The Empire State Building

Repositioning an Icon as a Model of Energy Efficient Investment

Paul Rode, P.E.
Johnson Controls Inc.

ACEEE National Symposium on Market Transformation

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Jones Lang LaSalle®
Real value in a changing world

Clinton Foundation | Clinton Climate Initiative

Rocky Mountain Institute

Johnson Controls

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)

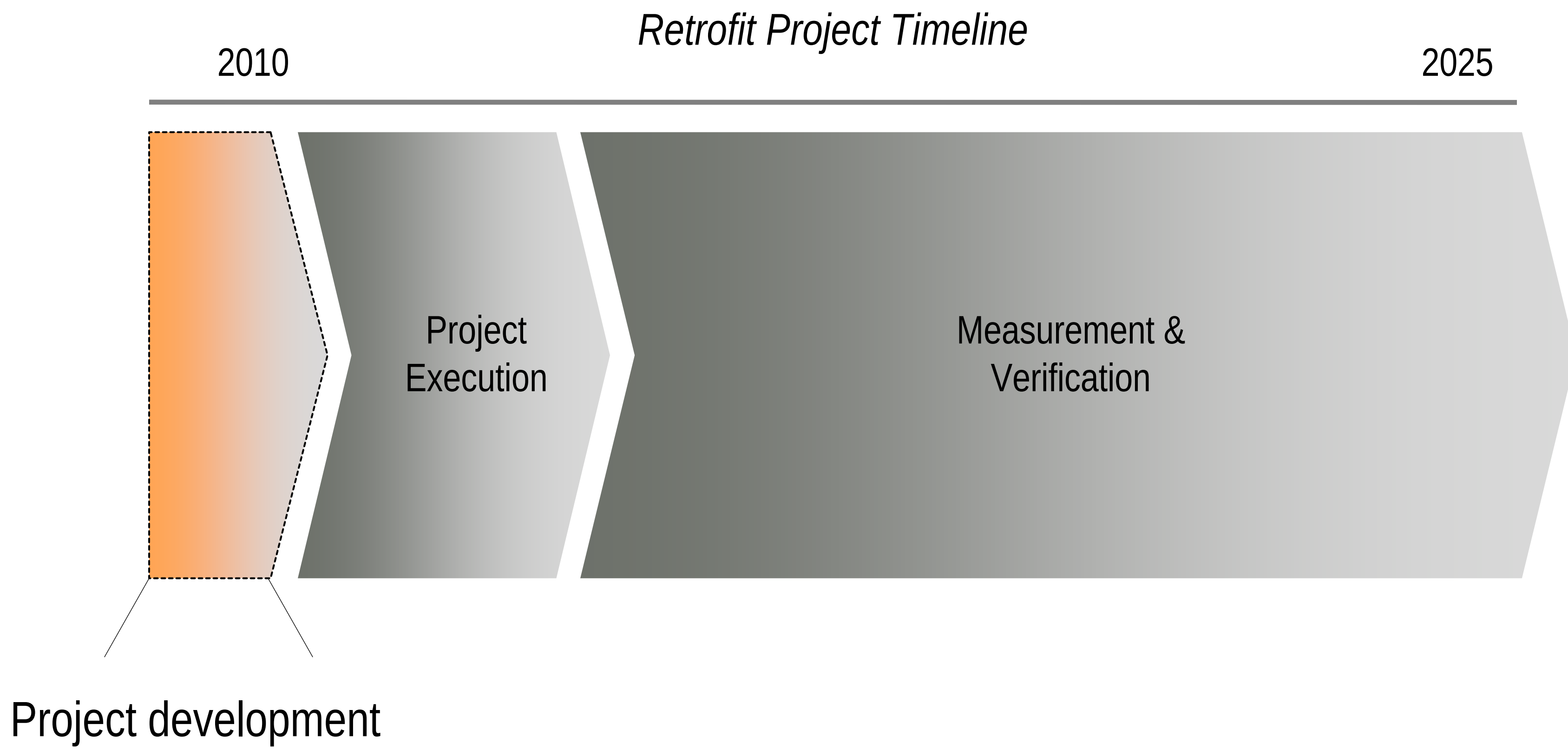
88 kBtu per sq ft per yr for the office building

CO_2 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.



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* • *May 7th/May 14th team workshops* • *June 2nd Presentation to Ownership*	• *June 18th Theoretical Minimum workshop* • *July 2nd workshop* • *July 15th Presentation to ownership*	• *July 30th Tenant Focus workshop* • *August 13th eQUEST workshop* • *August 27th Presentation to Ownership*	• *Sept. 10th workshop* • *Sept 29th Presentation to Ownership* • *October 6-8th Finance workshop (Boulder)* • *Nov 10th Presentation to Ownership*
Outputs	• *Baseline Capital Projects Report*	• *Baseline Energy Benchmark Report*	• *Tenant Initiatives (prebuilts, design guidelines, energy management) Report* • *Tuned eQUEST model*	• *Model (eQUEST, financial, GHG) outputs* • *Integrated Sustainability Master Plan Report (inc. Energy Master Plan)*

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.

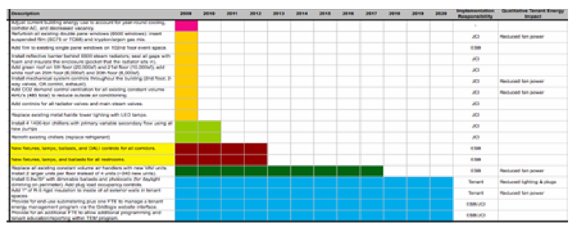
Design Tools

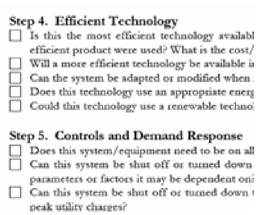
eQUEST

AGI32

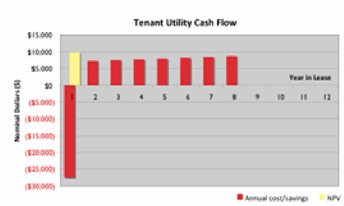
Google SketchUp

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

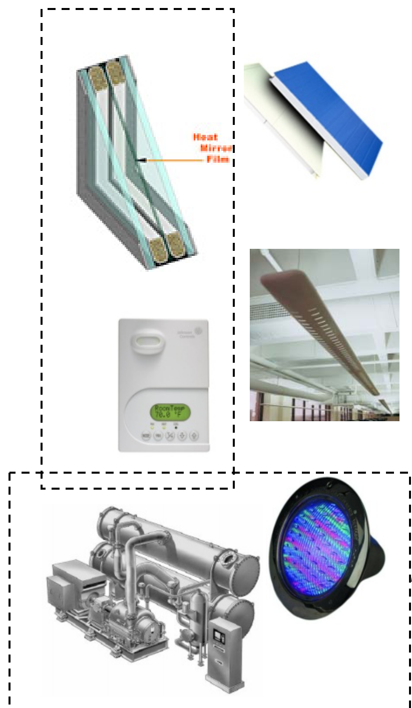
PROJECT DEVELOPMENT PROCESS

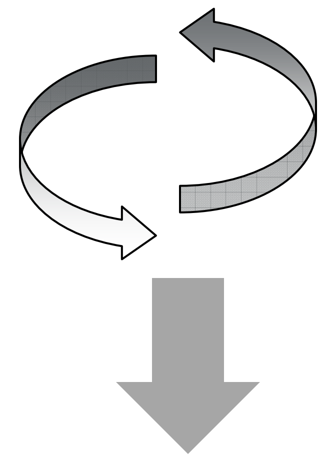
A 4-phase project development process helped guide progress.

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	Nightime 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 Contro
29	Controls-6	Radiator Contro/Window Opening
30	Controls-7	ESB Local HVAC Equip. (Air cooled chiller, CHW AHUs tied to ACC, DX AH
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

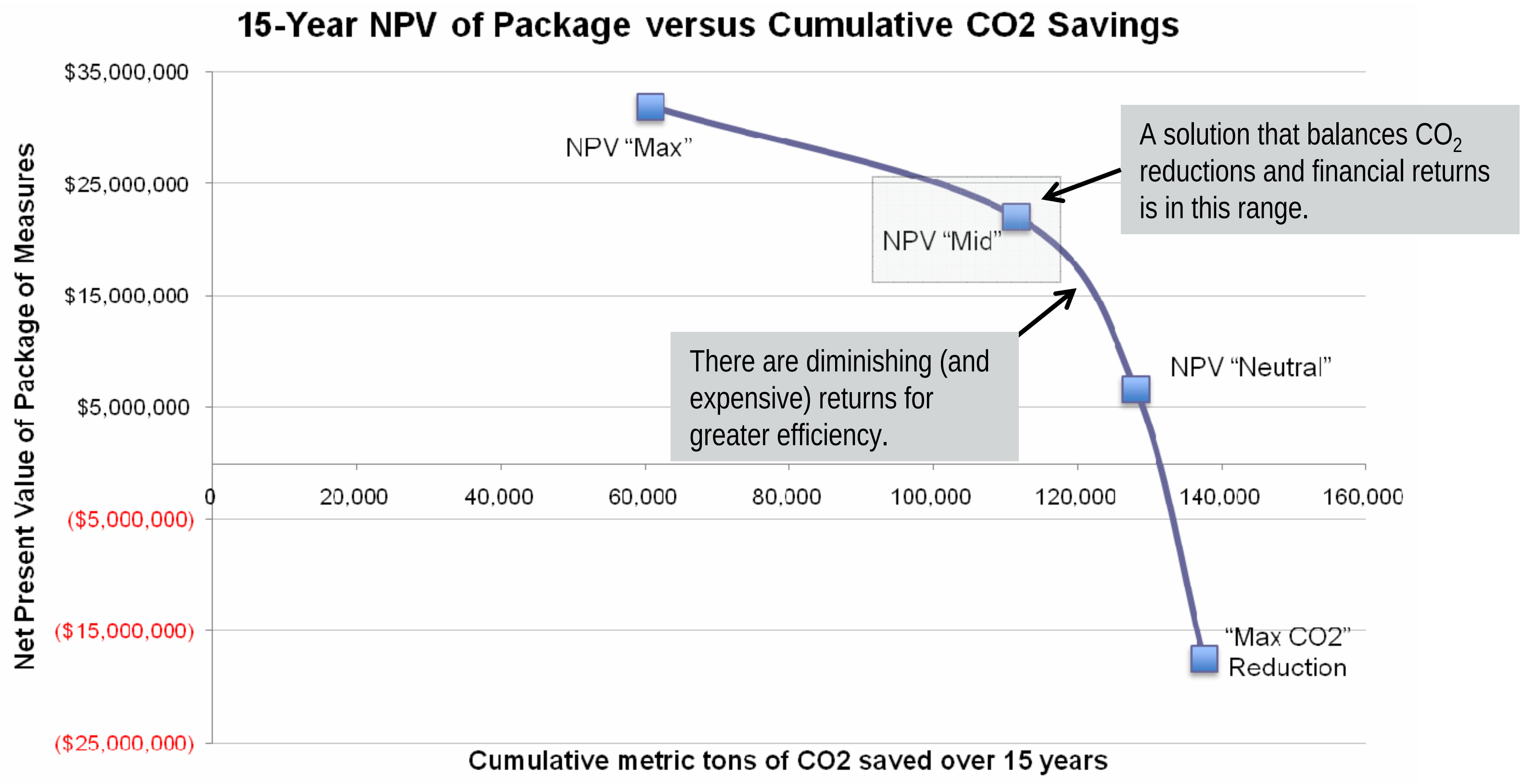




Outcome:
Package of measures with best economic & environmental benefits

Balance financial return & carbon reduction

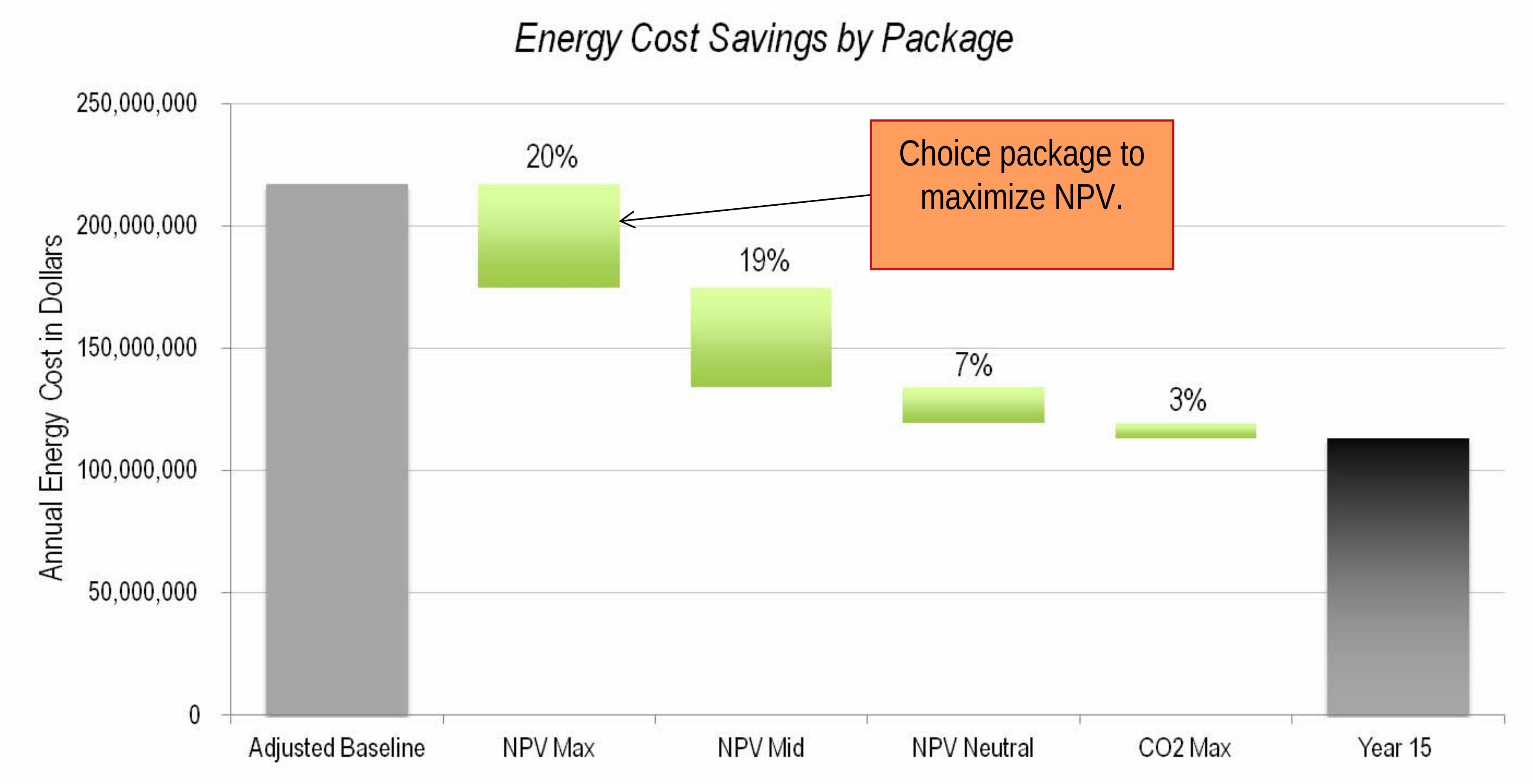
ESB can achieve a high level of CO_2 and energy reduction cost-effectively



LESSONS LEARNED

2) At a certain point, there is tension between CO_2 savings and business value.

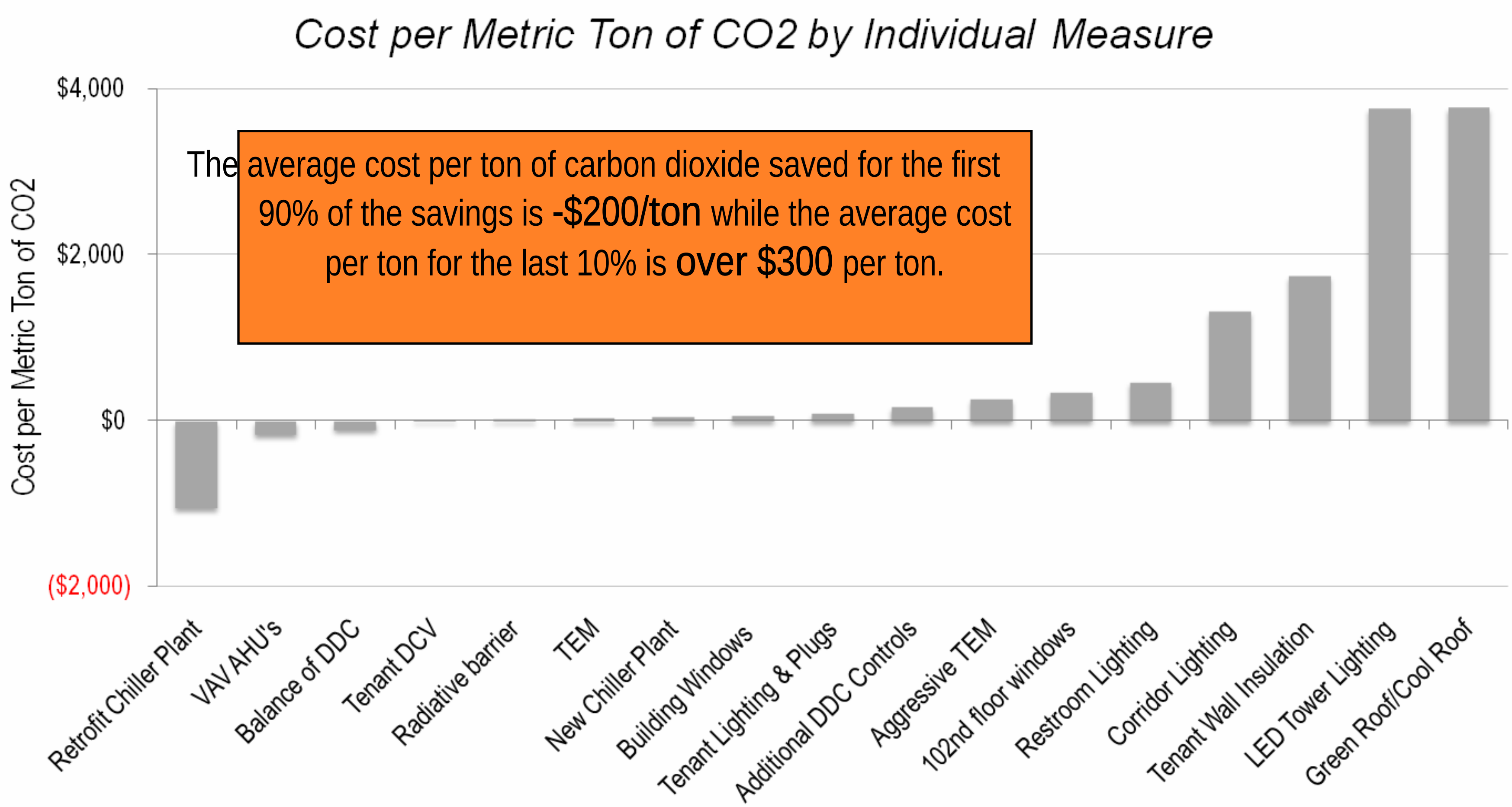
Maximizing business value leaves considerable CO_2 on the table.



KEY FINDINGS

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

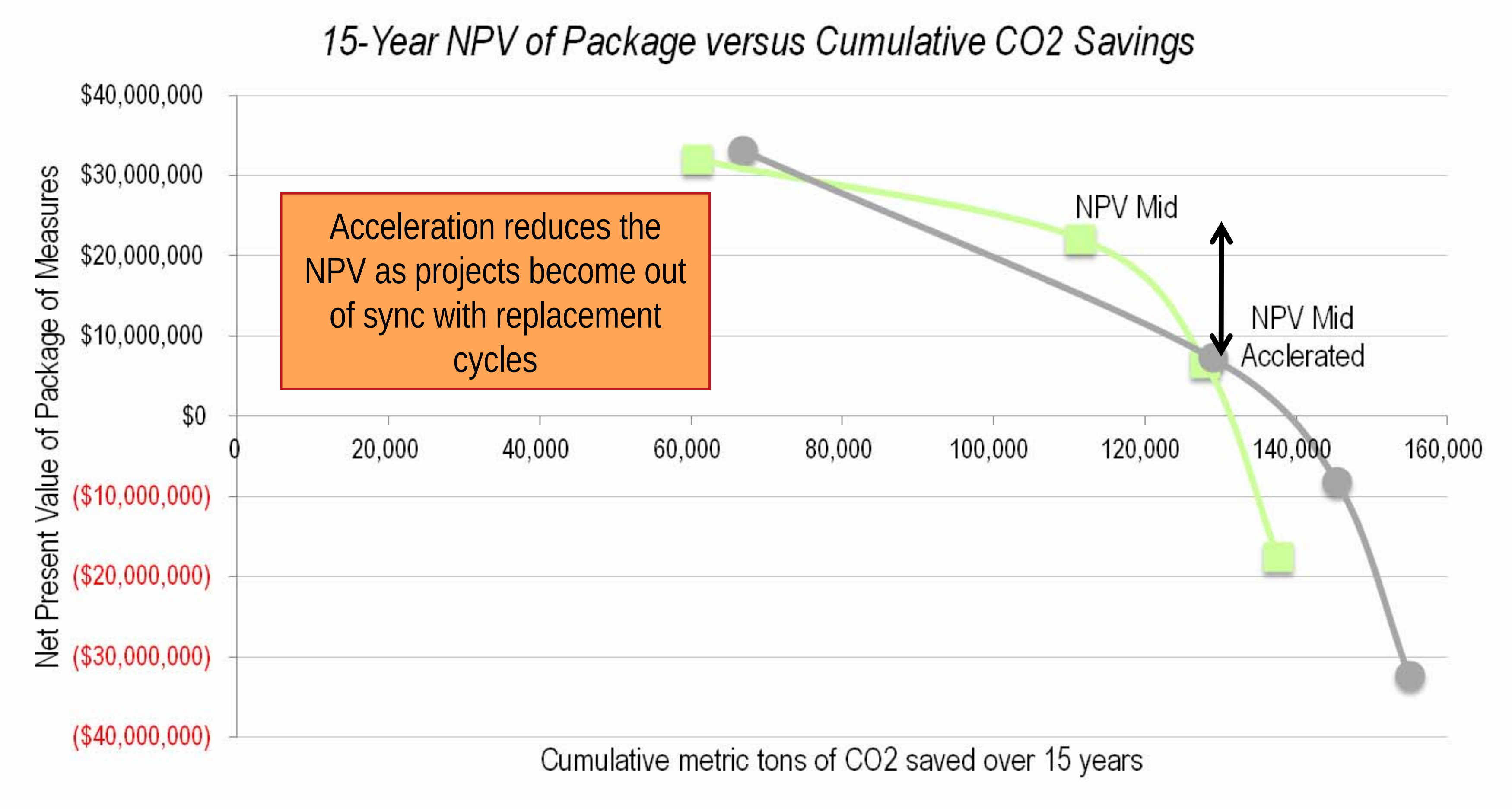
Achieving an energy reduction greater than 38% appears to be cost-prohibitive.



LESSONS LEARNED

At a certain point, CO_2 savings and business value become polarities.

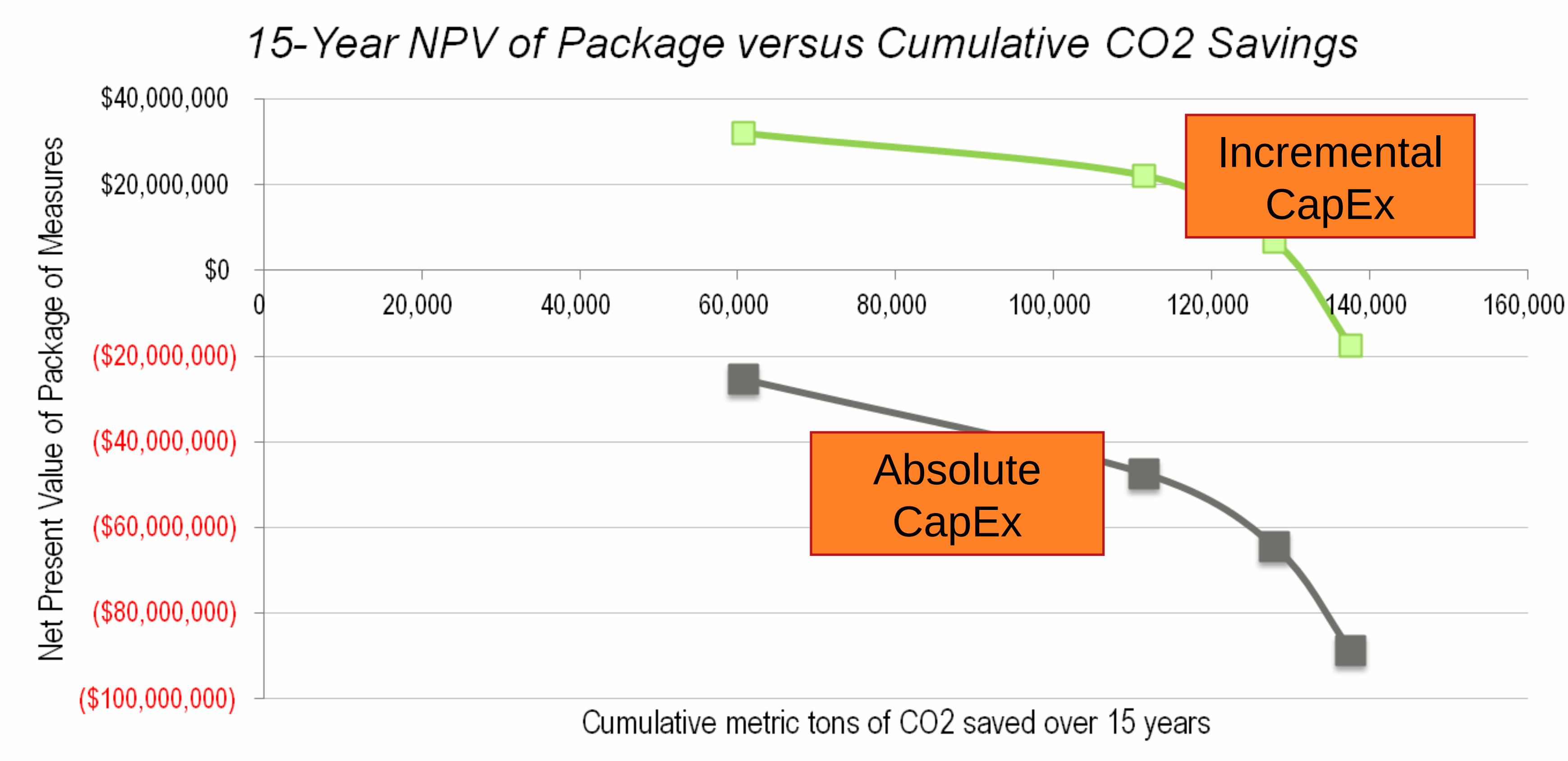
Attempting to save CO_2 faster may be cost prohibitive.



LESSONS LEARNED

Several approaches help maximize cost-effective savings.

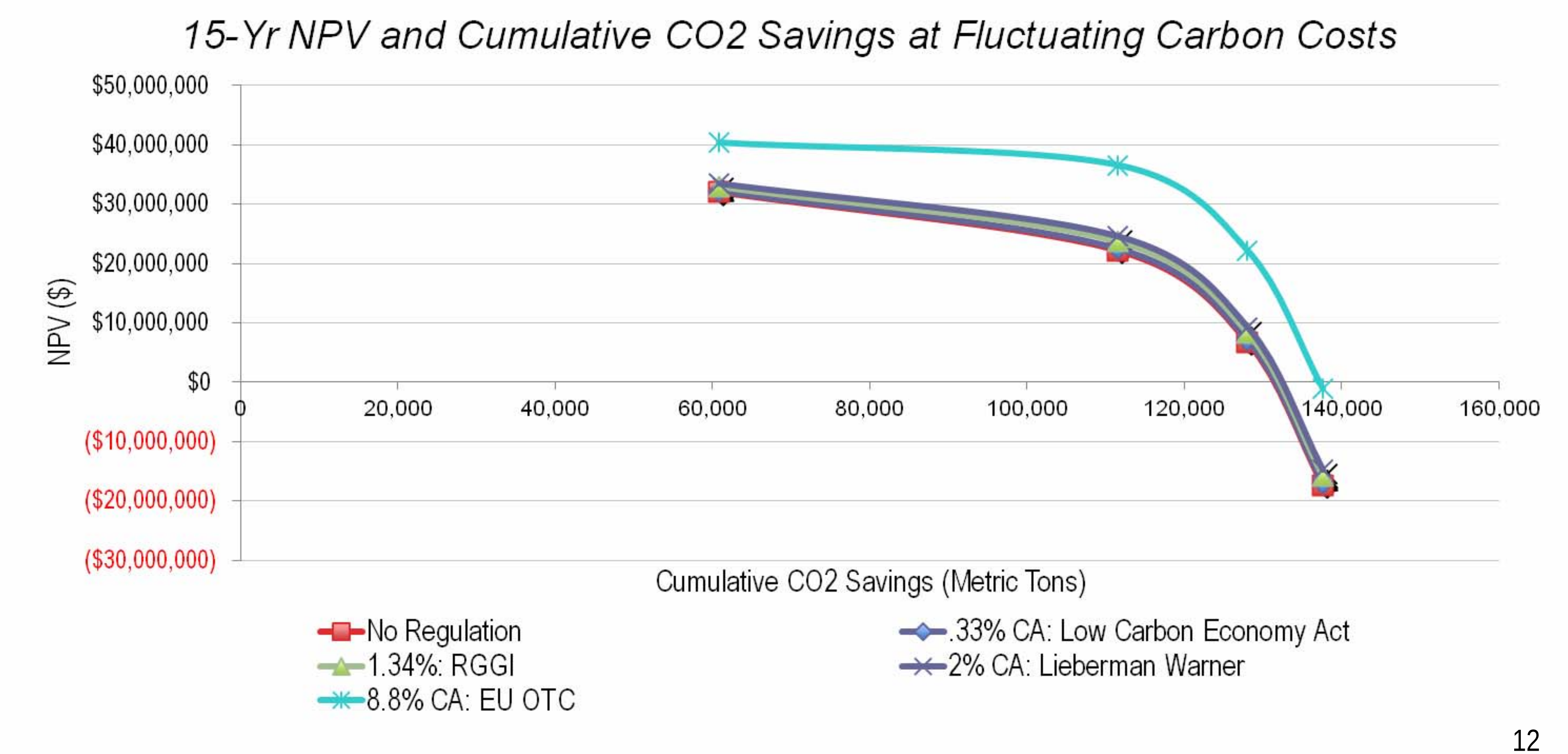
Projects are most cost-effective when coordinated with equipment replacement cycles.



LESSONS LEARNED

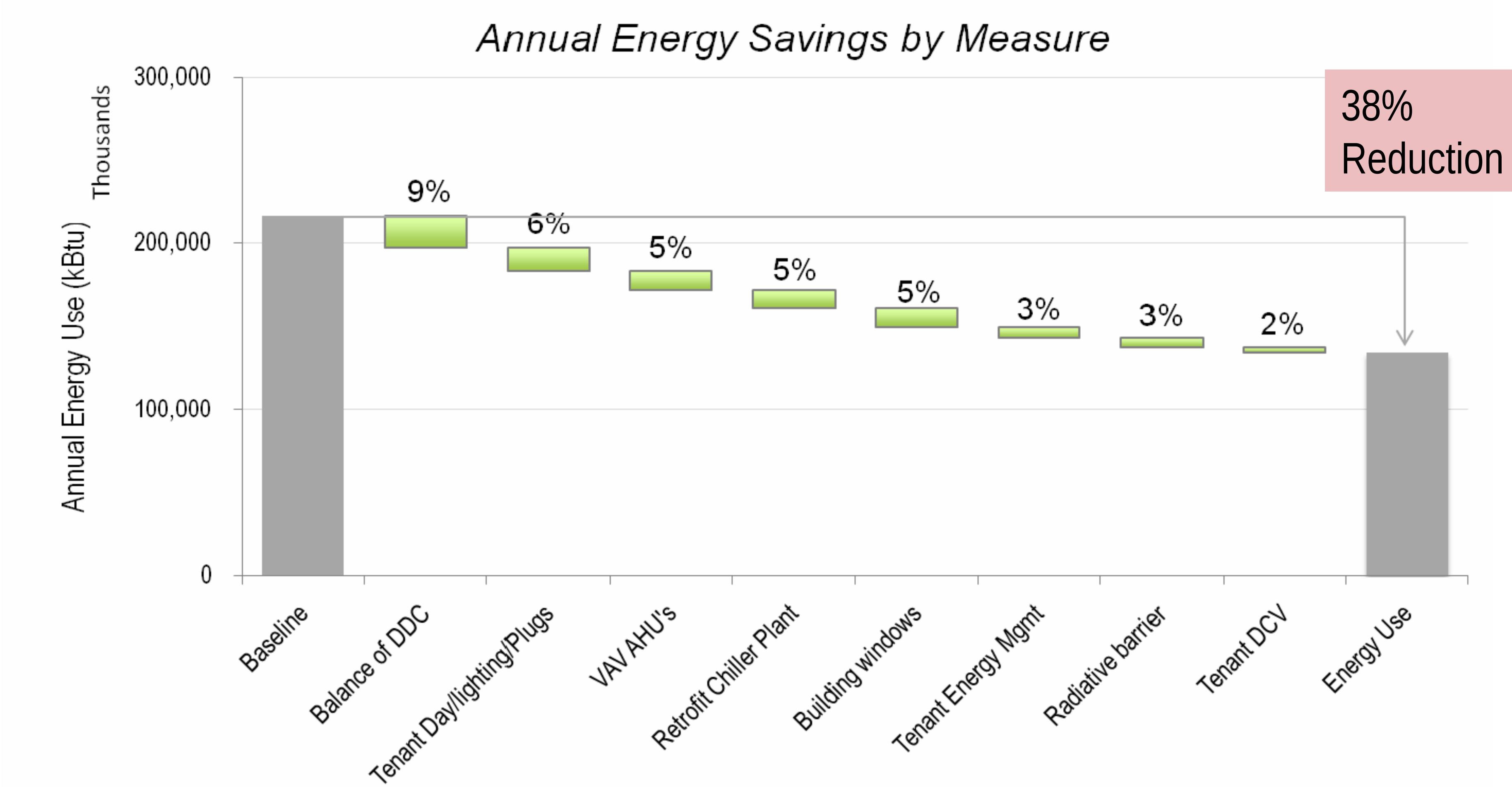
At a certain point, CO_2 savings and business value become polarities.

Anticipated CO_2 regulation in the U.S. doesn't change the solution set … though European levels of regulation would.



Implementing recommended measures

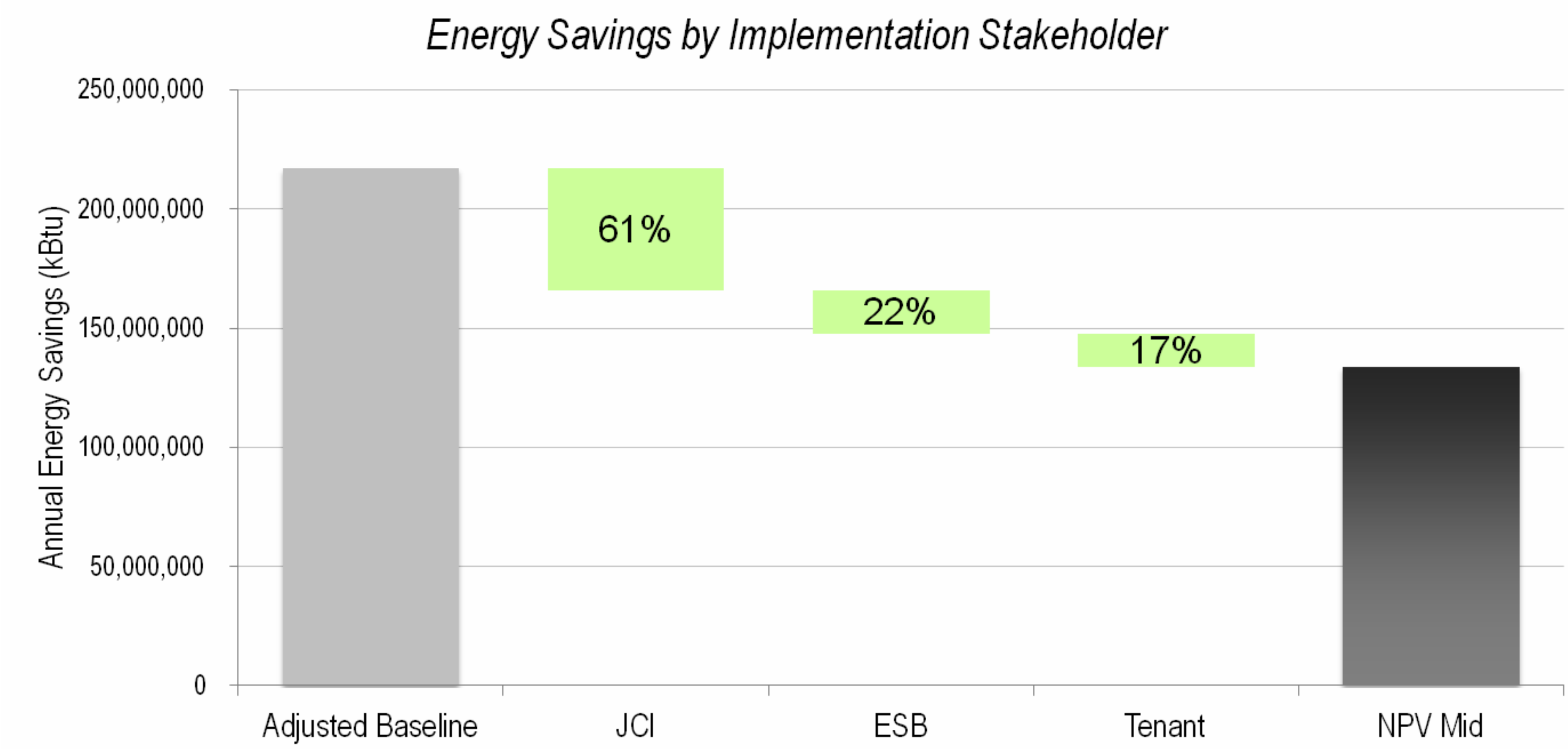
Eight interactive levers ranging from base building measures to tenant engagement deliver these results



IV. IMPLEMENTATION

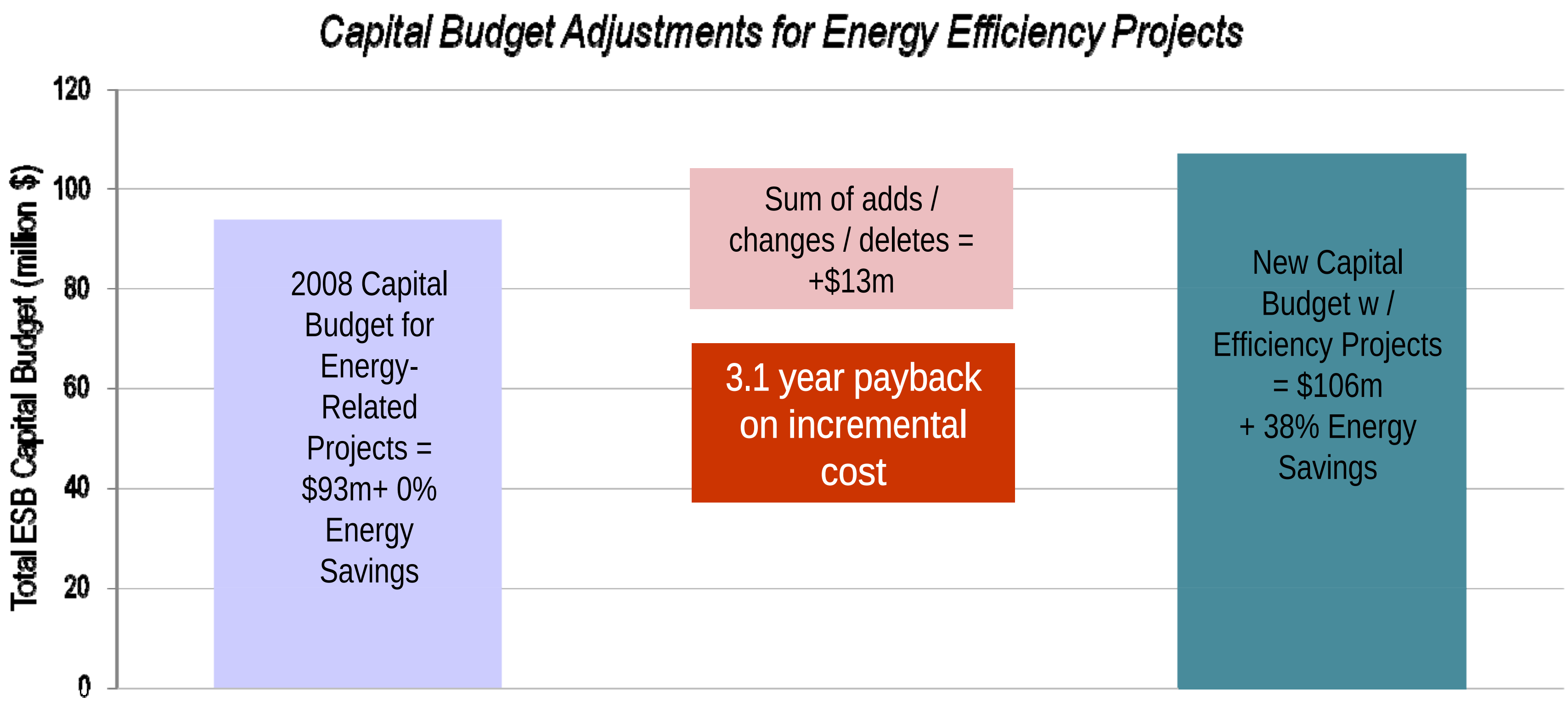
1) Three stakeholders, with different implementation mechanisms, will deliver the savings.

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



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.



III. KEY FINDINGS

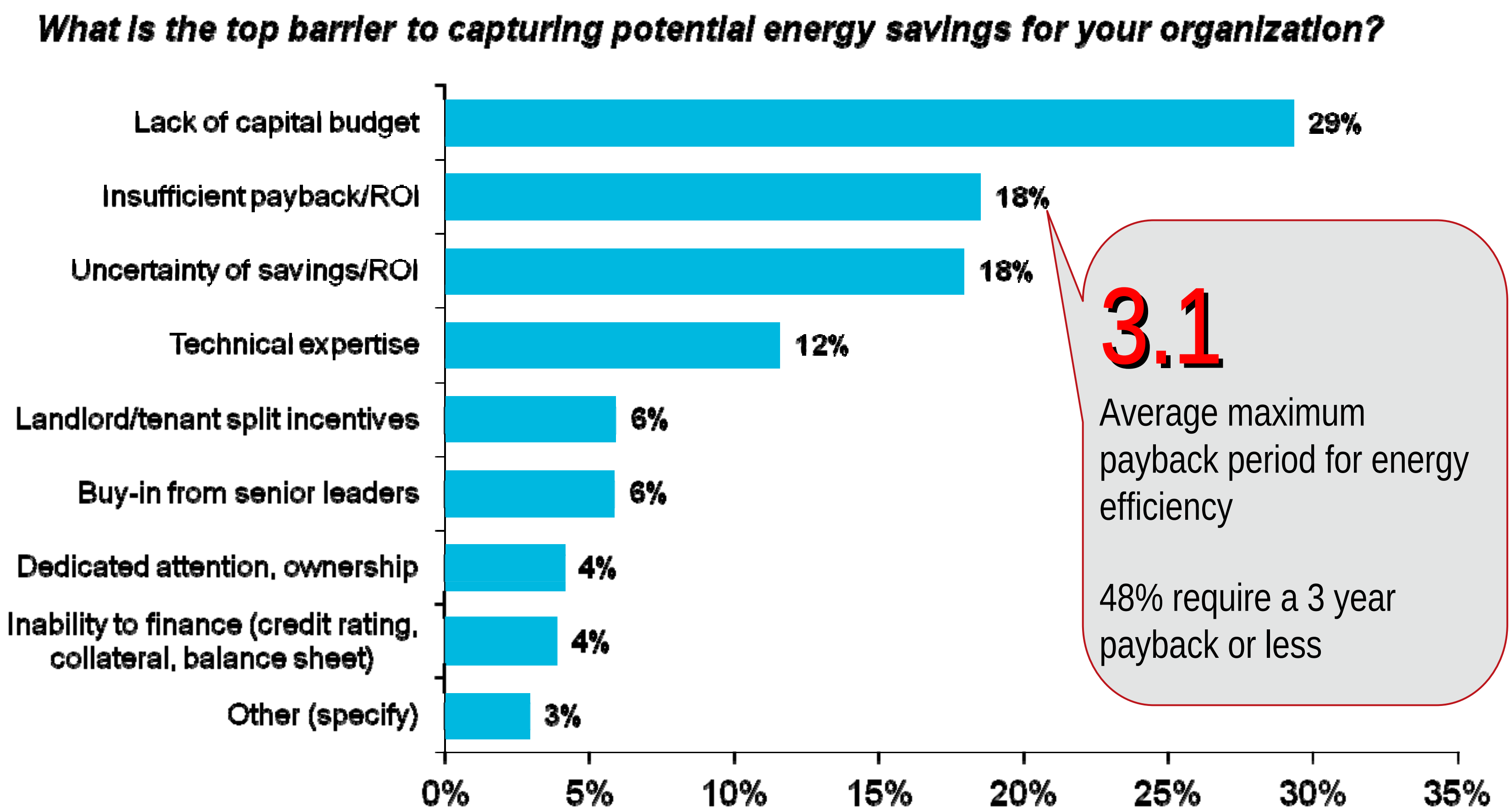
1) Eight interactive levers ranging from base building measures to tenant engagement deliver these results.

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.

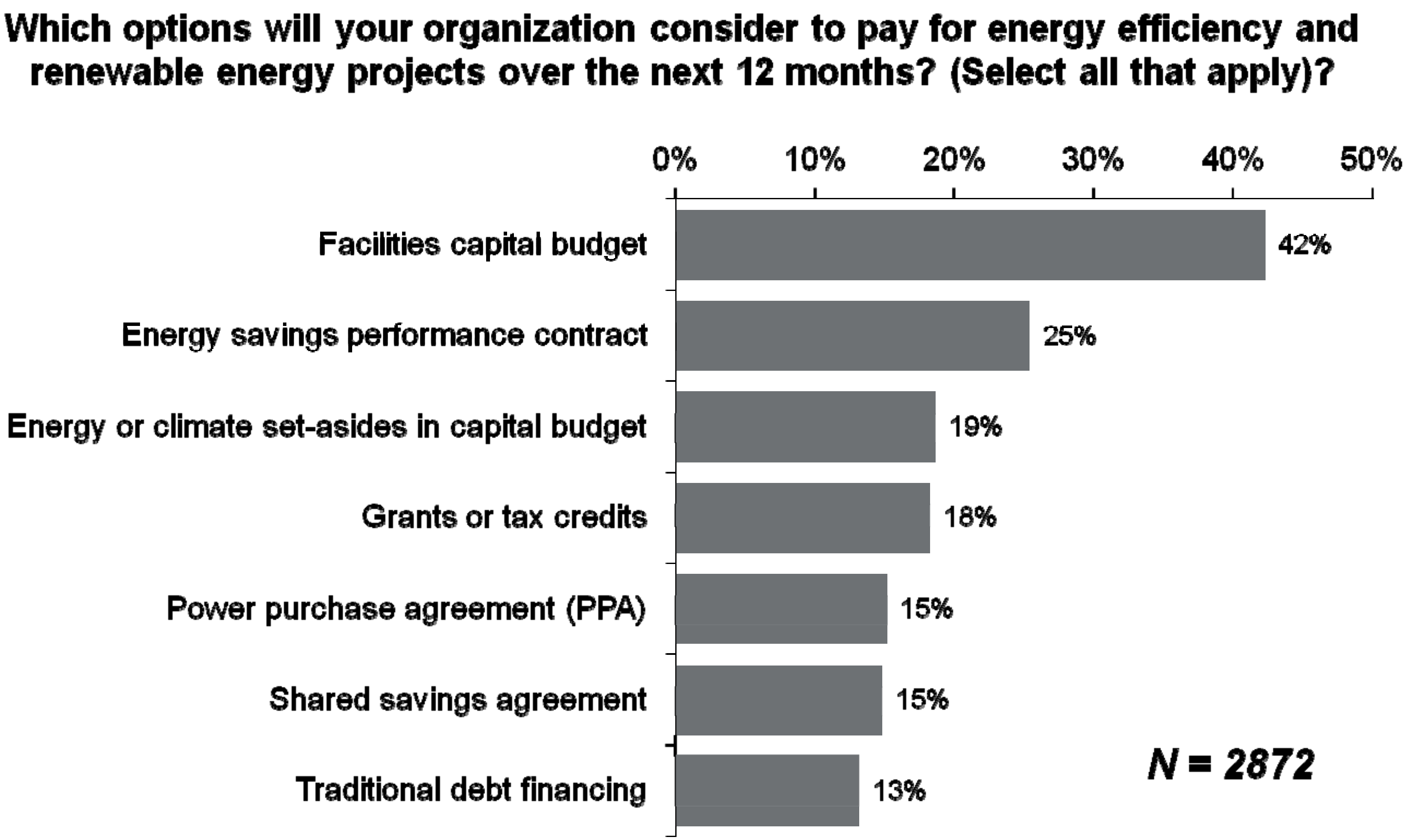
Project Description	*Projected Capital Cost*	*2008 Capital Budget*	*Incremental Cost*	*EstimatedAnnual Energy Savings**
Windows	$4.5m	$455k	$4m	$410k
Radiative Barrier	$2.7m	$0	$2.7m	$190k
DDC Controls	$7.6m	$2m	$5.6m	$741k
Demand Control Vent	Inc. above	$0	Inc. above	$117k
Chiller Plant Retrofit	$5.1m	$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.

Limited internal capital is greatest barrier



Internal capital budgets is primary funding source



VI. INDUSTRY NEEDS

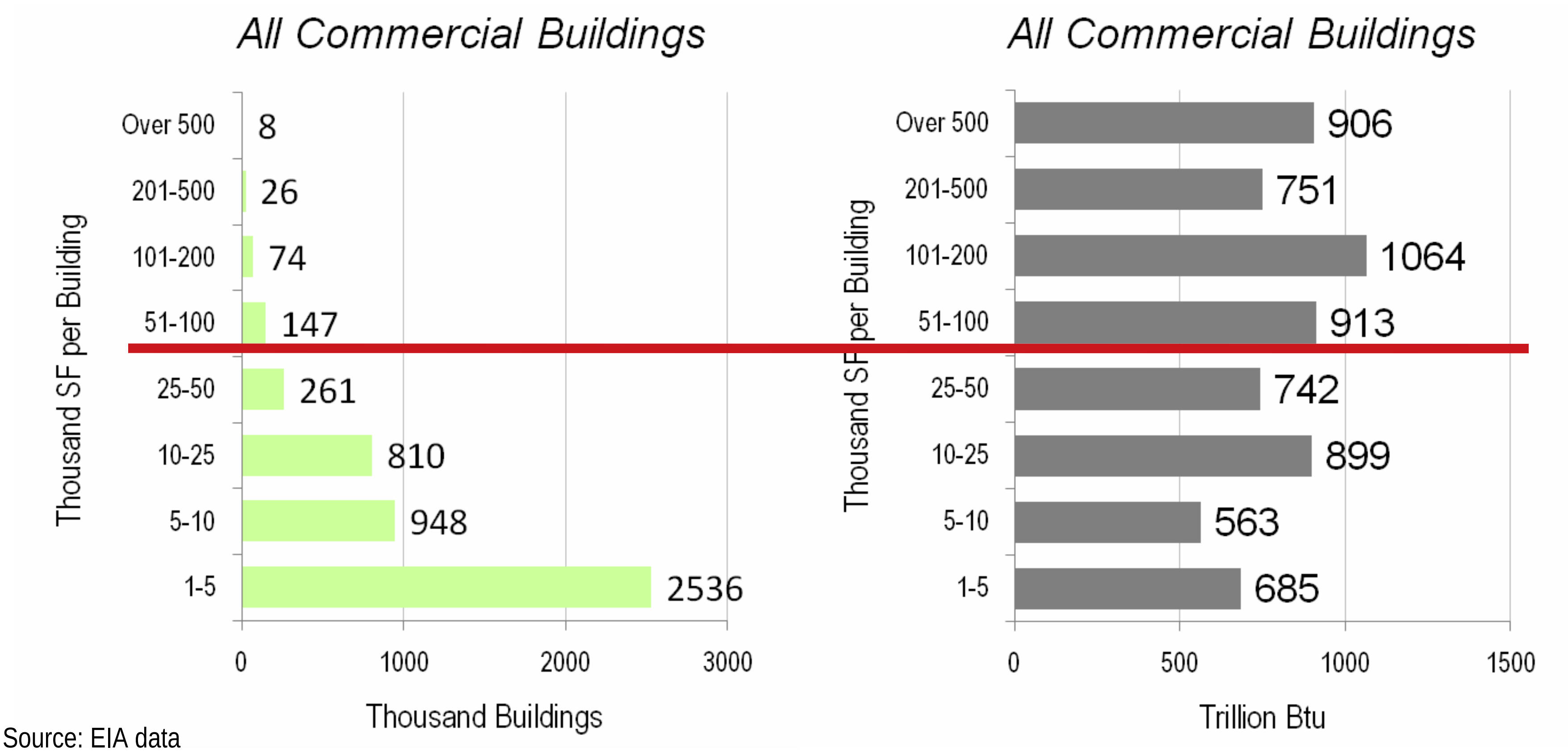
a) Select the right buildings for whole-systems retrofits

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