|---|---|---|---|
| Activities | • *April 14th kick-off meeting*<br>• *May 7th/May 14th team workshops*<br>• *June 2nd Presentation to Ownership* | • *June 18th Theoretical Minimum workshop*<br>• *July 2nd workshop*<br>• *July 15th Presentation to ownership* | • *July 30th Tenant Focus workshop*<br>• *August 13th eQUEST workshop*<br>• *August 27th Presentation to Ownership* | • *Sept. 10th workshop*<br>• *Sept 29th Presentation to Ownership*<br>• *October 6-8th Finance workshop (Boulder)*<br>• *Nov 10th Presentation to Ownership* |
| Outputs | • *Baseline Capital Projects Report* | • *Baseline Energy Benchmark Report* | • *Tenant Initiatives (prebuilts, design guidelines, energy management) Report*<br>• *Tuned eQUEST model* | • *Model (eQUEST, financial, GHG) outputs*<br>• *Integrated Sustainability Master Plan Report (inc. Energy Master Plan)* |

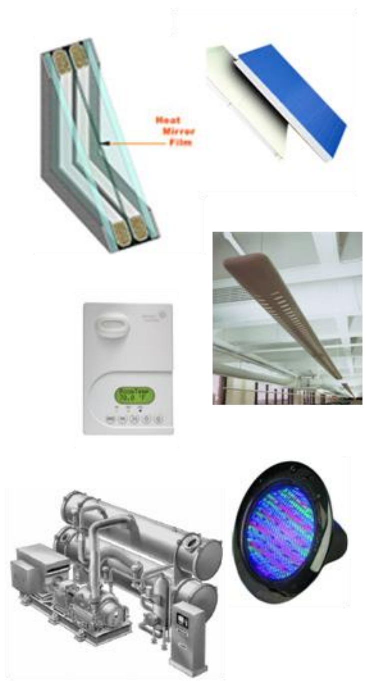
# II. PROJECT DEVELOPMENT PROCESS

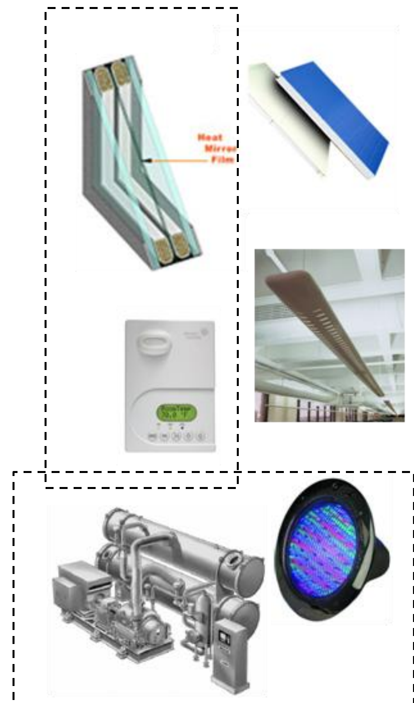
## 2) A 4-phase project development process helped guide progress.

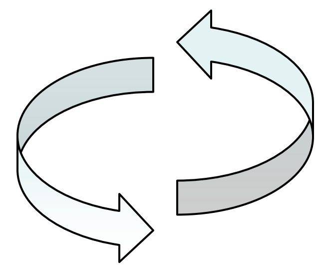
Determining the optimal package of retrofit projects involved identifying opportunities, modeling individual measures, and modeling packages of measures.

*Identify Opportunities* → *Model Individual Measures* → *Create Packages of Measures* → *Model Iteratively*

| | | |
|---|---|---|
| 4 | Chiller-4 | CW Waterside economizer for year round cooling for all zones |
| 5 | Chiller-5 | Multiple Tonnage Chiller Sizing |
| 6 | Chiller-6 | Best Practice Cooling Tower Sizing and Efficiency Pumping |
| 7 | Chiller-7 | Chilled water temperature reset |
| 8 | CHW Pumping -1 | Variable Flow CHW Pumping |
| 9 | CW Pumping-1 | VFD on CW Pumps, Flow Control |
| 10 | CW Pumping-2 | Best Possible Pumping Design - Reduced Pressure Drop and Max Pump E |
| 11 | Heating-1 | Heat Recovery from Broadcast Floors |
| 12 | Heating-2 | Run Around Glycol loop to preheat OA to observatory |
| 13 | Heating-3 | Basecase w/ electric reheat (space heaters) |
| 14 | AHU-1 | Install new VFD AHUs |
| 15 | AHU-2 | Best Practice AHU (Low dP,Higher Fan Eff) |
| 16 | AHU-3 | Underfloor/Displacement Air Distribution |
| 17 | AHU-4 | Install Low dP VFD AHUs |
| 18 | AHU-5 | Move to Central OA Supply |
| 19 | AHU-6 | Core Space Conditioning - Dedicated Unit |
| 20 | AHU-7 | Core Space Conditioning - Shared Unit (Cascade) |
| 21 | AHU-8 | Nighttime Purge to Precharge Thermal Mass |
| 22 | AHU-9 | Natural Ventilation. |
| 23 | AHU-10 | Eliminate local AHU and use chilled beams and radiant. |
| 24 | Controls-1 | Chiller Plant |
| 25 | Controls-2 | Controls - Chiller sequencing |
| 26 | Controls-3 | Controls - Optimized Start/Stop |
| 27 | Controls-4 | Controls - Variable Primary/Secondary control |
| 28 | Controls-5 | Radiator Control |
| 29 | Controls-6 | Radiator Control/Window Opening |
| 30 | Controls-7 | ESB Local HVAC Equip. (Air cooled chiller, CHW AHUs tied to ACC, DX AF |
| 31 | Controls-8 | Old AHUs Control (S/S, OA Damper, CHW Valve, Zone Temp |
| 32 | Controls-9 | New AHUs Control (S/S, OA Damper, CHW Valve, Zone Temp) |
| 33 | Controls-10 | New VFD AHUs Control (S/S, OA Damper, CHW Valve, Zone Temp,VFD) |
| 34 | Controls-11 | New VFD AHUs with OA Demand Control |
| 35 | Controls-12 | Thermal Comfort Space Temperature Control (ASHRAE 55) |
| 36 | DHW-1 | Electric Instantaneous DHW 19+/LL-18 Heat Recovery |
| 37 | Envelope-1 | Install Window Film |
| 38 | Envelope-2 | Install New Window Glazing Option A |
| 39 | Envelope-3 | Install New Window - Glazing Option B |
| 40 | Envelope-4 | Install Thermally Broken Frames |
| 41 | Envelope-5 | Provide and install insulated sheet metal barriers behind each radiator. |
| 42 | Envelope-6 | Provide furring strip insulation on Perimeter Walls |
| 43 | Envelope-7 | Install Green Roof |
| 44 | Envelope-8 | Install White Roof |
| 45 | Cogen-1 | Steam driven back-pressure turbine/Absorption Chiller/DHW/Electric Chiller |
| 46 | Cogen-2 | Install Fuel Cell/DHW Heat Recovery/Absorption Chiller |
| 47 | Lighting-1 | Lighting -Restrooms Occ Sensor Commission |
| 48 | Lighting-2 | Lighting - Restrooms Lighting Retrofit |
| 49 | Lighting-3 | Lighting - ESB Common Hallways Retrofit |
| 50 | Lighting-4 | Lighting - Tenant Space Prebuilt |





*Outcome:*

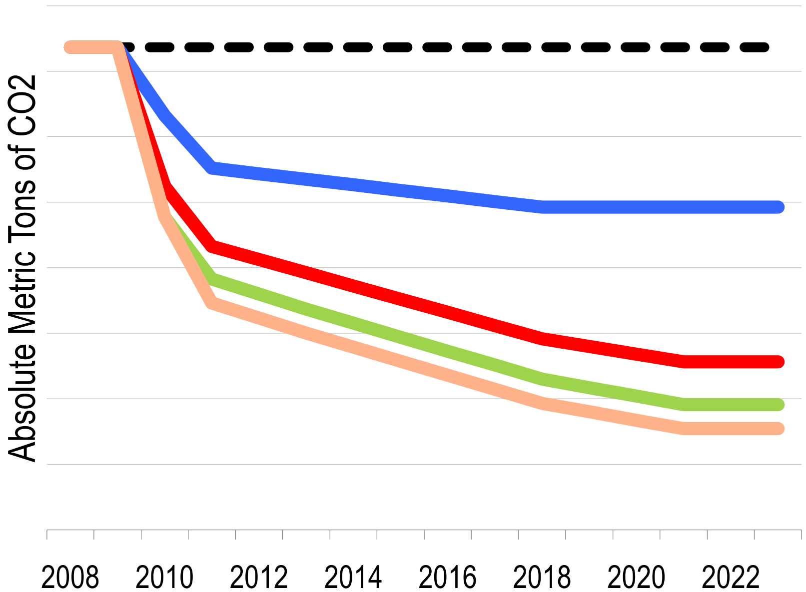
*Package of measures with best economic & environmental benefits*

# II. PROJECT DEVELOPMENT PROCESS

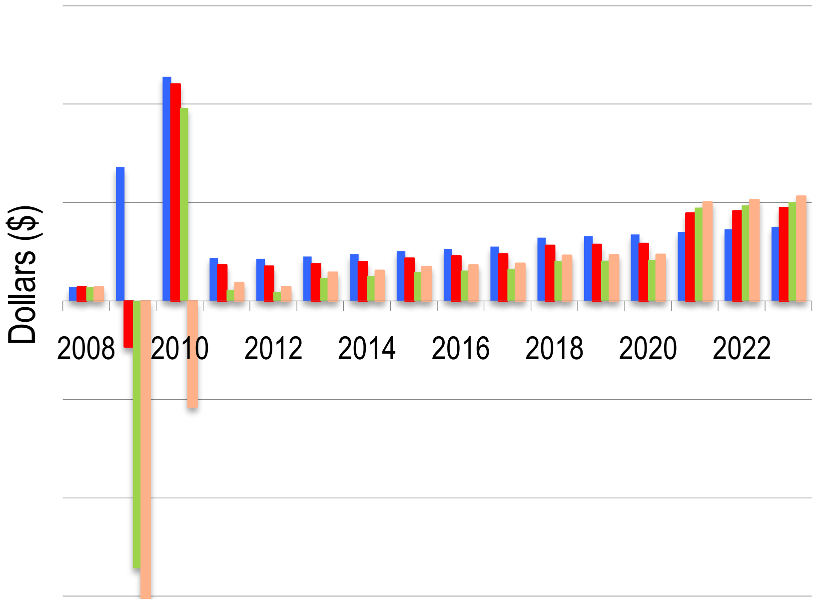
2) A 4-phase project development process helped guide progress.

Significant time was spent 1) refining energy and financial model inputs to ensure outputs were accurate and 2) understanding the critical relationship between economics and CO2 reductions.

*CO2 Emissions for each Package*




*Incremental Cash Flow for each Package of Measures*




Baseline NPV Max NPV Mid NPV Neutral CO 2 Max

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

2) A 4-phase project development process helped guide progress.

3) A variety of complementary tools were used and developed to triangulate to the best answer.

# II. PROJECT DEVELOPMENT PROCESS

## 3) A variety of tools were used and developed to triangulate to the best answer.

Industry standard and newly developed design tools, decision-making tools, and rating tools helped to evaluate and benchmark existing and future performance.

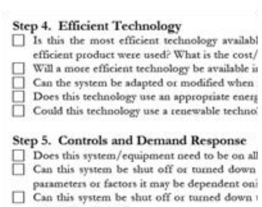
*Design Tools*

eQUEST

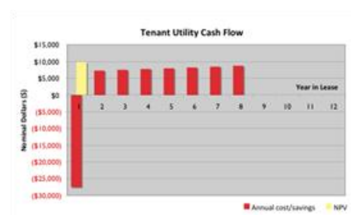
AGI32

Google SketchUp

*Decision-Making Tools*


Step 4. Efficient Technology
☐ Is this the most efficient technology availabl
efficient product were used? What is the cost/
☐ Will a more efficient technology be available i
☐ Can the system be adapted or modified when
☐ Does this technology use an appropriate energ
☐ Could this technology use a renewable techno

Step 5. Controls and Demand Response
☐ Does this system/equipment need to be on all
☐ Can this system be shut off or turned down
parameters or factors it may be dependent on
☐ Can this system be shut off or turned down
peak utility charges?




*Rating Tools*

Quantification of Sustainability Tool*

ENERGY STAR

U.S. Green Building Council LEED Certified 2007

Green Globes

# III. KEY FINDINGS

At current energy costs, the Empire State Building can cost-effectively reduce energy use by 38% and save (a minimum of) 105,000 metric tons of CO2 over the next 15 years.

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

2) Key reductions in peak cooling and electric loads are possible.

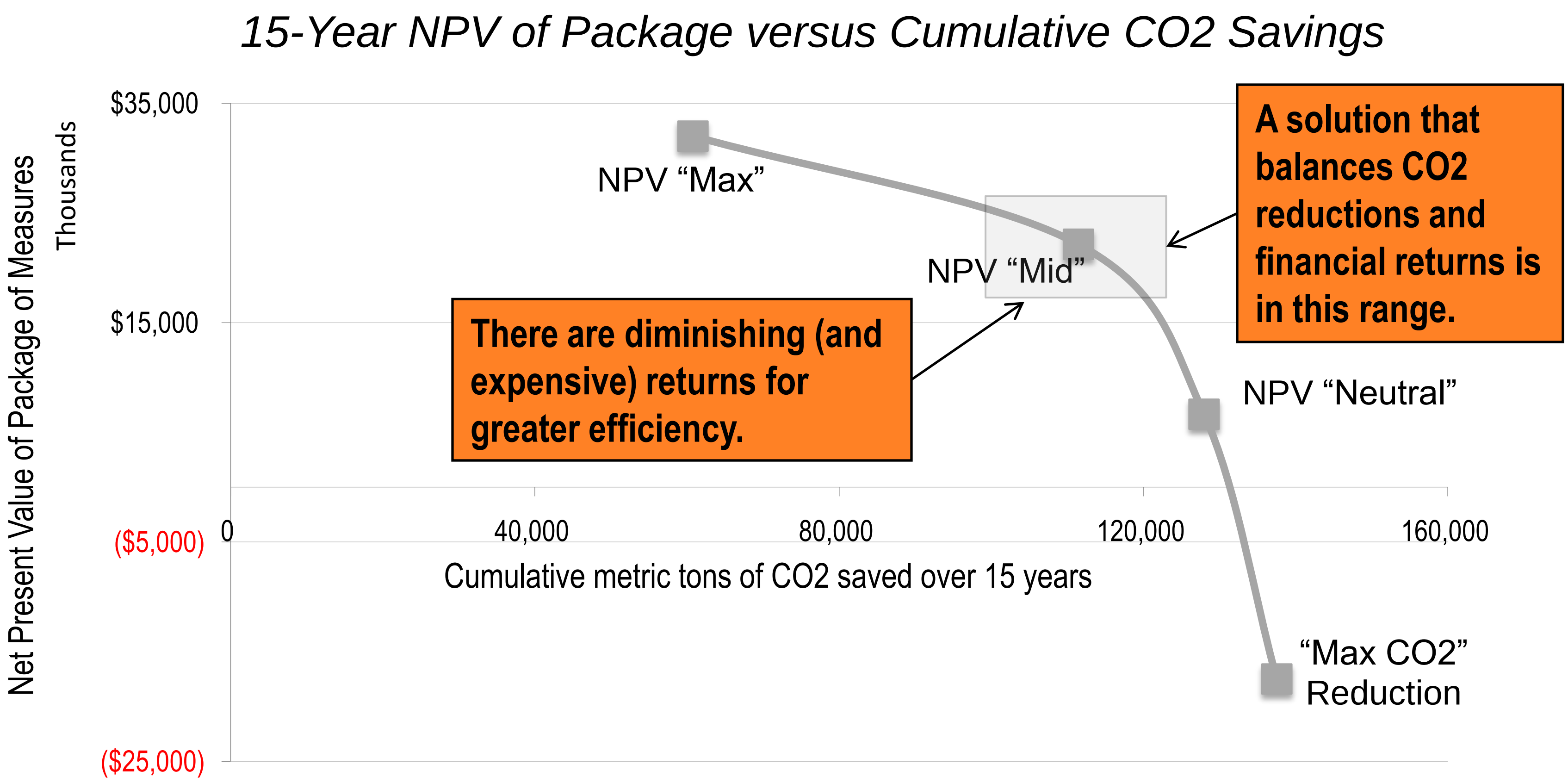
3) Enhanced work environments are created.

4) Various green certifications can be obtained.

# III. KEY FINDINGS

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

The Empire State Building can achieve a high level of energy and CO2 reduction cost-effectively.



# III. KEY FINDINGS

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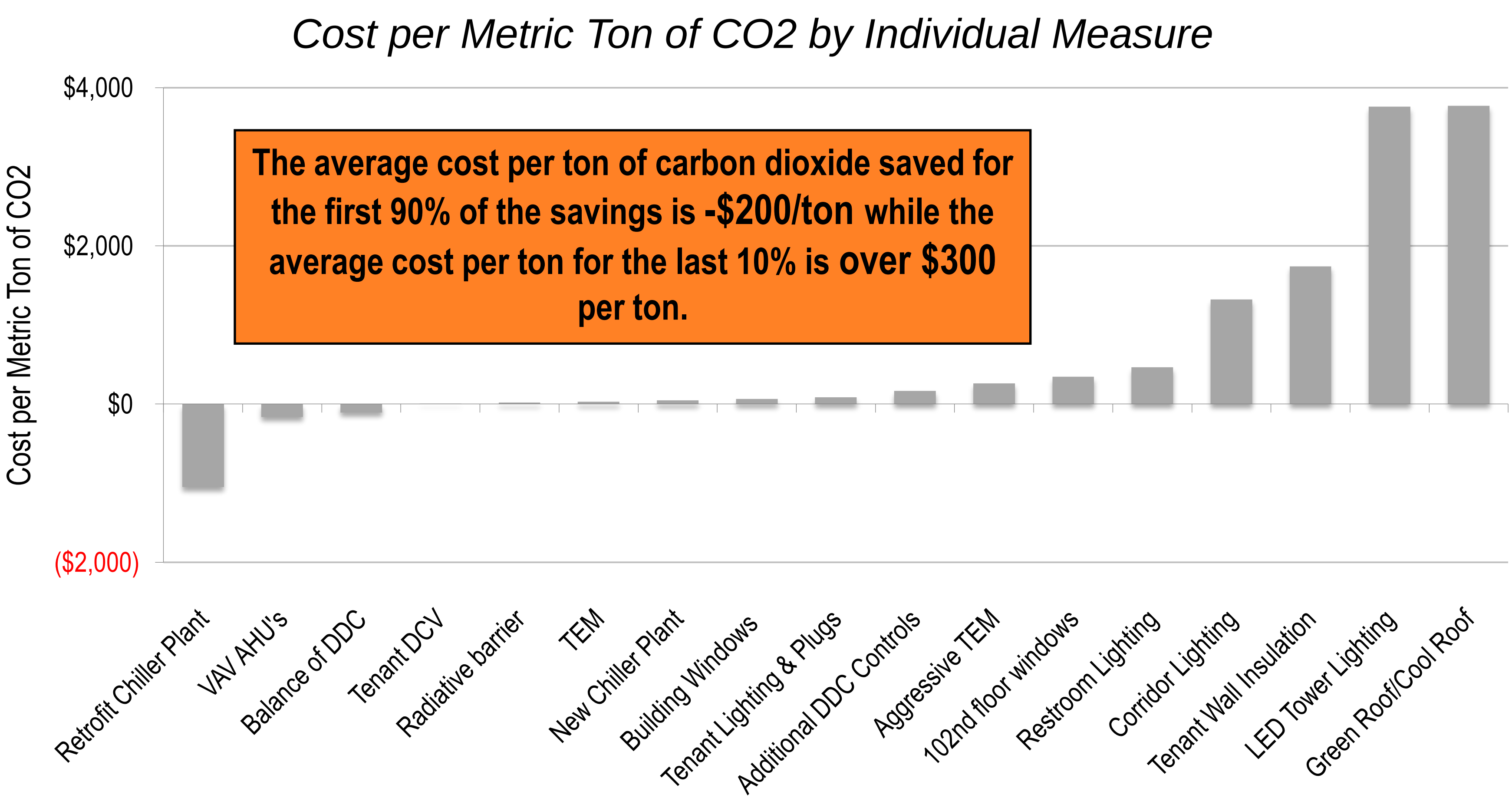
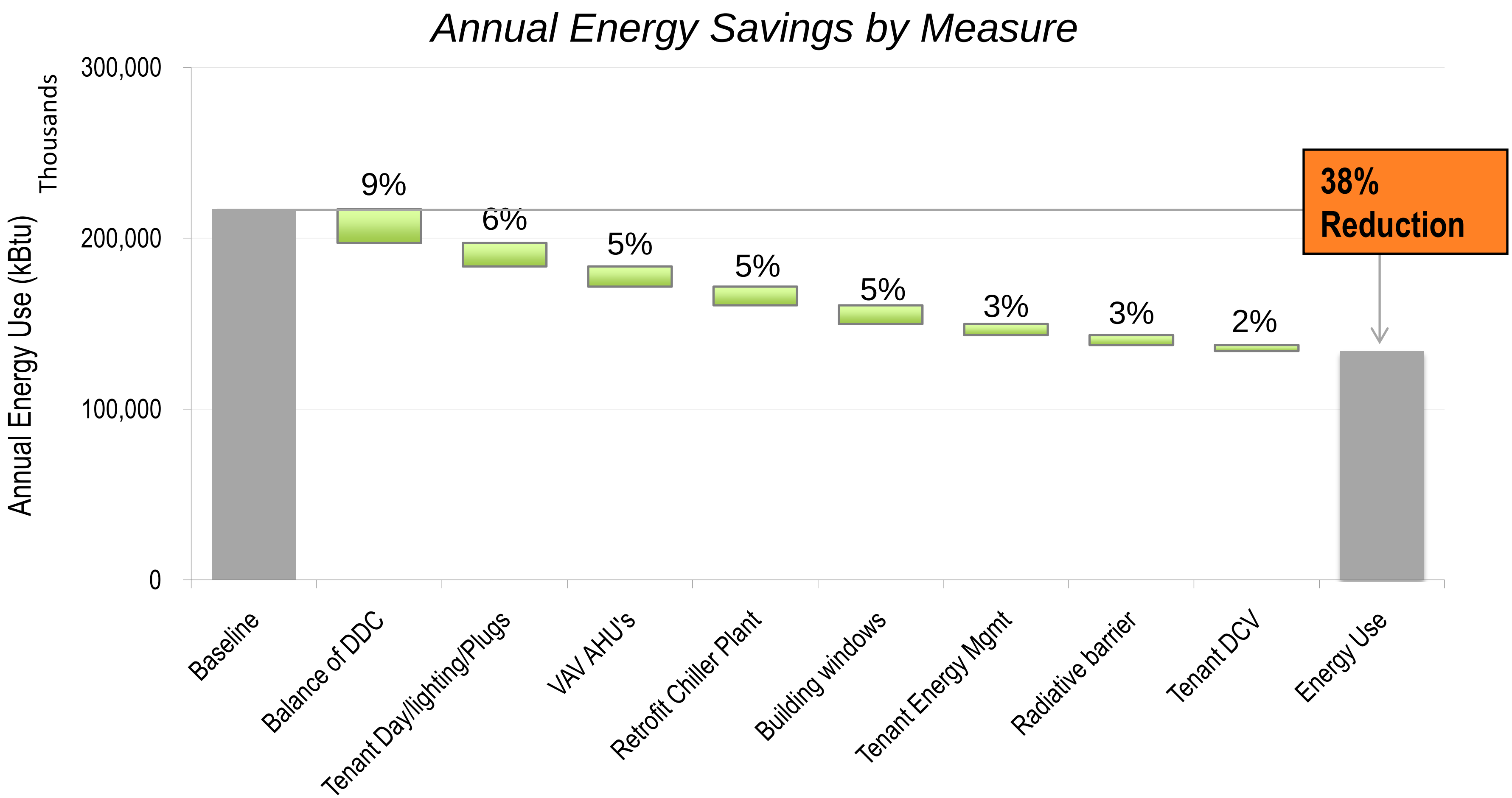
Achieving an energy reduction greater than 38% appears to be cost-prohibitive.



# III. KEY FINDINGS

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

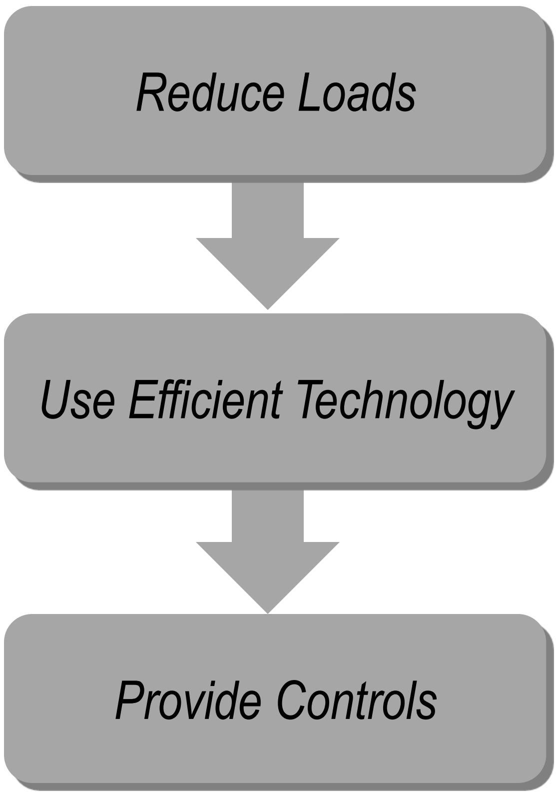
Energy and CO2 savings in the optimal package result from 8 key projects.

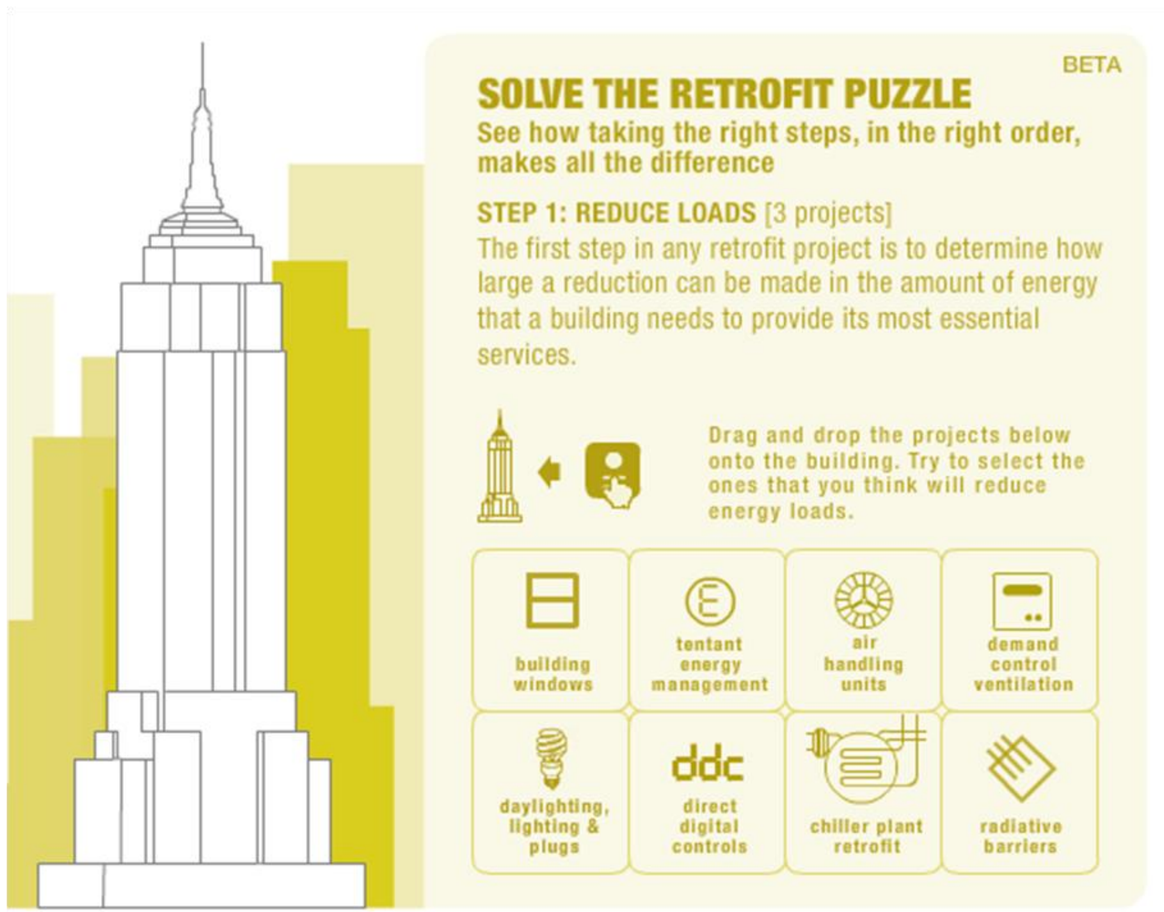


# III. KEY FINDINGS

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

Taking the right steps in the right order ensures loads are minimized prior to investigating expensive new equipment or controls.

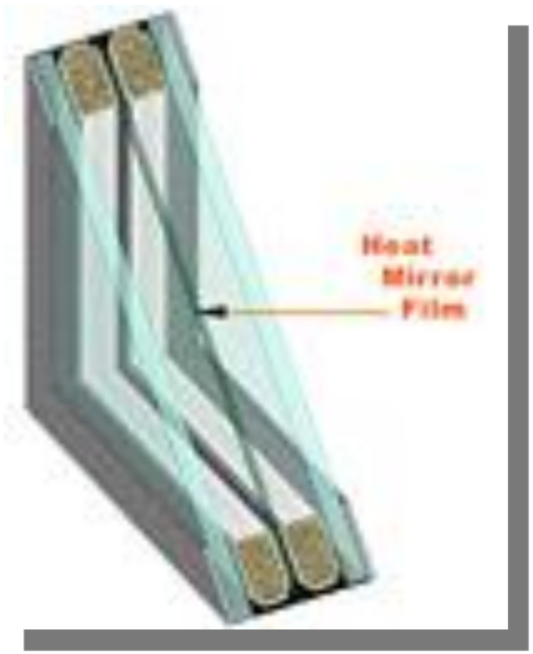


# III. KEY FINDINGS

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

*WINDOWS:* Remanufacture existing insulated glass units (IGU) within the Empire State Building's approximately 6,500 double-hung windows to include suspended coated film and gas fill.




# III. KEY FINDINGS

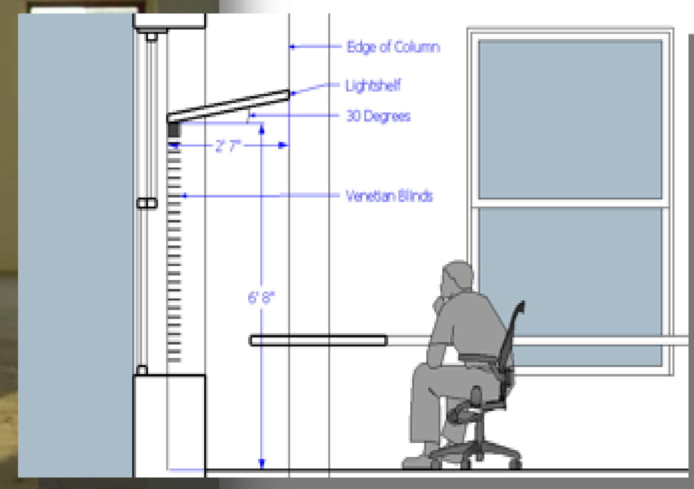
1) Eight interactive levers ranging from base building measures to tenant engagement deliver these results.

*RADIATIVE BARRIER:* Install more than six-thousand insulated reflective barriers behind radiator units located on the perimeter of the building.

# III. KEY FINDINGS

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

*TENANT DAYLIGHTING / LIGHTING / PLUGS:* This measure involves reducing lighting power density in tenant spaces, installing dimmable ballasts and photosensors for perimeter spaces, and providing occupants with a plug load occupancy sensor for their personal workstation.



# III. KEY FINDINGS

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

*CHILLER PLANT RETROFIT:* The chiller plant retrofit project includes the retrofit of four industrial electric chillers in addition to upgrades to controls, variable speed drives, and primary loop bypasses.

# III. KEY FINDINGS

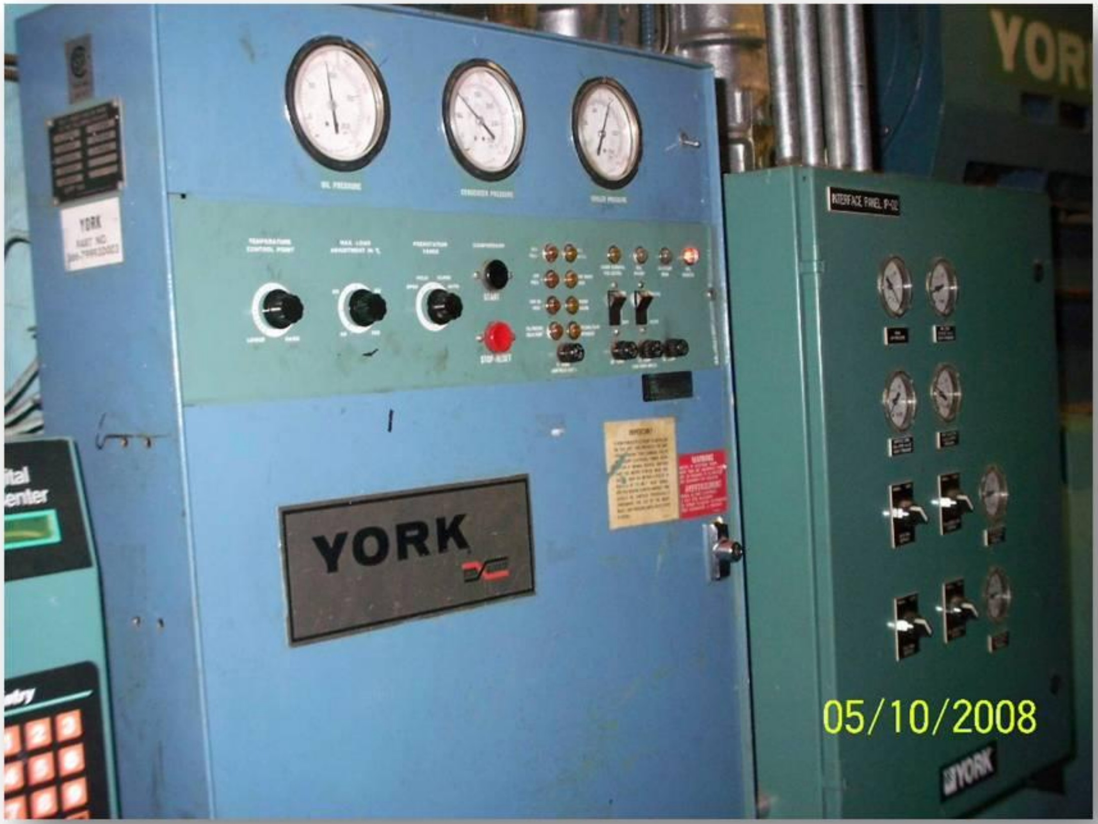
## 1) Eight interactive levers ranging from base building measures to tenant engagement deliver these results.

*VAV AIR HANDLING UNITS:* Replace existing constant volume units with variable air volume units using a new air handling layout (two floor-mounted units per floor instead of four ceiling-hung units).

# III. KEY FINDINGS

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

*DDC CONTROLS:* The measure involves upgrading the existing control systems at the Empire State Building.




# III. KEY FINDINGS

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

*DEMAND CONTROL VENTILATION:* This project involves the installation of $CO_2$ sensors for control of outside air introduction to chiller water and DX Air Handling Units.

# III. KEY FINDINGS

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

*TENANT ENERGY MANAGEMENT:* This project will provide tenants with access to online energy and benchmarking information as well as sustainability tips and updates.

# 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.

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

***Note that energy savings are also incremental to the original capital budget.**

# III. KEY FINDINGS

At current energy costs, the Empire State Building can cost-effectively reduce energy use by 38% and save (a minimum of) 105,000 metric tons of $CO_2$ over the next 15 years.

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

2) Key reductions in peak cooling and electric loads are expected.

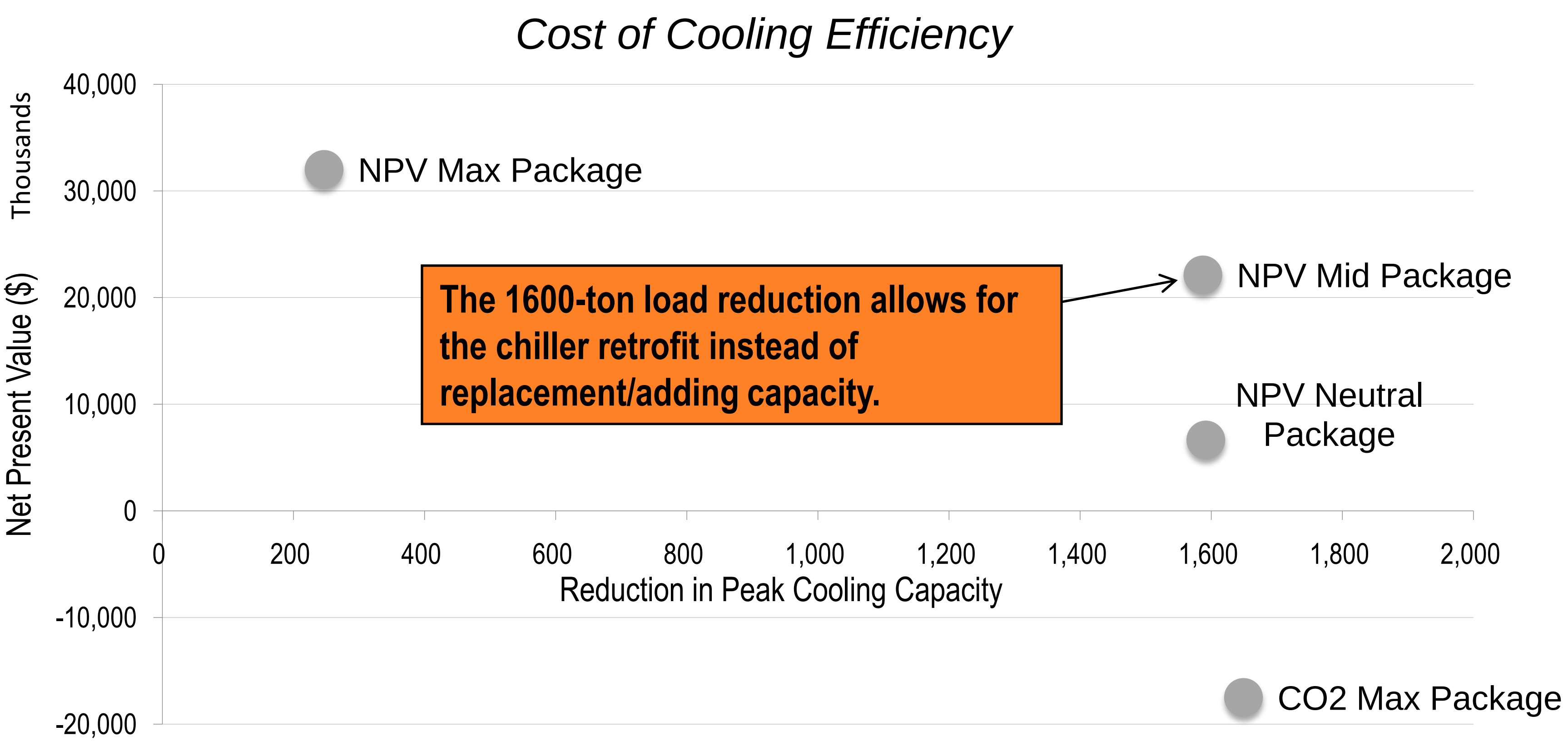
3) Enhanced work environments are created.

4) Various green certifications can be obtained.

# III. KEY FINDINGS

## 2) Key reductions in peak cooling and electric loads are expected.

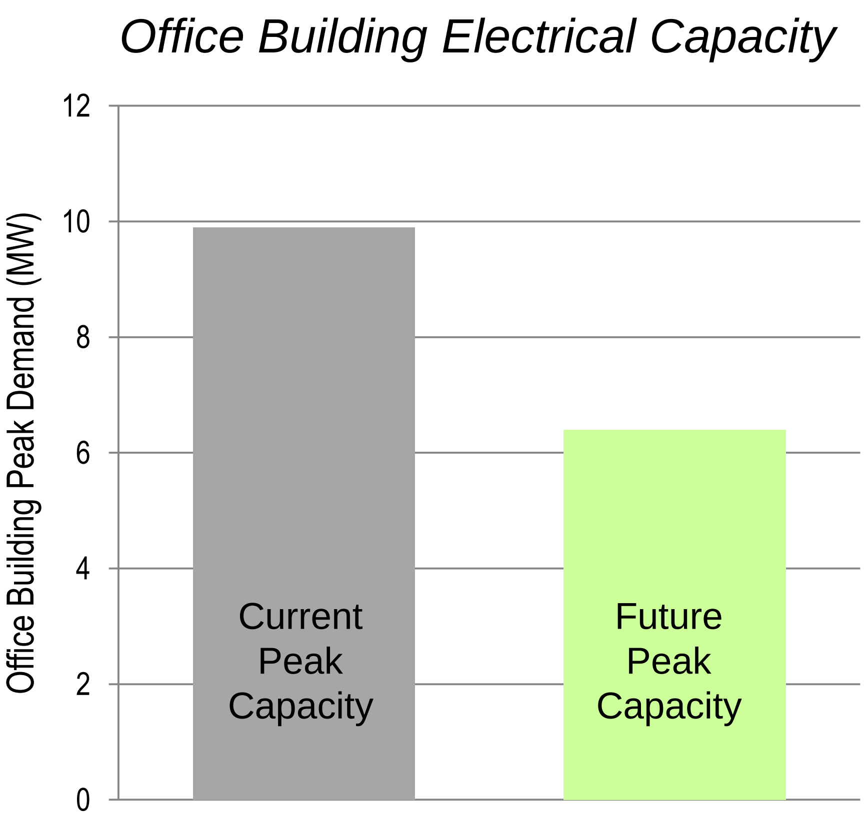
The selected package of measures reduces peak cooling requirements by 33% (1600 tons) enabling immediate and future CapEx avoidance.



# III. KEY FINDINGS

## 2) Key reductions in peak cooling and electric loads are expected.

The optimal package of measures also reduces peak electrical demand by 3.5 MW, benefitting both the building and the utility.




***If on-site back-up generation is desired, options include:***

- **Cogeneration;**
- **Gas-fired/bio-fuel fired generation;**
- **Fuel cells;**
- **Renewables (PV/wind); and**
- **Purchasing new capacity from Con Edison**

# III. KEY FINDINGS

At current energy costs, the Empire State Building can cost-effectively reduce energy use by 38% and save (a minimum of) 105,000 metric tons of $CO_2$ over the next 15 years.

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

2) Key reductions in peak cooling and electric loads are expected.

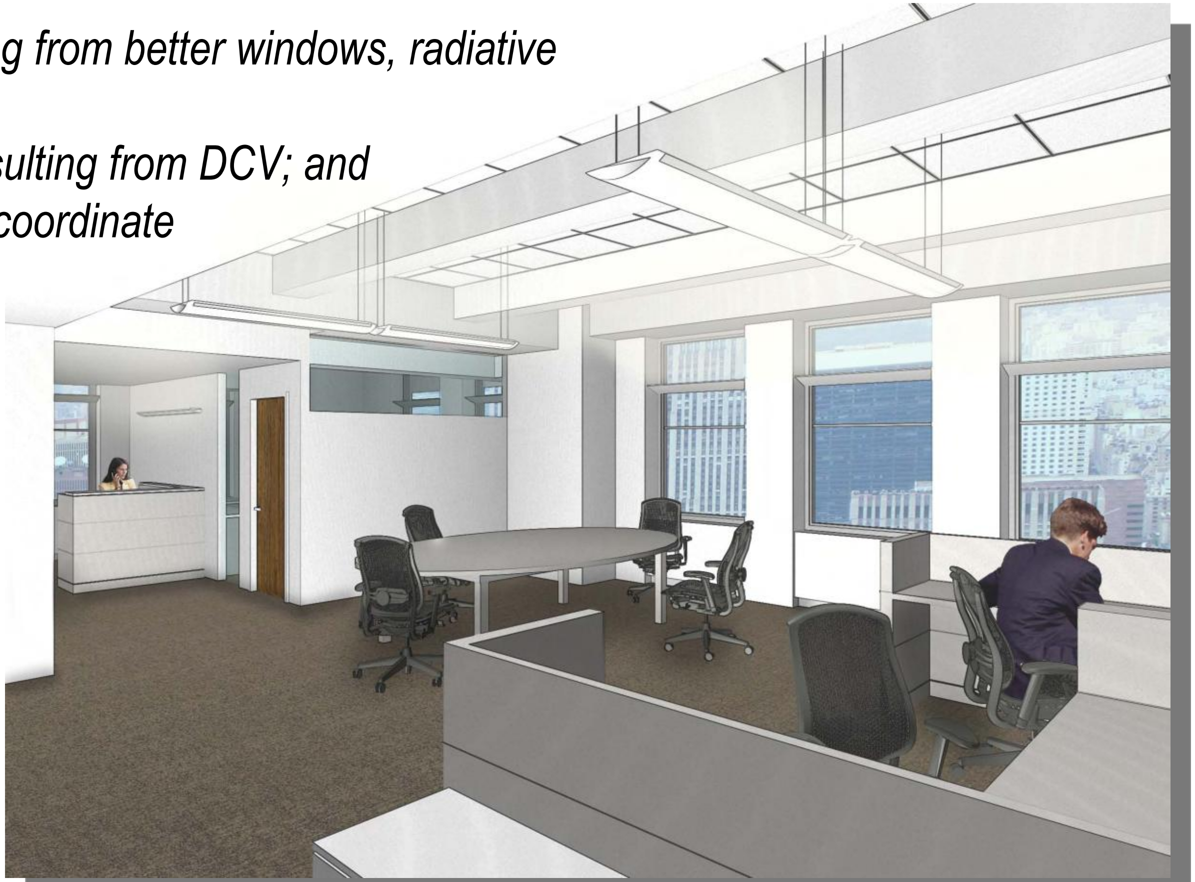
3) Enhanced work environments are created.

4) Various green certifications can be obtained.

# III. KEY FINDINGS
## 3) Enhanced work environments are created.

This package of measures also results in enhanced indoor environmental quality and additional amenities for tenants:

- *Better thermal comfort resulting from better windows, radiative barrier, and better controls;*
- *Improved indoor air quality resulting from DCV; and*
- *Better lighting conditions that coordinate ambient and task lighting.*



# III. KEY FINDINGS

At current energy costs, the Empire State Building can cost-effectively reduce energy use by 38% and save (a minimum of) 105,000 metric tons of $CO_2$ over the next 15 years.

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2) Key reductions in peak cooling and electric loads are expected.

3) Enhanced work environments are created.

4) Various green certifications can be obtained.

# III. KEY FINDINGS

## 4) Various green certifications can be achieved.

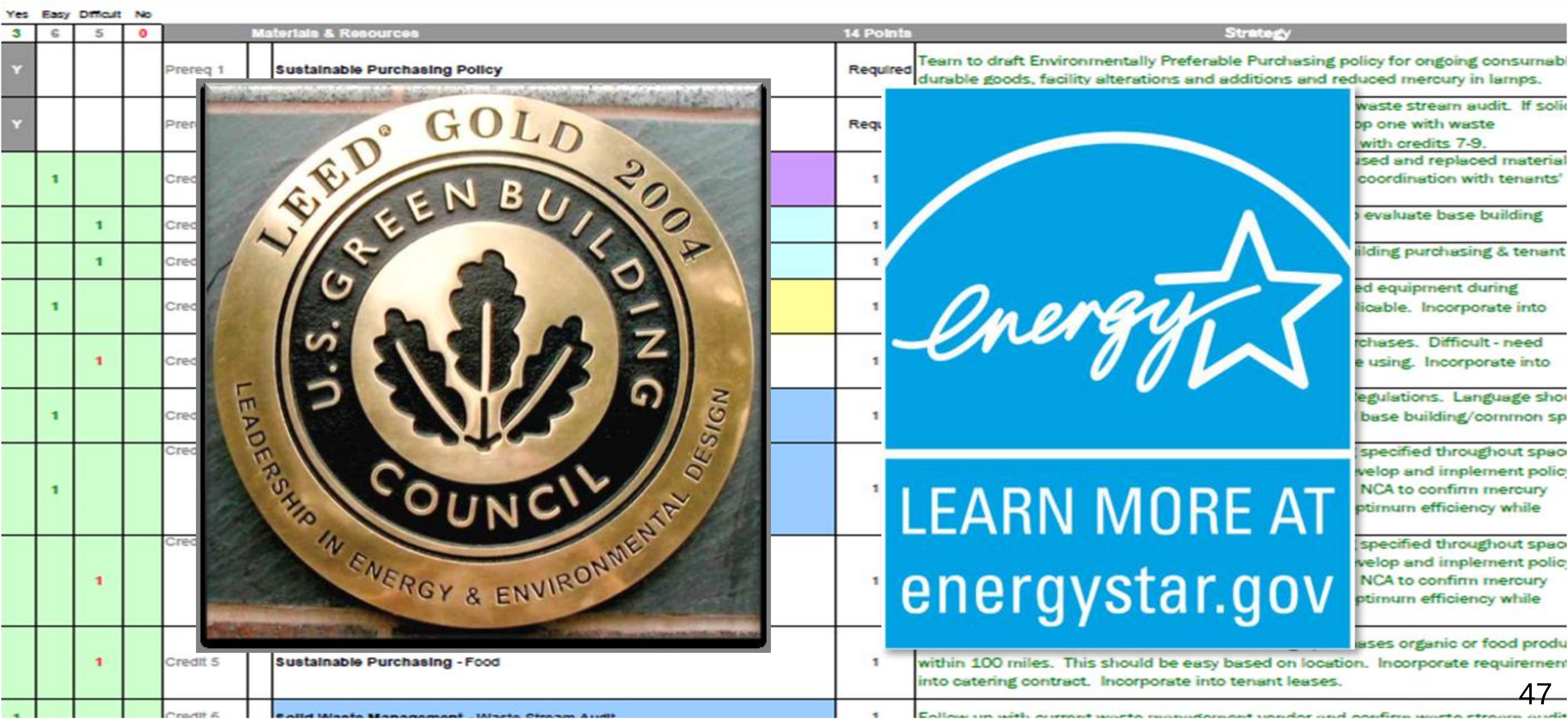
This recommended package of measures helps to earn 12 LEED EBOM points, an Energy Star score of 90, and a 72% Green Globes score.

| *Package* | *Energy Savings** | *Energy Star* | *LEED Points* | *Green Globes* |
|---|---|---|---|---|
| NPV Max | 20% | 82 | 8 | 64% |
| **NPV Mid** | **38%** | **90** | **12** | **72%** |
| NPV Neutral | 45% | 91 | 13 | 76% |
| CO2 Max | 48% | 92 | 13 | 78% |

# III. KEY FINDINGS

## 4) Various green certifications can be achieved.

The Empire State Building will be pursuing the Energy Star label as well as Gold certification under the LEED for Existing Buildings: Operation & Maintenance Rating System.



# IV. IMPLEMENTATION

Clear energy targets and responsible parties must be determined for each of the 8 major savings measures to fully maximize the environmental and economic benefits.

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

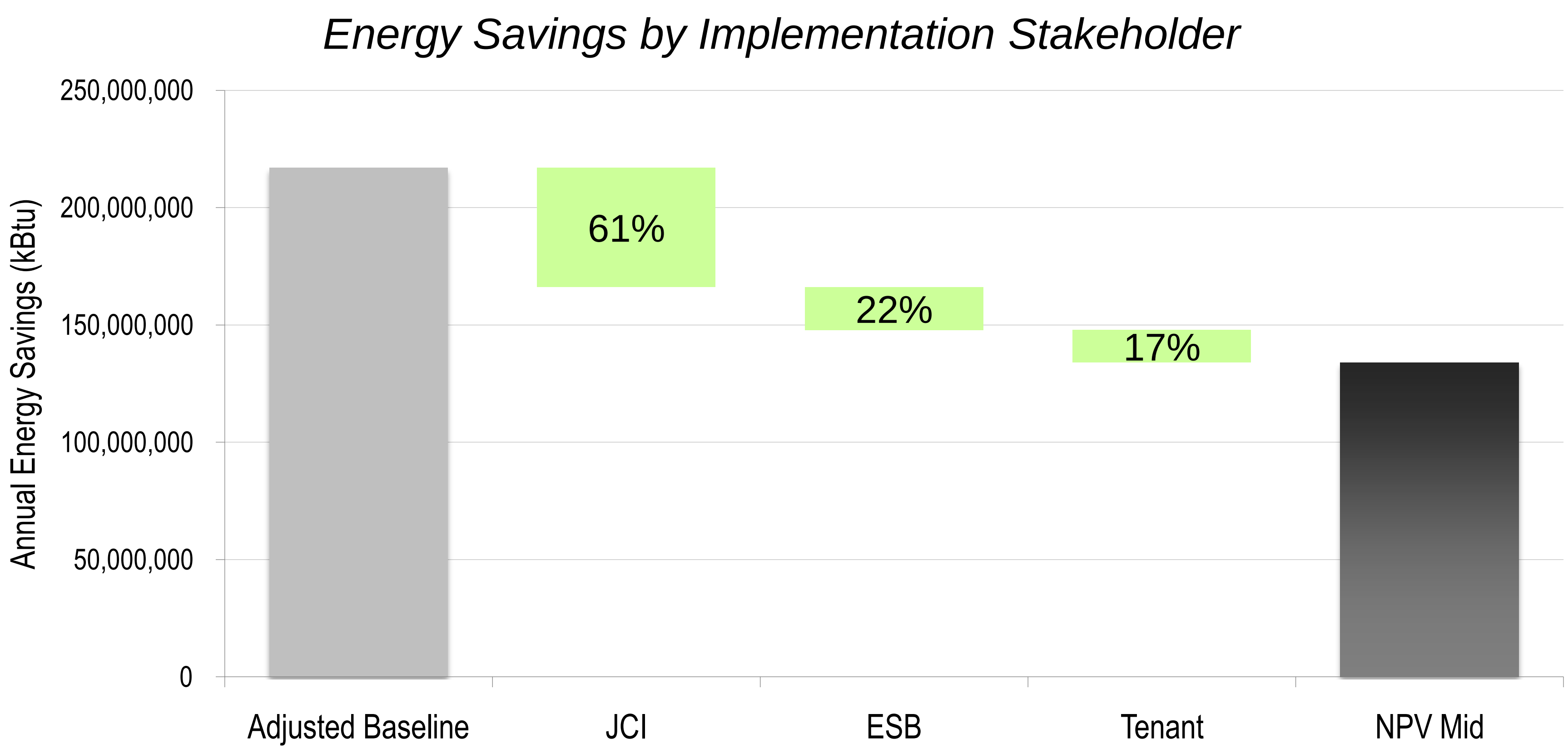
2) The project will be financed out of cash flow, though other financing opportunities are being investigated.

3) Work has already started and will be complete by 2013 (55% of the savings will be in place by December 31, 2010).

# 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.



# IV. IMPLEMENTATION

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

Who implements each project?

| *Project Description* | *Implementer* |
|---|---|
| Windows | Johnson Controls |
| Radiative Barrier | Johnson Controls |
| DDC Controls | Johnson Controls |
| Demand Control Vent | Johnson Controls |
| Chiller Plant Retrofit | Johnson Controls |
| VAV AHUs | Empire State Building |
| Tenant Day/Lighting/Plugs | Tenants & Empire State Building |
| Tenant Energy Mgmt. | All |

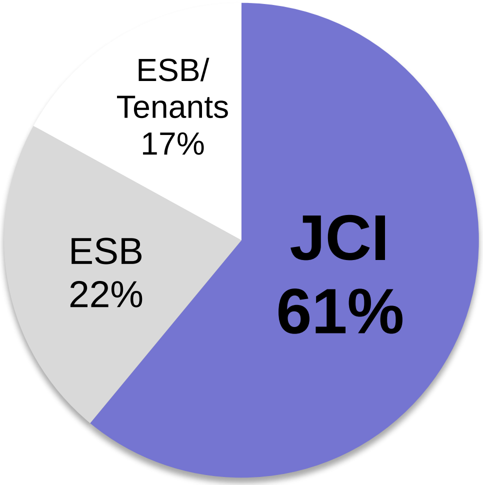
# IV. IMPLEMENTATION

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

Johnson Controls Inc will deliver 61% of the total savings using a performance contract mechanism. Five different performance contracts have a total cost of $20 million and guaranteed savings of ~20% percent.

***How does the Performance Contract work?***

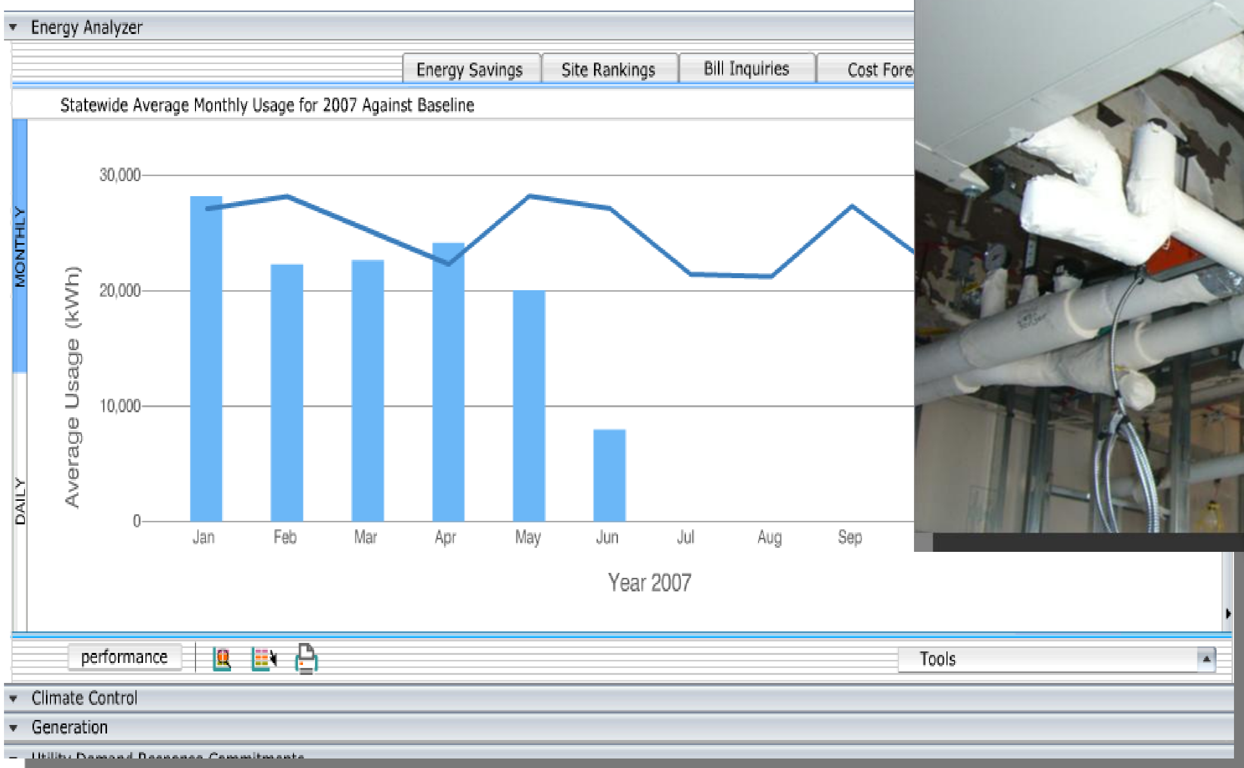
1. ESB pays JCI guaranteed maximum price for capital cost of all projects
2. ESB accrues energy savings as a result of the retrofit projects … if savings are too low, JCI pays ESB the difference.
3. Savings guarantee term is 15 years

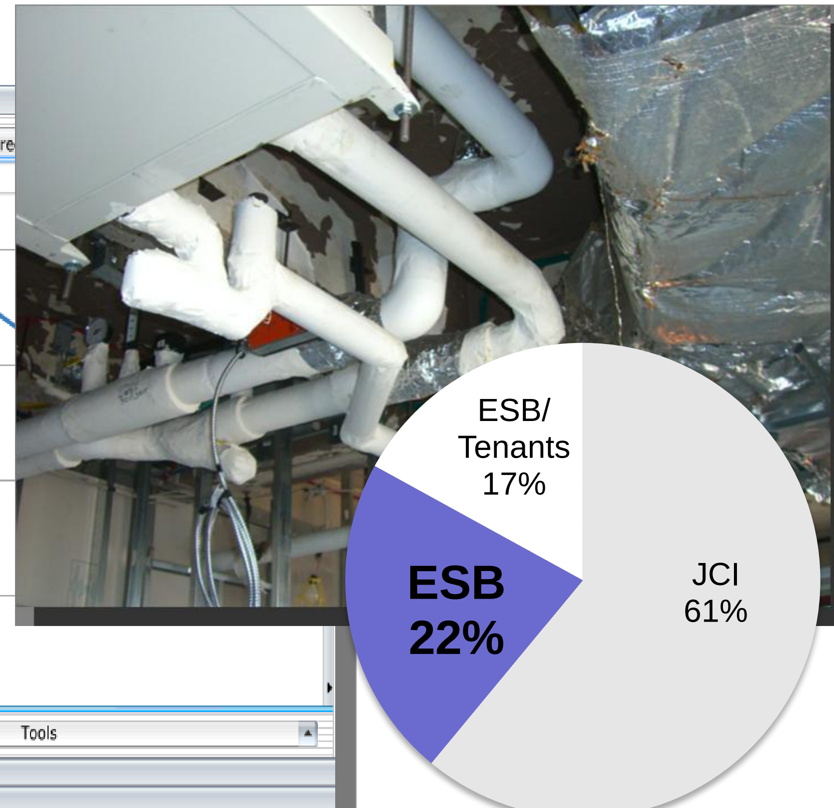


# IV. IMPLEMENTATION

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

Empire State Building will deliver 22% of the total available savings as air handling units and pre-built spaces are replaced over the next 4 years.

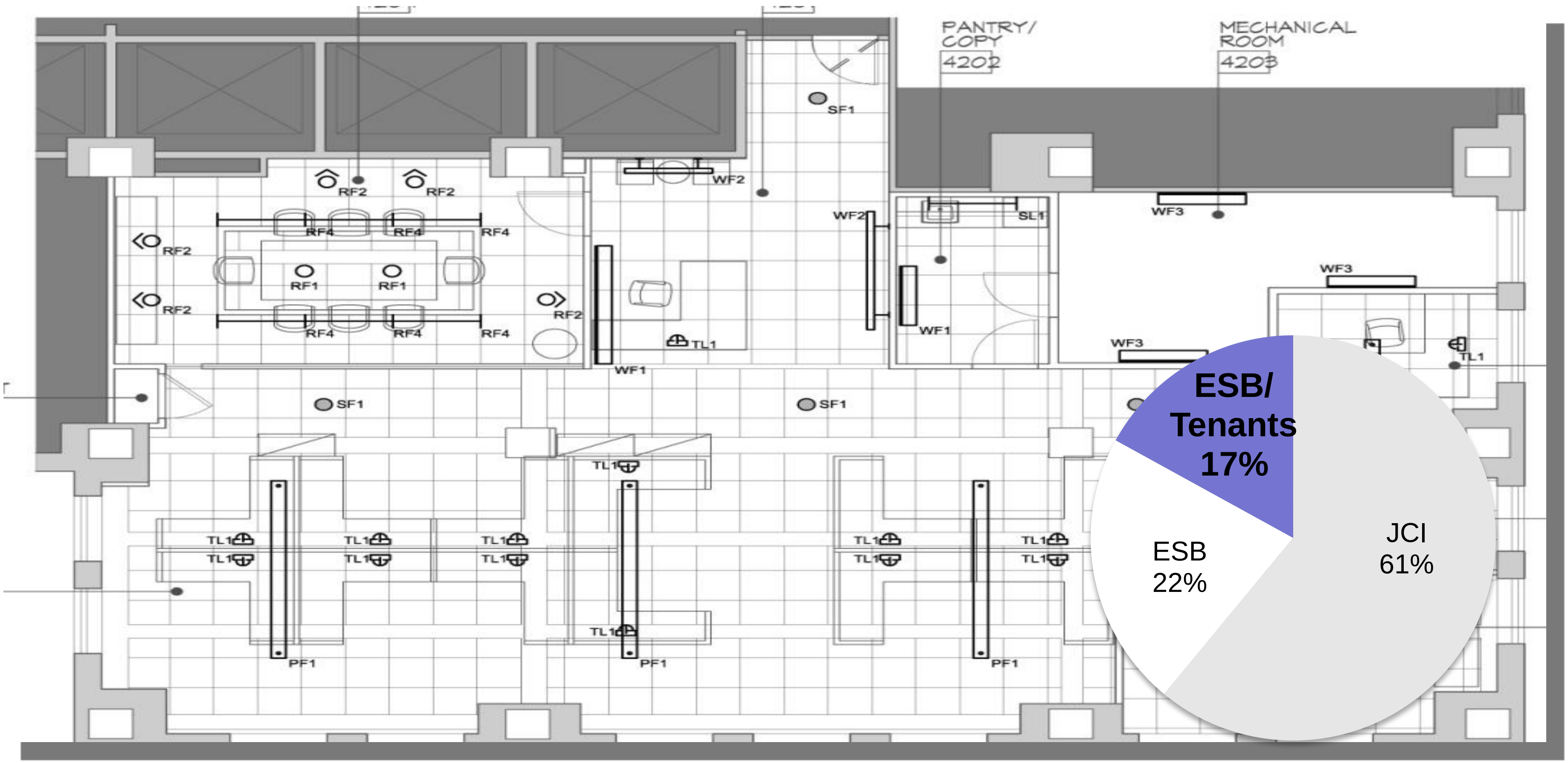


# IV. IMPLEMENTATION

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

ESB is responsible for helping/incentivizing tenants to pay for and achieve nearly 20% of the total available energy savings as spaces turnover.



# IV. IMPLEMENTATION

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

The team has identified 3 programs that will help to reduce and manage tenant energy use:

1. **Tenant pre-built program:** The proposed green pre-built design will save $0.70 - $0.90/sq. ft. in operating costs annually for an additional cost of $6/sq. ft. and help ESB demonstrate design principles for all tenants to endorse.

2. **Tenant design guidelines:** Design guidelines, based on the pre-built program, will provide green ESB standards. Tenants can verify the economic validity of the recommendations by accessing the eQUEST model or tenant financial tool.

3. **Tenant energy management program:** ESB will begin sub-metering all tenant spaces and manage a feedback/reporting tool to inform tenants about their energy use. This program will also assist tenants with their own carbon reporting efforts.

# IV. IMPLEMENTATION

Clear energy targets and responsible parties must be determined for each of the 8 major savings measures to fully maximize the environmental and economic benefits.

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

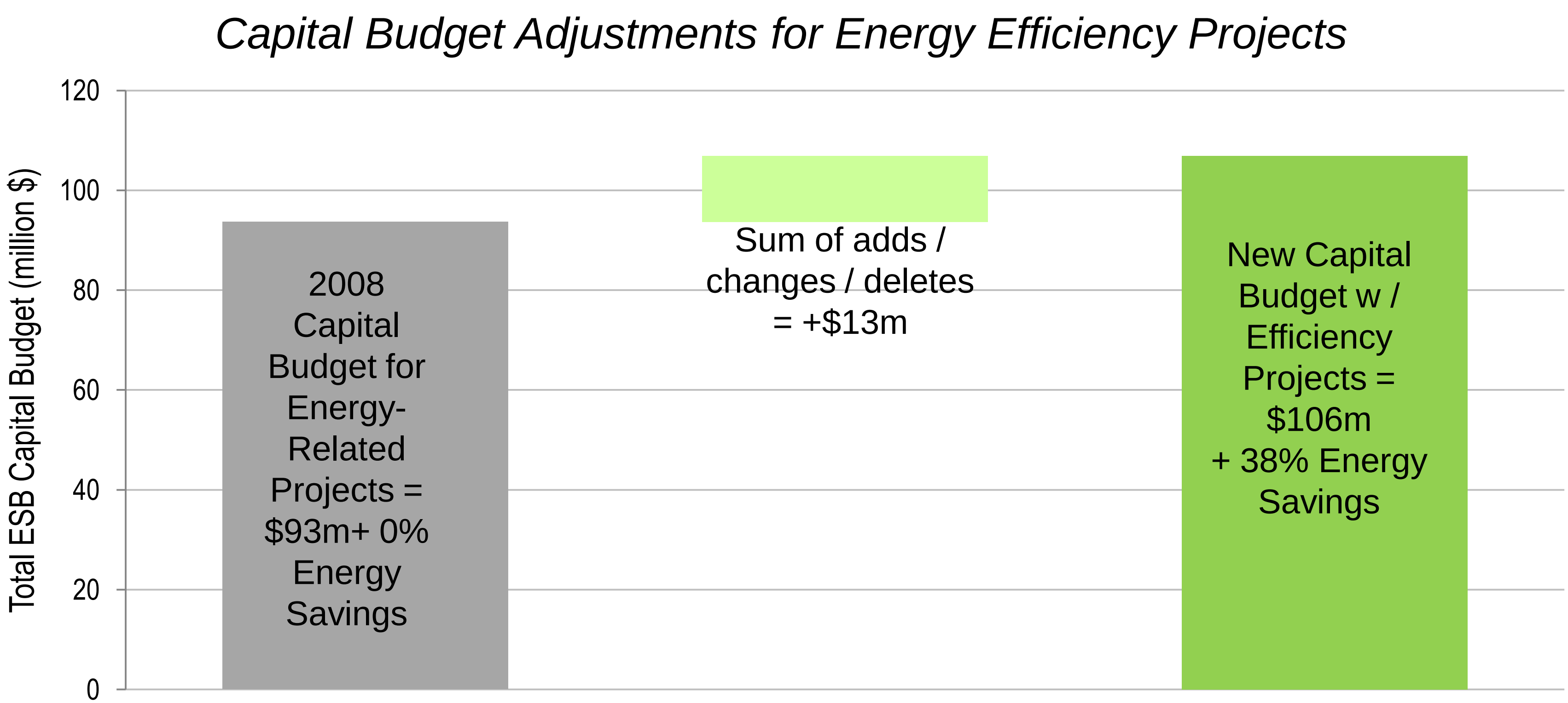
2) The project will be financed out of cash flow, though other financing opportunities are being investigated.

3) Work has already started and will be complete by 2013 (55% of the savings will be in place by December 31, 2010).

# IV. IMPLEMENTATION

## 2) The project will be financed out of cash flow, though other financing opportunities are being investigated.

The additional $13.2 million required for energy efficiency projects will be paid for out of cash flow.



# IV. IMPLEMENTATION

Clear energy targets and responsible parties must be determined for each of the 8 major savings measures to fully maximize the environmental and economic benefits.

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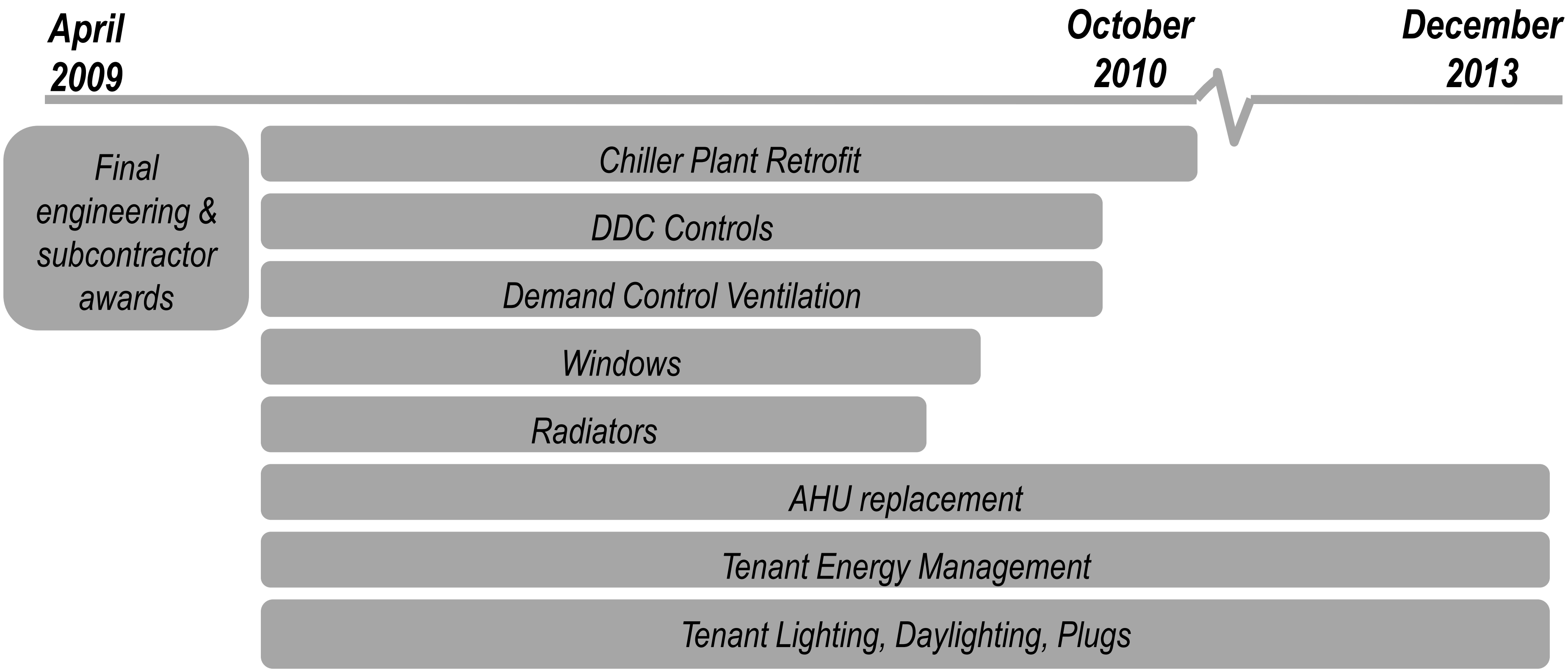
# IV. IMPLEMENTATION

## 3) Work has already started and will be complete by 2013.

The projects to be implemented via the Johnson Controls performance contract will be complete by October 2010. The remaining projects will be complete by December 2013.



# V. LESSONS LEARNED

Key lessons learned for the retrofit of large commercial office buildings include:

1) The maximum cost-effective savings are achieved by:
   a) Taking a whole-systems, dynamic, life-cycle approach;
   b) Coordinating projects with equipment replacement cycles; and
   c) Addressing tenant spaces.

2) At a certain point, there is tension between $CO_2$ savings and business value (even with anticipated $CO_2$ regulations).

3) The process can and must be streamlined.

# V. LESSONS LEARNED

## 1) Several approaches help maximize cost-effective savings.

A. Teams must take a whole-systems, dynamic, life-cycle approach.

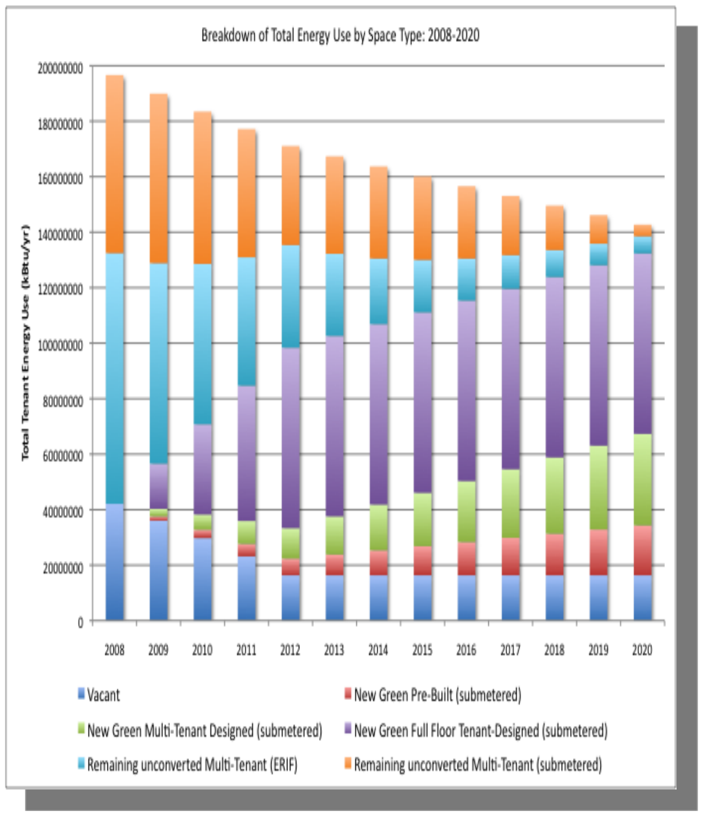
*Reduce Loads*

↓

*Use Efficient Technology*

↓

*Provide Controls*

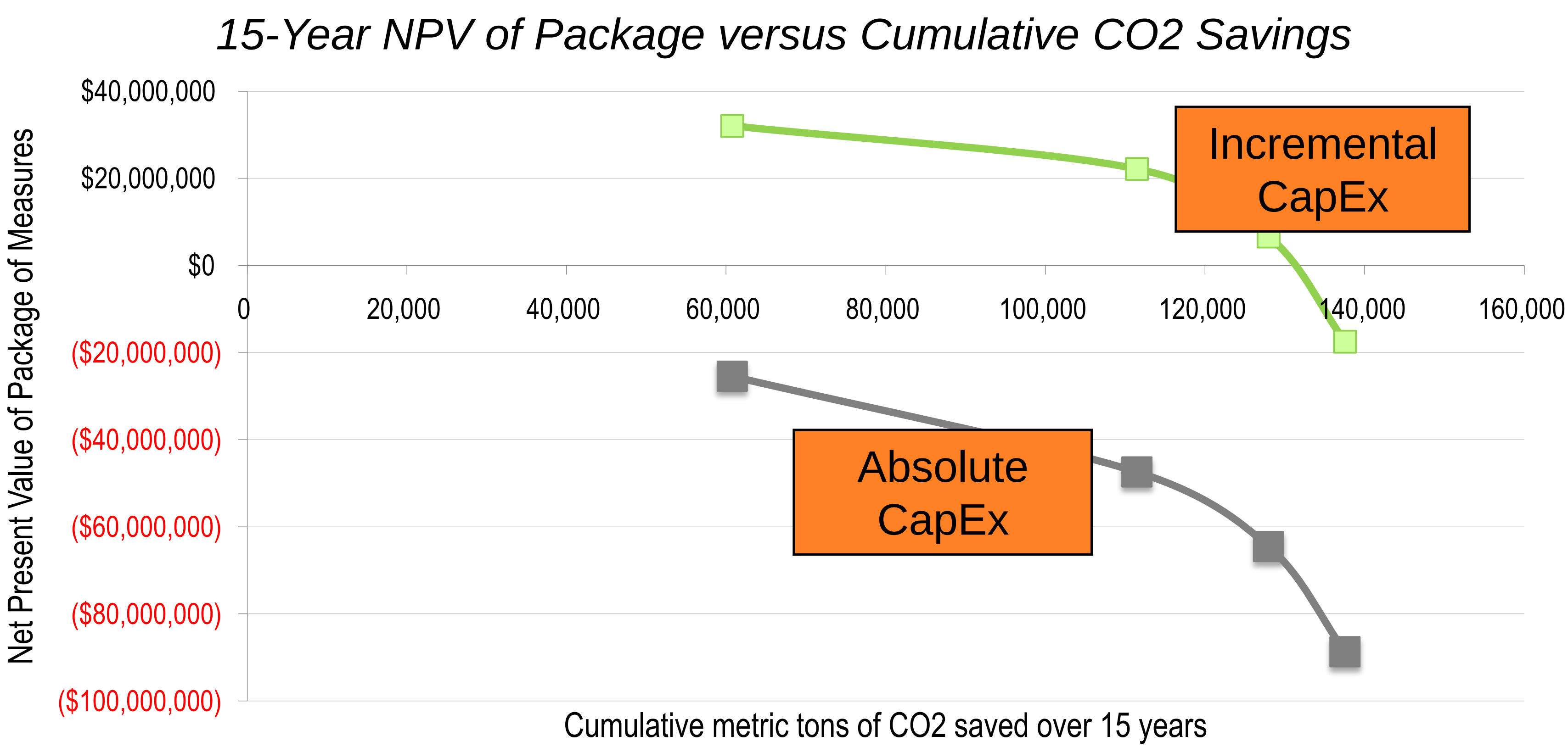



- *Capital Cost*
- *Utility Savings*
- *Utility Rebates*
- *Tax Implications*
- *O&M Impacts*
- *Escalation Assumptions*
- *Discount Rate*
- *Future Cost of CO2*
- *Tenant Utility Structure*

# V. LESSONS LEARNED

1) Several approaches help maximize cost-effective savings.

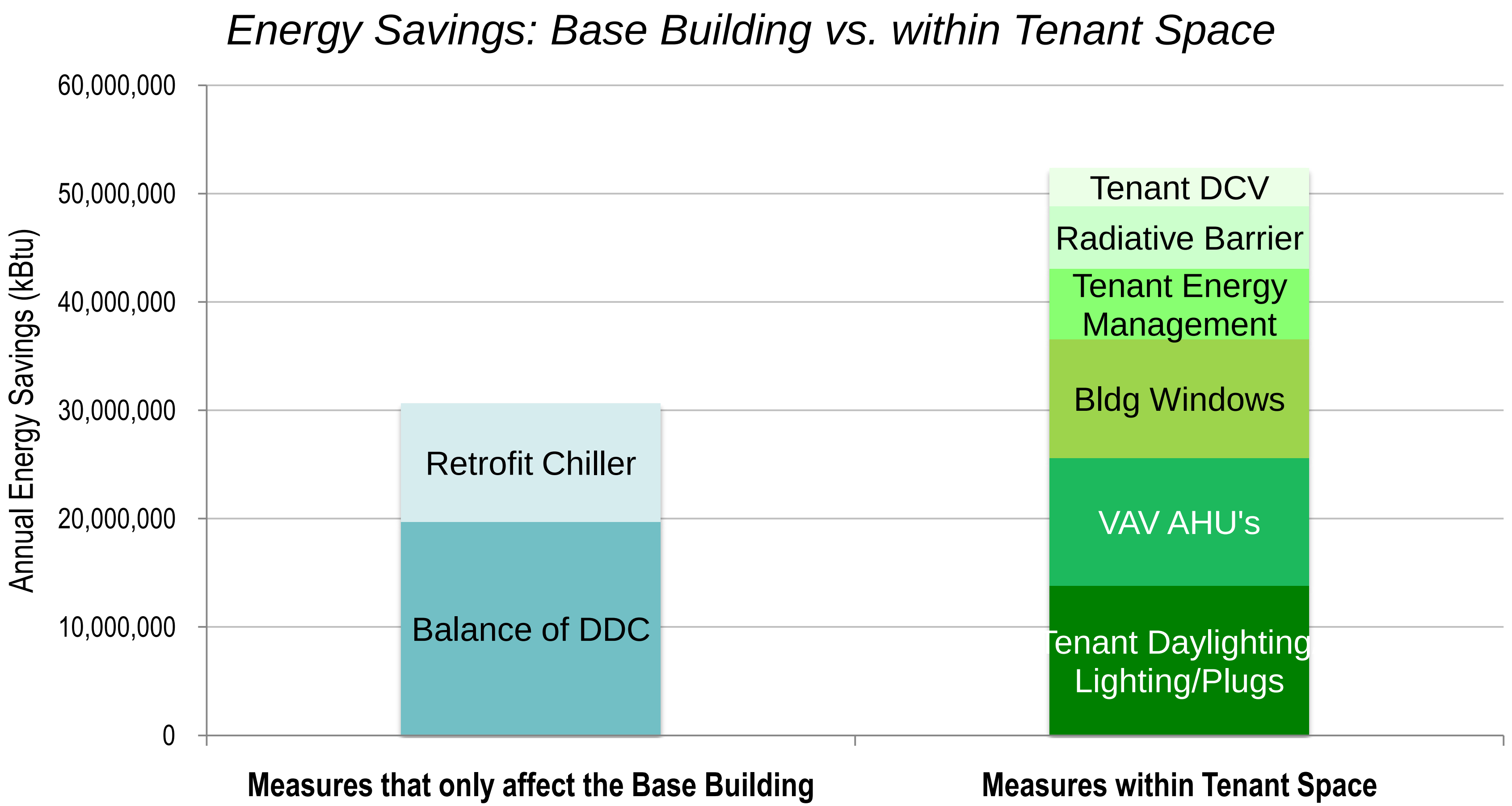
B. Projects are most cost-effective when coordinated with equipment replacement cycles.



# V. LESSONS LEARNED

## 1) Several approaches help maximize cost-effective savings.

C. More than half the savings exist within tenant spaces – don't ignore them!



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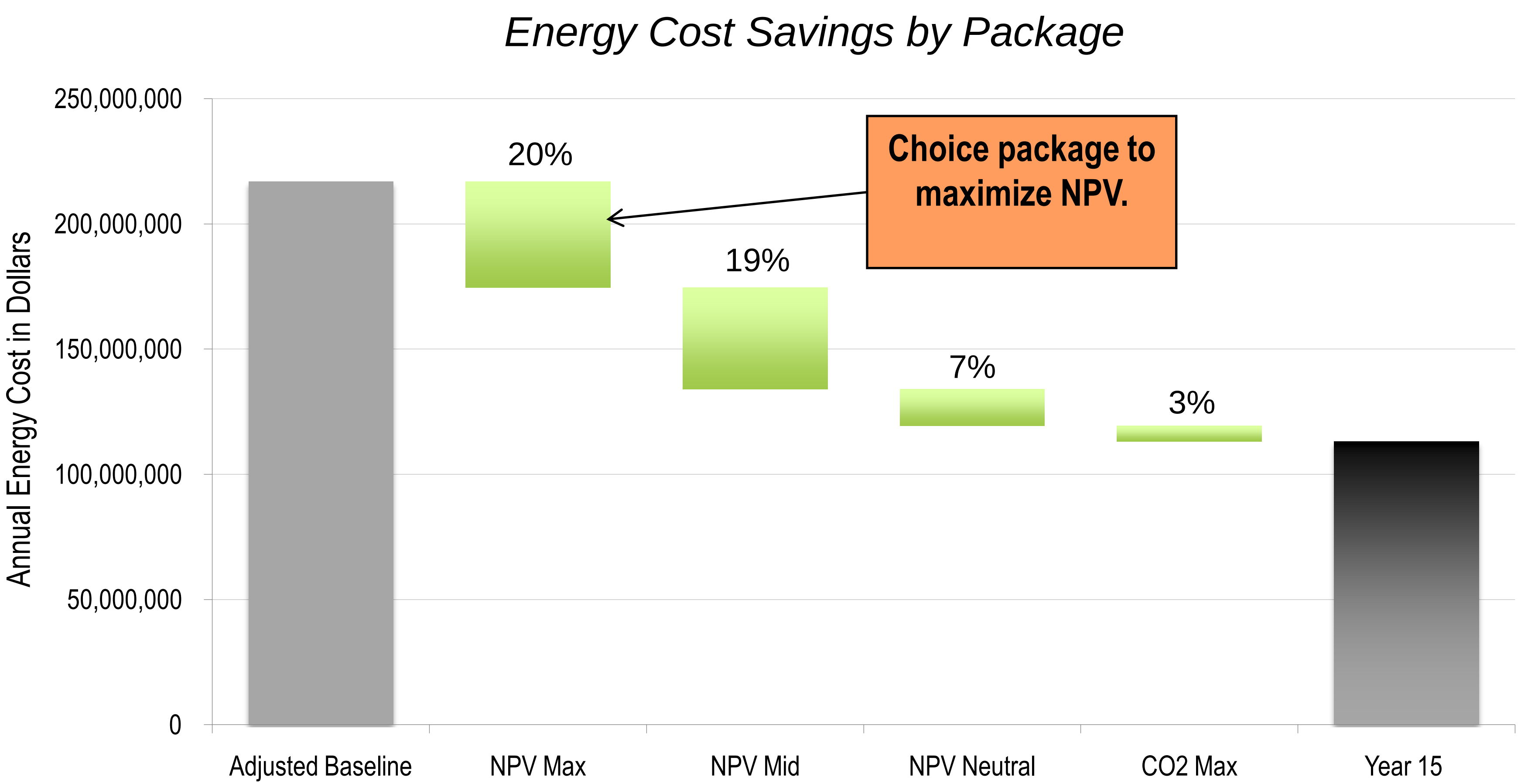
3) The process can and must be streamlined.

# V. LESSONS LEARNED

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

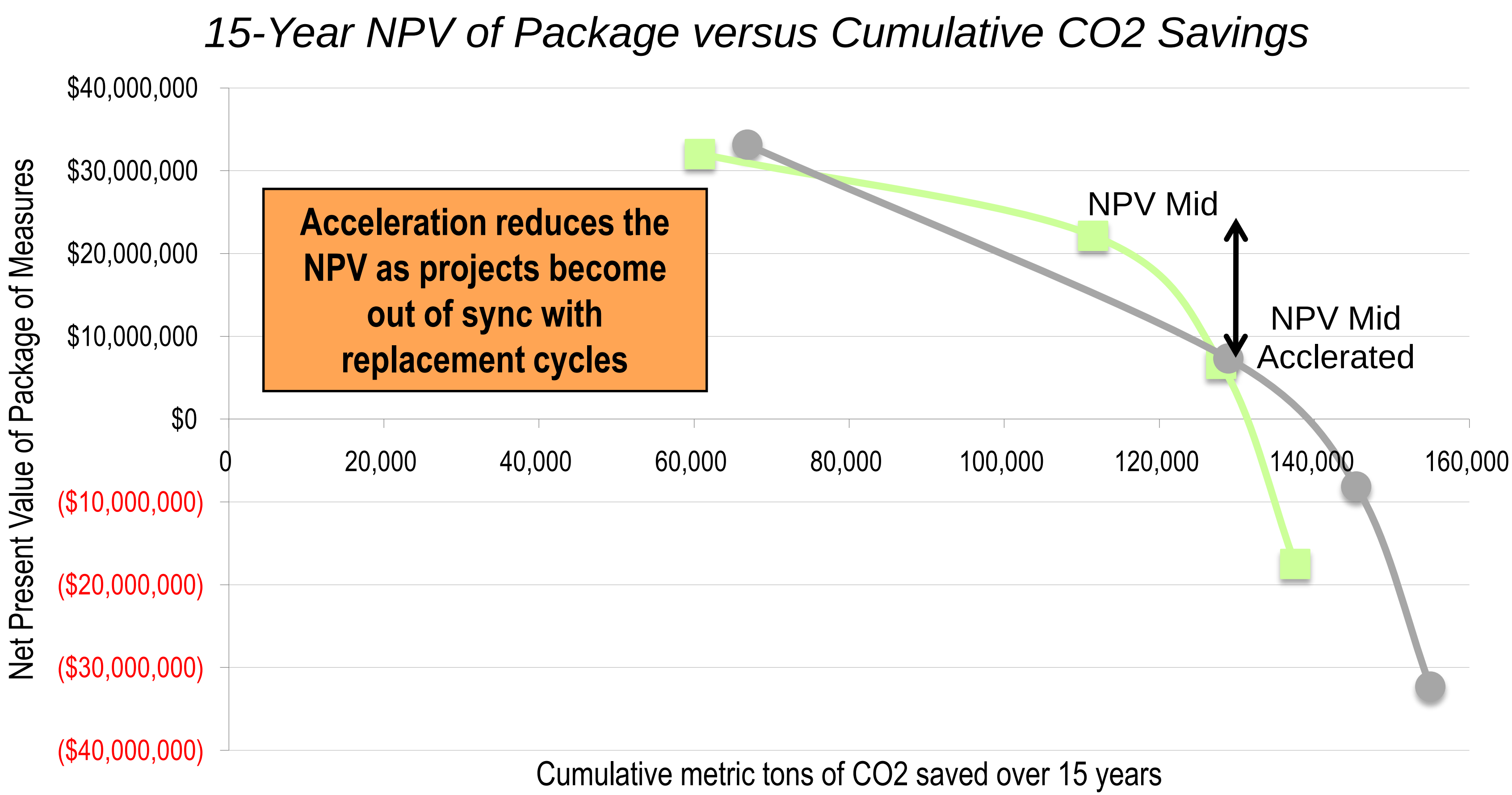
Maximizing business value leaves considerable CO2 on the table.



# V. LESSONS LEARNED

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

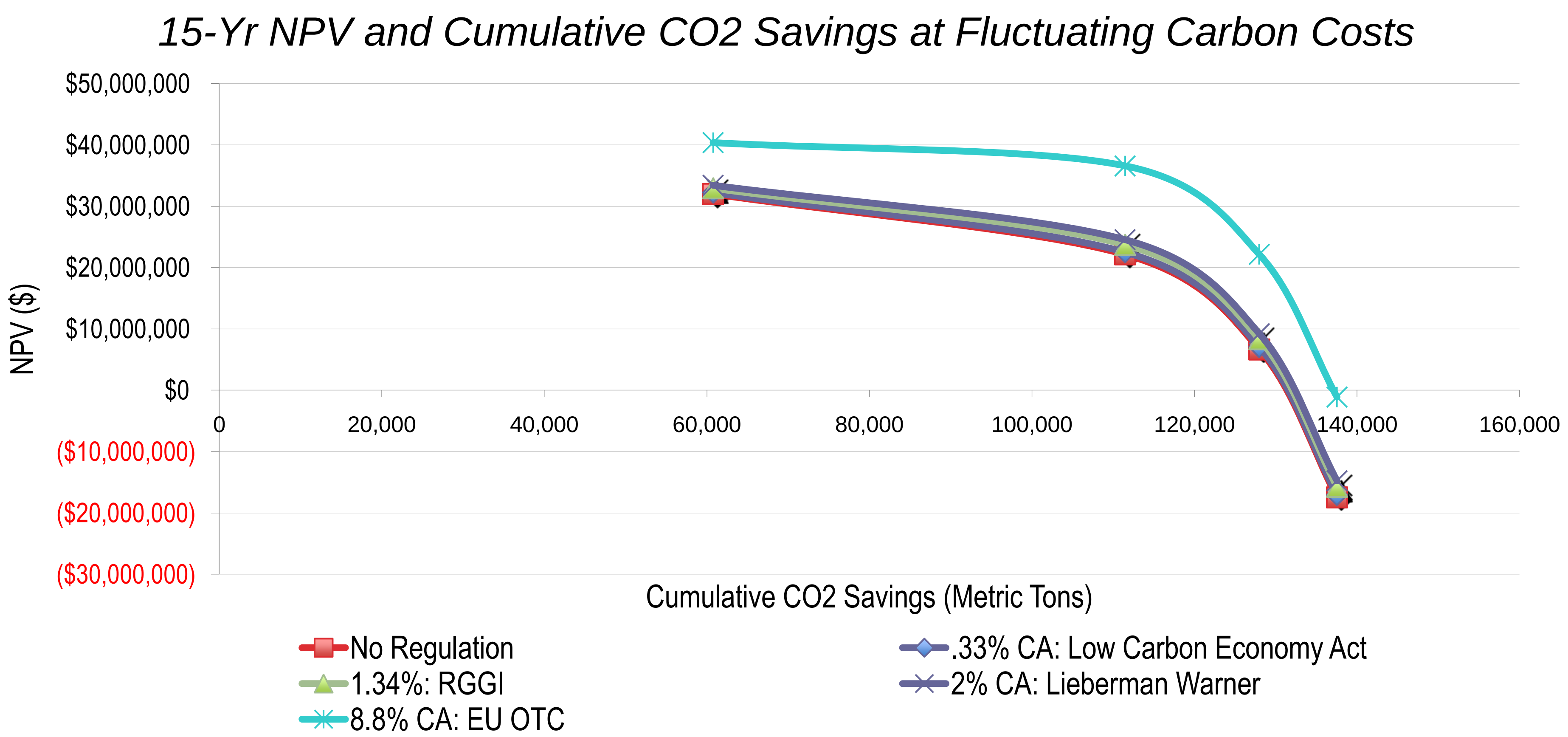
Attempting to save CO2 faster may be cost prohibitive.



# V. LESSONS LEARNED

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

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



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Key lessons learned for the retrofit of large commercial office buildings include:

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3) The process can and must be streamlined.

# V. LESSONS LEARNED

## 3) The process can and must be streamlined.

Several opportunities to reduce the time and cost of the project development process exist.

*Opportunities to Improve Project Development Process*

# VI. INDUSTRY NEEDS

This project was a great "test lab", but what now? If all buildings need to be retrofitted to profitably reduce greenhouse gas emissions by 75% by 2050, we have a lot of work to do in a short amount of time.

***Outcome:*** *75% Reduction by 2050*

***Opportunity Areas:*** *Residential, Commercial, Industrial*

***Barriers:*** *What is preventing us from reaching our goal?*

***Strategies:*** *What is the most impactful way to overcome barriers?*

***Coordination:*** *Who is working on what and what can you do?*

# VI. INDUSTRY NEEDS

Barriers exist in each phase of the retrofit process. Below are the major barriers this team believes are paramount to overcome in order to reach our 2050 goal.

| *Retrofit Project Phases* | | | | |
|---|---|---|---|---|
| Project Origin | Project Development | Financing& Contracting | Construction & Commissioning | Measurement & Verification |
| *a. Selecting the right buildings for whole-systems retrofits*<br>*b. Developing solutions for all building types* | *c. Project development analysis tools*<br>*c. Policy*<br>*e. Engineering capacity*<br>*f. Cost of measures* | *g. Financing (base building and tenant)*<br>*h. Performance-based design and construction contracts* | • *TBD* | • *TBD* |

# VI. INDUSTRY NEEDS

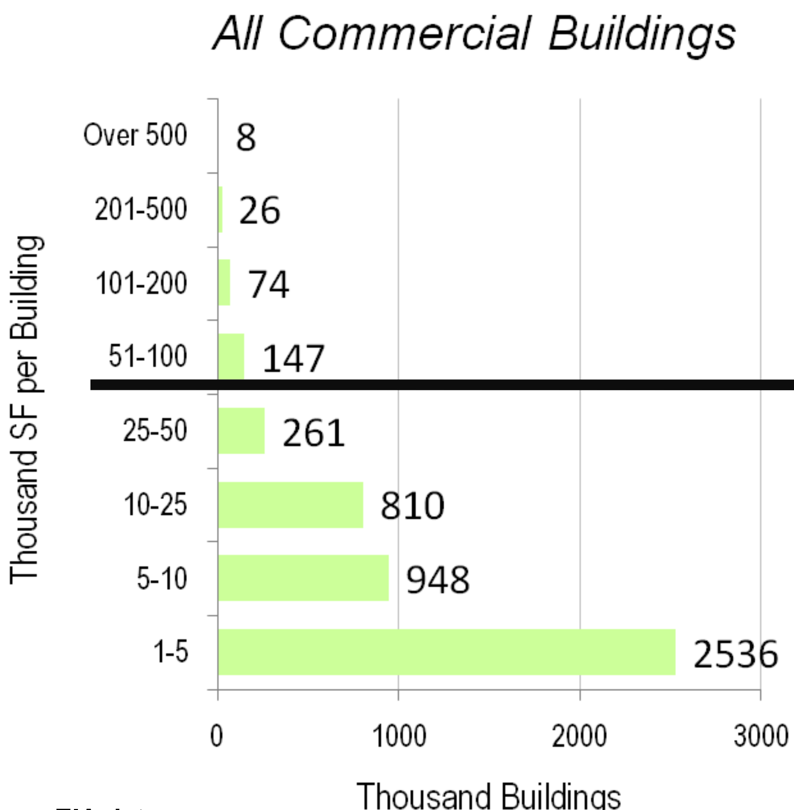
## a) Select the right buildings for whole-systems retrofits

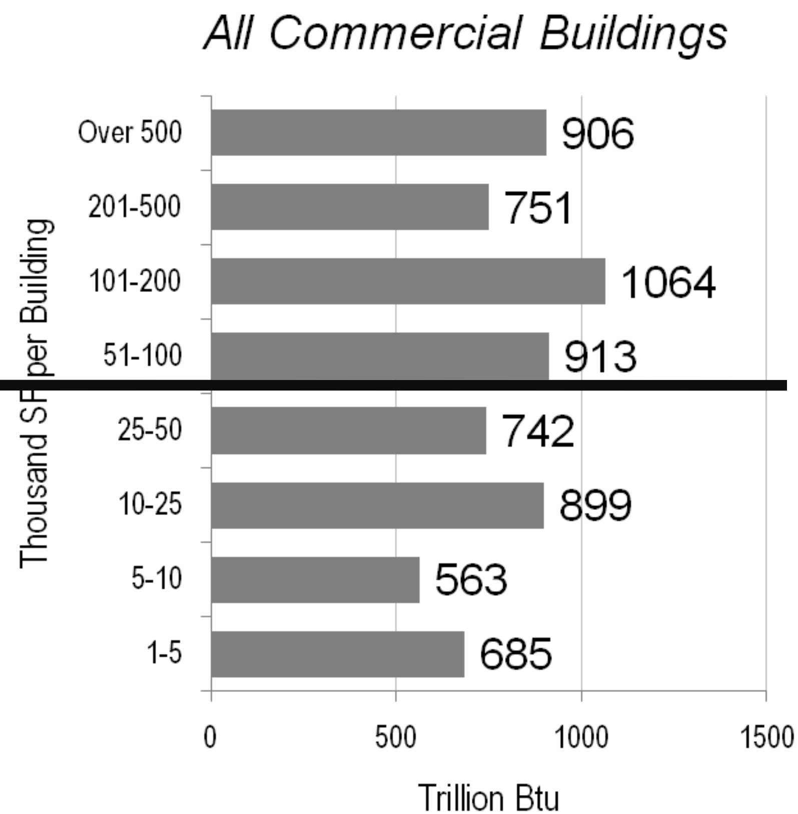
Retrofitting the right buildings in the right order can reduce the societal cost ($/metric ton) for carbon abatement.

# 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.



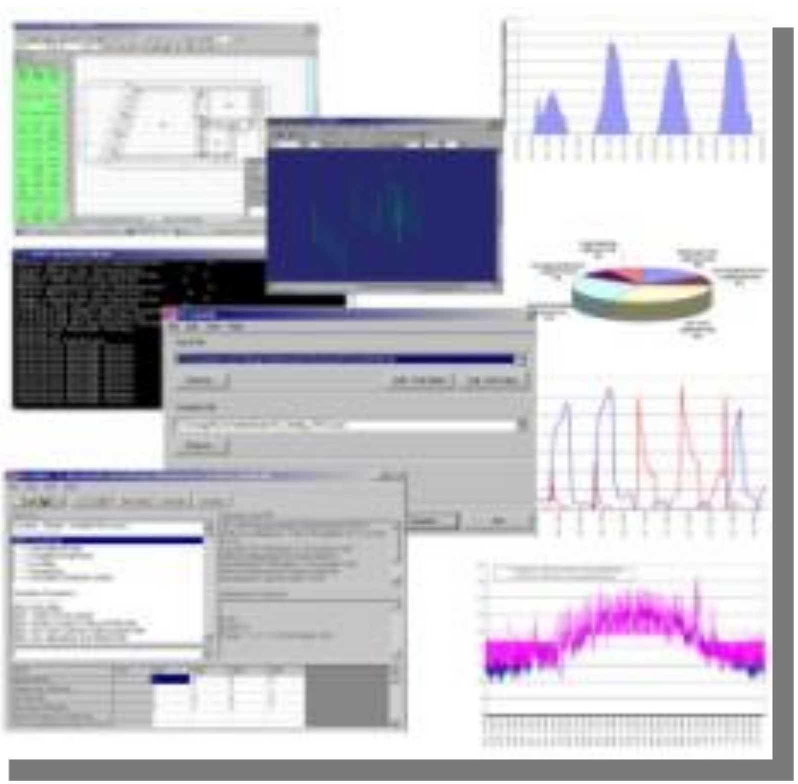




Source: EIA data

# VI. INDUSTRY NEEDS

## c) Develop better project development tools.

Significant time was spent creating the energy and financial models for this building and then iterating between them. Quicker and simpler tools could help accelerate the process.



| Description | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Implementation Responsibility | Qualitative Tenant Energy Impact |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adjust current building energy use to account for year-round cooling, corridor AC, and decreased vacancy. | | | | | | | | | | | | | - | |
| Refurbish all existing double pane windows (6500 windows): insert suspended film (SC75 or TC88) and krypton/argon gas mix. | | | | | | | | | | | | | JCI | Reduced fan power |
| Add film to existing single pane windows on 102nd floor event space. | | | | | | | | | | | | | ESB | |
| Install reflective barrier behind 6500 steam radiators; seal all gaps with foam and insulate the enclosure (pocket that the radiator sits in). | | | | | | | | | | | | | JCI | |
| Add green roof on 5th floor (20,000sf) and 21st floor (10,000sf); add white roof on 25th floor (6,000sf) and 30th floor (6,000sf). | | | | | | | | | | | | | JCI | |
| Install mechanical system controls throughout the building (2nd floor, 2-way valves, OA control, exhaust). | | | | | | | | | | | | | JCI | Reduced fan power |
| Add CO2 demand control ventilation for all existing constant volume AHU's (485 total) to reduce outside air conditioning. | | | | | | | | | | | | | JCI | Reduced fan power |
| Add controls for all radiator valves and main steam valves. | | | | | | | | | | | | | JCI | |
| Replace existing metal halide tower lighting with LED lamps. | | | | | | | | | | | | | JCI | |
| Install 4 1400-ton chillers with primary variable secondary flow using all new pumps | | | | | | | | | | | | | JCI | |
| Retrofit existing chillers (replace refrigerant) | | | | | | | | | | | | | JCI | |
| New fixtures, lamps, ballasts, and DALI controls for all corridors. | | | | | | | | | | | | | ESB | |
| New fixtures, lamps, and ballasts for all restrooms. | | | | | | | | | | | | | ESB | |
| Replace all existing constant volume air handlers with new VAV units. Install 2 larger units per floor instead of 4 units (~240 new units). | | | | | | | | | | | | | ESB | Reduced fan power |
| Install 0.8w/SF with dimmable ballasts and photocels (for daylight dimming on perimeter). Add plug load occupancy controls. | | | | | | | | | | | | | Tenant | Reduced lighting & plugs |
| Add 1" of R-5 rigid insulation to inside of all exterior walls in tenant spaces | | | | | | | | | | | | | Tenant | Reduced fan power |
| Provide for end-use submetering plus one FTE to manage a tenant energy management program via the Gridlogix website interface. | | | | | | | | | | | | | ESB/JCI | |
| Provide for an additional FTE to allow additional programming and tenant education/reporting within TEM program. | | | | | | | | | | | | | ESB/JCI | |

# VI. INDUSTRY NEEDS

d) Use policy and regulation to incentivize deeper savings and to make the process cheaper and more transparent.

Federal stimulus money, city or state mandated retrofits, and more shared data on opportunities and performance will make retrofits faster and cheaper.


**MAYOR BLOOMBERG AND SPEAKER QUINN ANNOUNCE MAJOR PACKAGE OF LEGISLATION TO CREATE GREENER, GREATER BUILDINGS PLAN FOR NEW YORK CITY**

Source: Recovery.gov

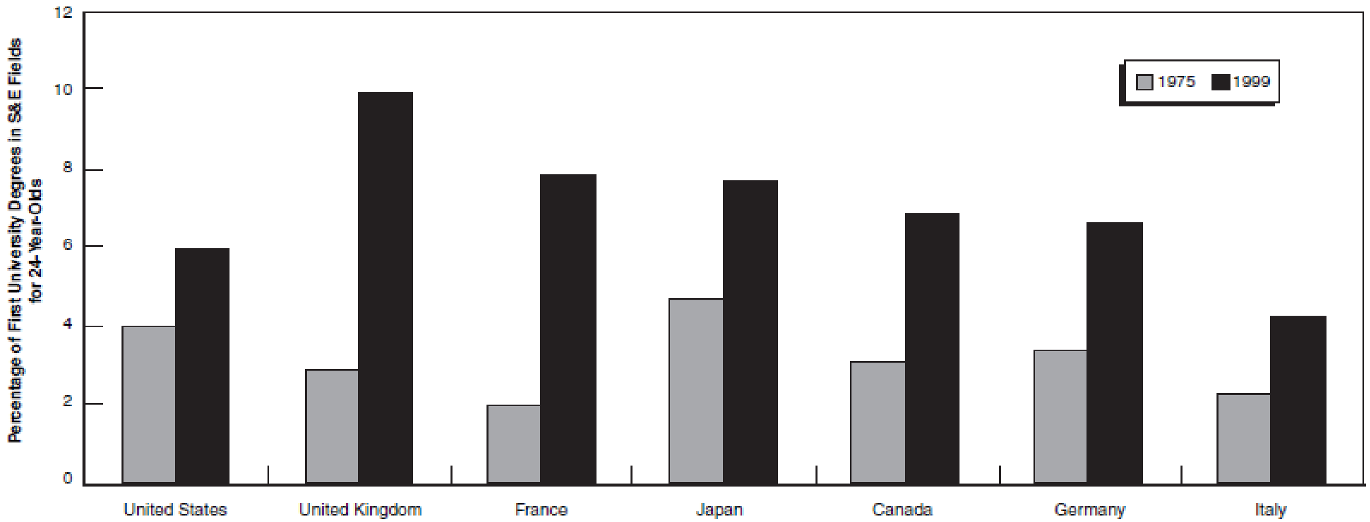
# VI. INDUSTRY NEEDS

e) Increase workforce capacity of whole-systems trained auditors, engineers, operators, and commissioning agents.

There is a lack of American engineers who are trained and ready to rebuild efficient buildings, cities, and cars.

Science & Engineering

**A YOUNG ADULT'S PROBABLITY OF GETTING AN S&E DEGREE HAS RISEN MUCH LESS IN THE UNITED STATES THAN ABROAD**




Source: *Science and Engineering Indicators* (2002).

*"There is no negawatt university" – Amory Lovins*

Source: RAND Issue paper - http://www.rand.org/pubs/issue_papers/IP241/IP241.pdf

# VI. INDUSTRY NEEDS

## f) Determine how to make efficiency measures and renewable energy technologies more cost-effective.

Value-chain analyses can help determine opportunities for cost reductions for technologies that can save significant amounts of energy.

- **Additional controls;**
- **Easy to install methods to retrofit exterior wall systems to increase thermal resistance;**
- **LED lighting;**
- **DALI lighting controls;**
- **Chilled beam systems;**
- **Heat recovery systems;**
- **Green roofs;**
- **Rainwater collection;**
- **Condenser water savings;**
- **Dessicant systems; and**
- **Even higher performance windows.**

# VI. INDUSTRY NEEDS

## g) Determine solutions for both base building and tenant financing.

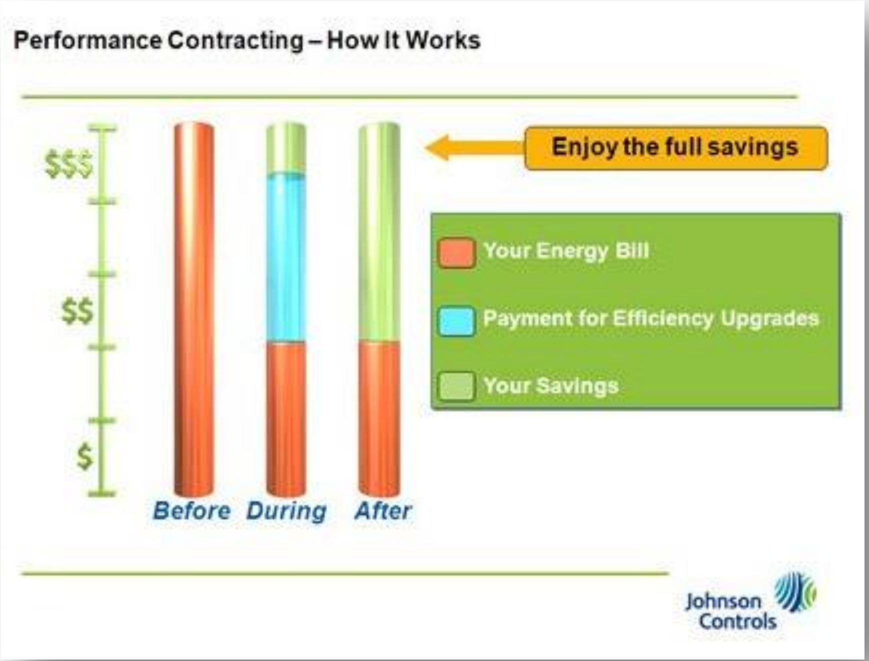
Availability of capital is a major hurdle and a variety of innovative solutions that work for large, small, owner-occupied, and leased spaces is needed.

# VI. INDUSTRY NEEDS

## h) Standardize (and use) performance-based design and construction contracts.

Design and engineering parties are often incentivized by different outcomes, thus deterring the group from optimizing energy efficiency.

**Get paid for what you save, not what you spend.**



# CONCLUSION

There is a compelling need as well as an economic case for reducing greenhouse gas emissions in existing buildings. The Empire State Building case study provides an example of how this can be done. However, significant challenges remain that must be addressed in order to quickly and cost-effectively capture the full greenhouse gas reduction opportunity for building retrofits on a widespread basis.

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More project information available at:
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Jones Lang LaSalle
*Real value in a changing world*

Clinton Foundation
Clinton Climate Initiative

Rocky Mountain Institute

Johnson Controls