Prioritizing Energy Efficiency Investments in Corporate Campuses: Opportunities and the Role of Policy

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CIFE Center for Integrated Facility Engineering

Precourt Energy Efficiency Center

- Building energy conservation measures (ECMs) do not achieve their full potential.
- Strategies for choosing ECMs contribute to this problem.
- Policy can help mitigate the issue.

For commercial buildings in the US in 2012:

848 Trillion Btu: Potential for energy saving (**30% savings**)

$72 Billion: Potential for energy efficiency investments.

	Residential	Commercial	Institutional	Total
Economic/Financial Impact				
Energy Savings (Trillion Btu)	1,892	848	293	**3,033**
Total Investment ($ Bn)	182	72	25	**279**
Social Impact				
Cumulative Job Years Created (# FTEs over course of investment program, '000s)	2,152	857	296	**3,305**
Environmental Impact				
Greenhouse Gas Emission Reduction (million metric tons of CO_2 mitigated per year)	382	175	59	**616**

Source: Rockefeller Foundation, 2012. McKinsey, Unlocking Energy Efficiency in the U.S. Economy (2009); Center for American Progress, The Economic Benefits of Investing in Clean Energy (2009); Energy Information Administration Commercial Building Energy Consumption Survey 2003, Residential Energy Consumption Survey 200. Note: Analysis is based on an assumption of 30% energy savings in buildings built before 1980. Category impact information represents an aggregation of the values calculated for the segments associated with that category. TBtu = Trillion Btu.

Actual savings are far lower than the potential.

- Investment in commercial buildings energy efficiency: **$7.7B**
- Energy per square foot reduction achieved: **1.4%**
- On average, retrofit projects under-achieve predicted savings by a factor of more than 2.

ACEEE (2008) 2004 data

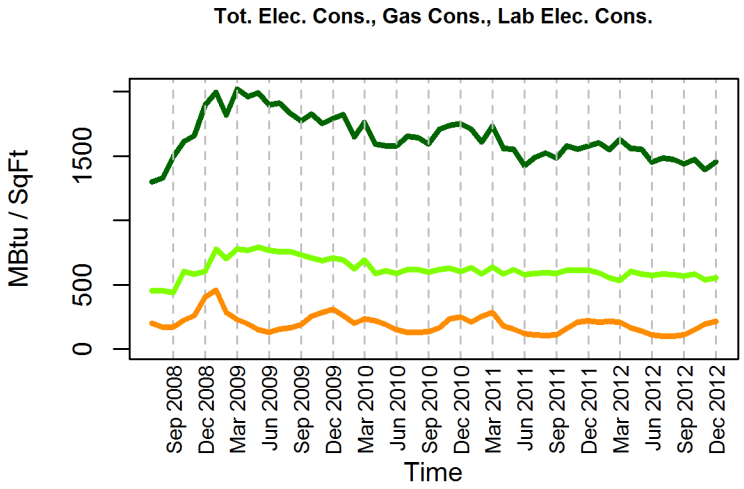
Deutsche Bank & Living Cities (2011); Shapiro (2011)

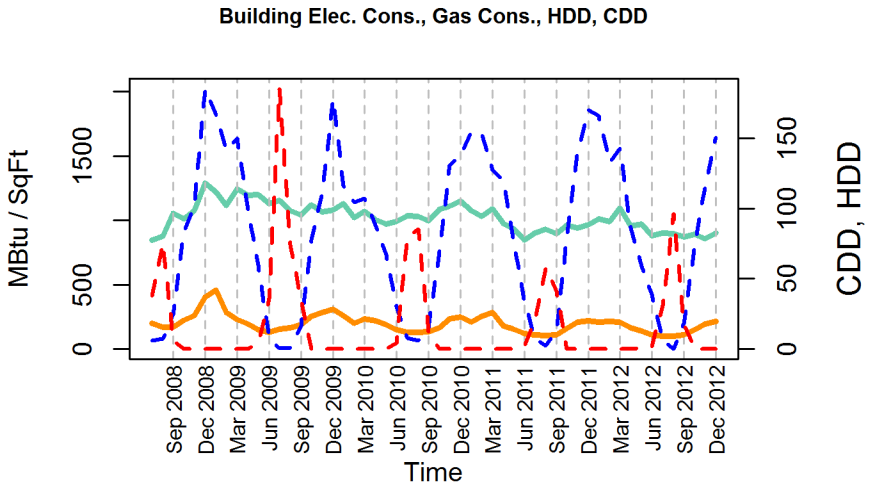
Strategies for choosing ECMs

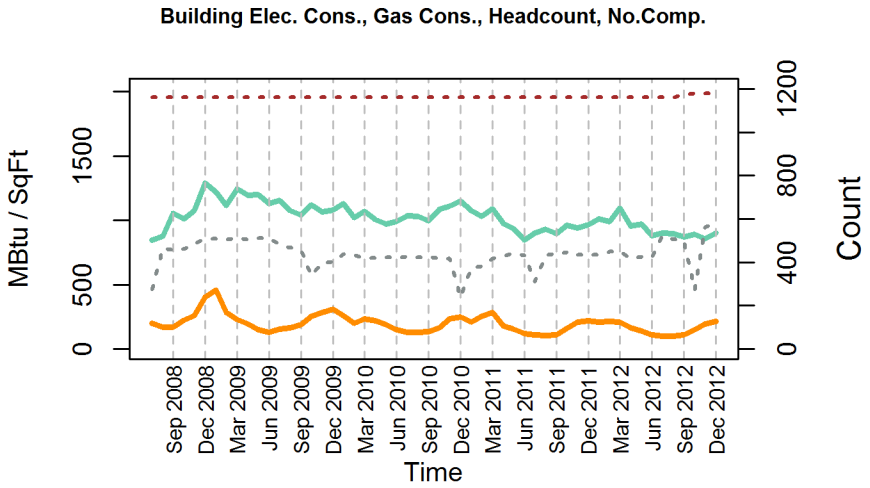
buildings

retrofits

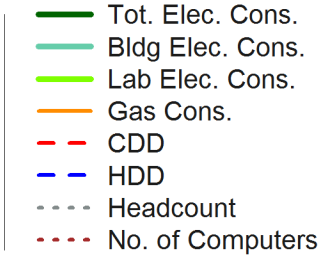
Case study: Strategies for choosing ECMs



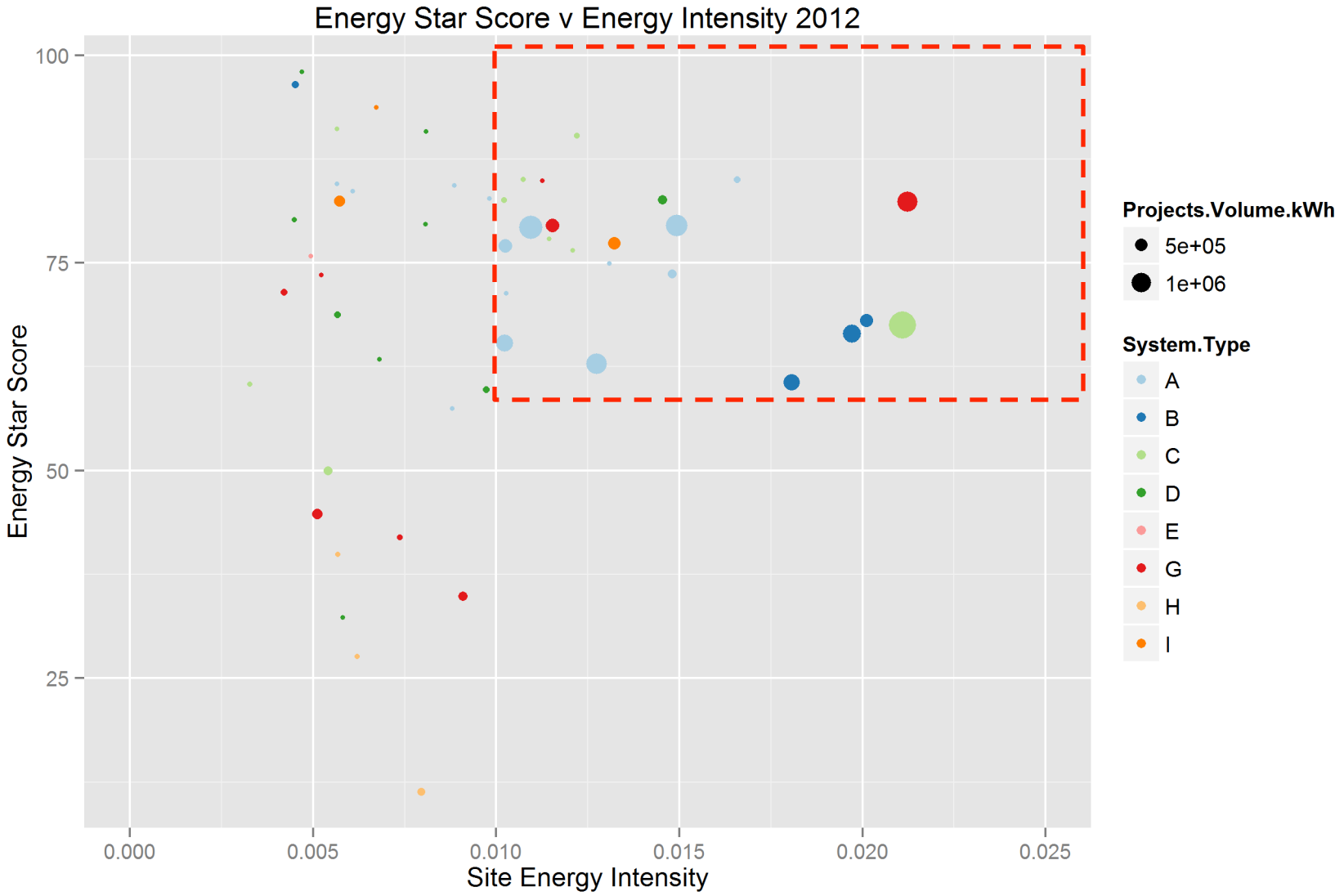




Name: 9
ID: 8
Type: Developer Building
System Type: A
Office Space: 107250.6
Lab Space: 7689
Cafe Space: 15670.7
Warehouse: 0
Tot. Fl. Area: 130610.3



(1/3) Large, energy-intense buildings are disproportionately chosen for retrofit.

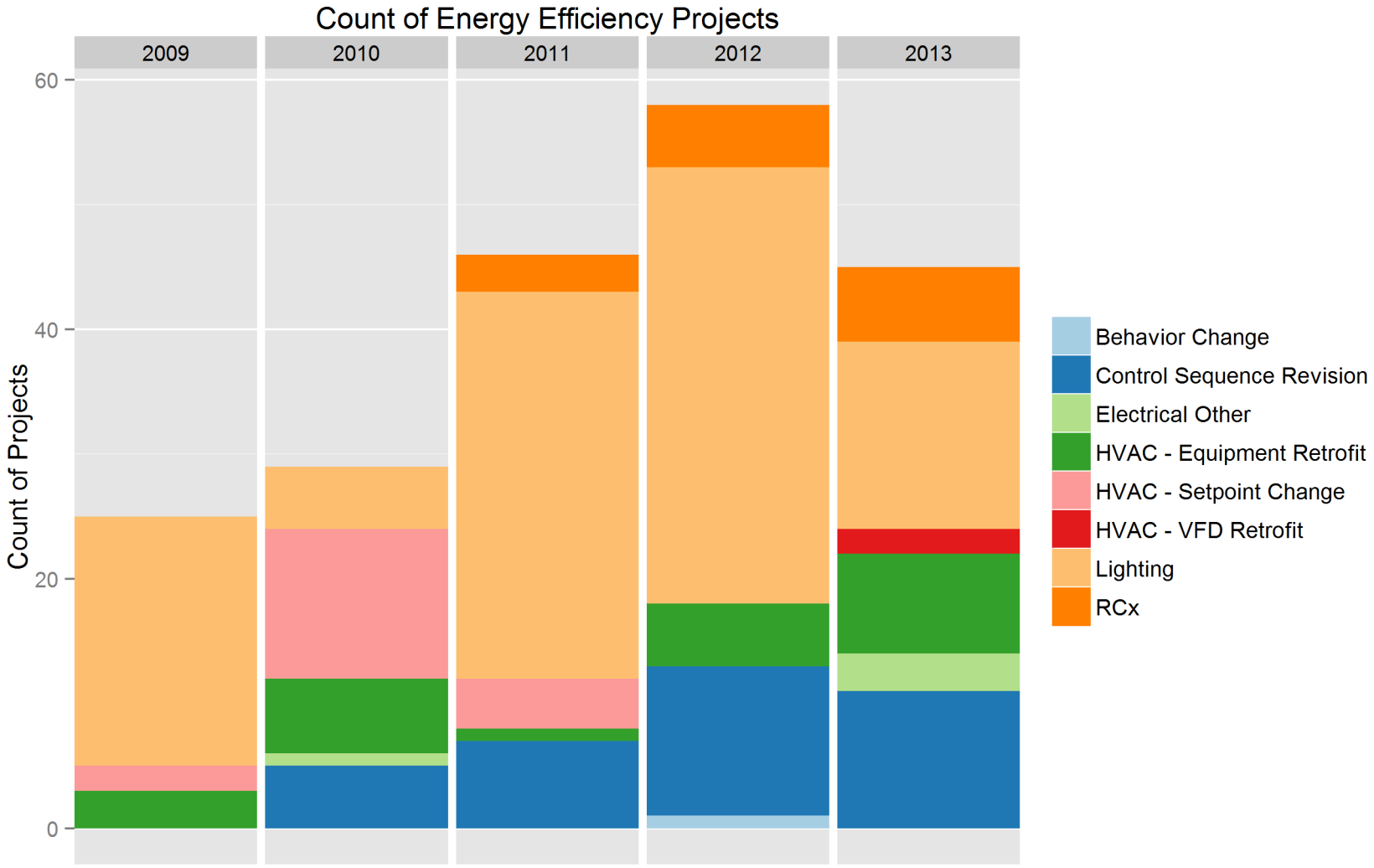


Large, energy-intense buildings are disproportionately chosen for retrofit.

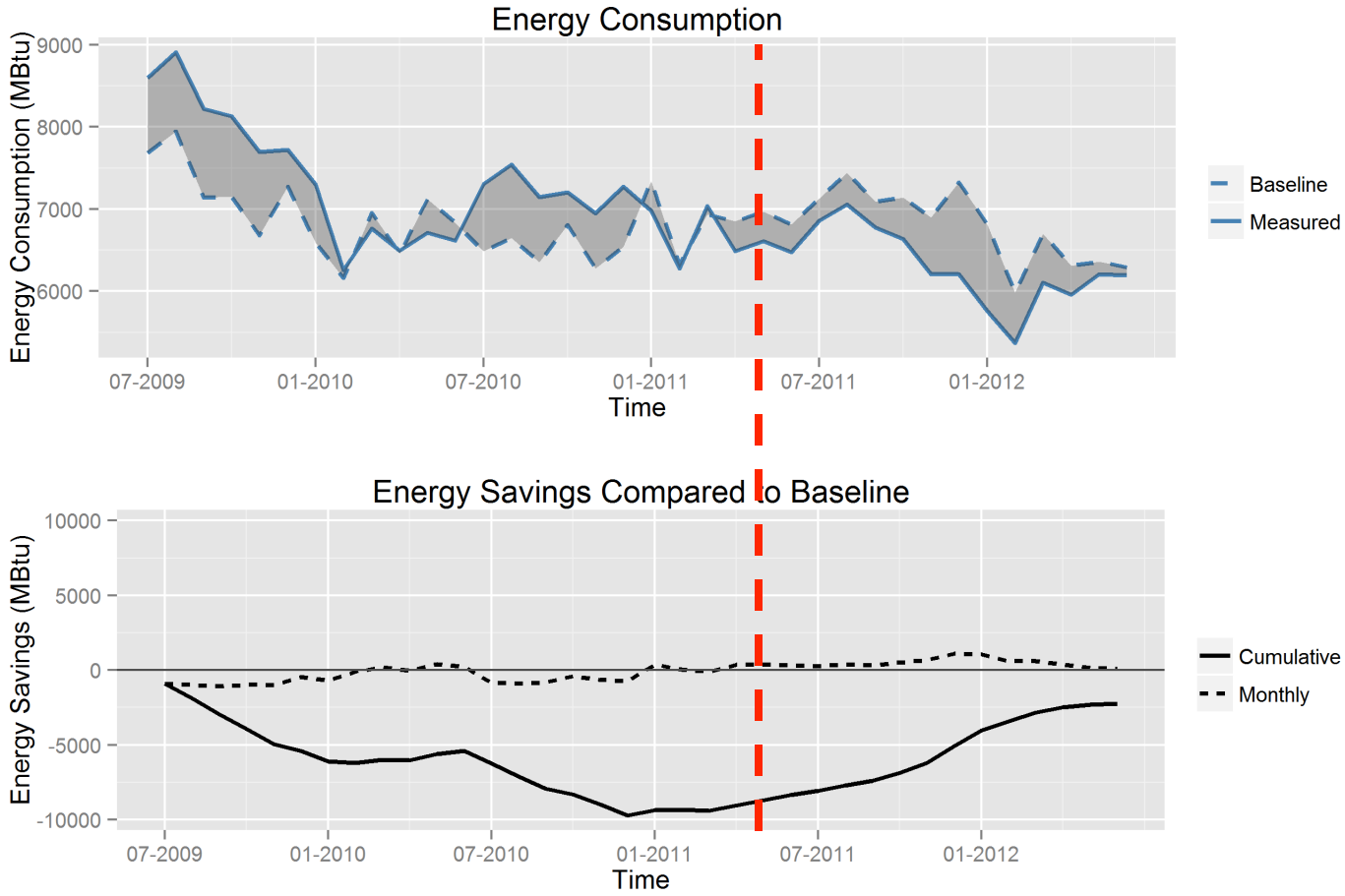
- All else equal, this is a good strategy.
  - When installing a new chiller system that is 20% more efficient, better to start from high-intensity buildings.

- High-potential kWh savings in small & medium buildings are ignored for small-scale retrofits in largest buildings.

(2/3) Majority of projects are focused on Lighting, Control Sequence Revision, and Setpoint Change



(3/3) Passive strategy for retrofits: “if it’s not broken, don’t fix it”.



Barriers to optimal decision making for EE projects

1. Unreliable information on potential savings.

2. Lack of actionable benchmarking metrics.

3. Split incentives (both externally and internally).

(1/3) Energy audits are unreliable and biased.

- 53% over-estimate savings potential.
- 60% did not thoroughly review the building.
- 60% under-estimated installed costs by a factor of 2+.
- 80% did not consider all potential improvements.

- Commercial building audits are focused on HVAC and lighting.
- And widely ignore insulation and infiltration.

Shapiro (2011) based on a study of 300 energy audits

(2/3) Ratings are used for visibility purposes instead of decision support.

"Going after Energy Star is kind of a **public tool**. We've used LEED a couple of times now to basically **demonstrate to people** that we are serious and we're taking into account sustainable design elements. “

Commercial Real Estate Executive

(3/3) Split incentives (external)

- Tenant v. owner

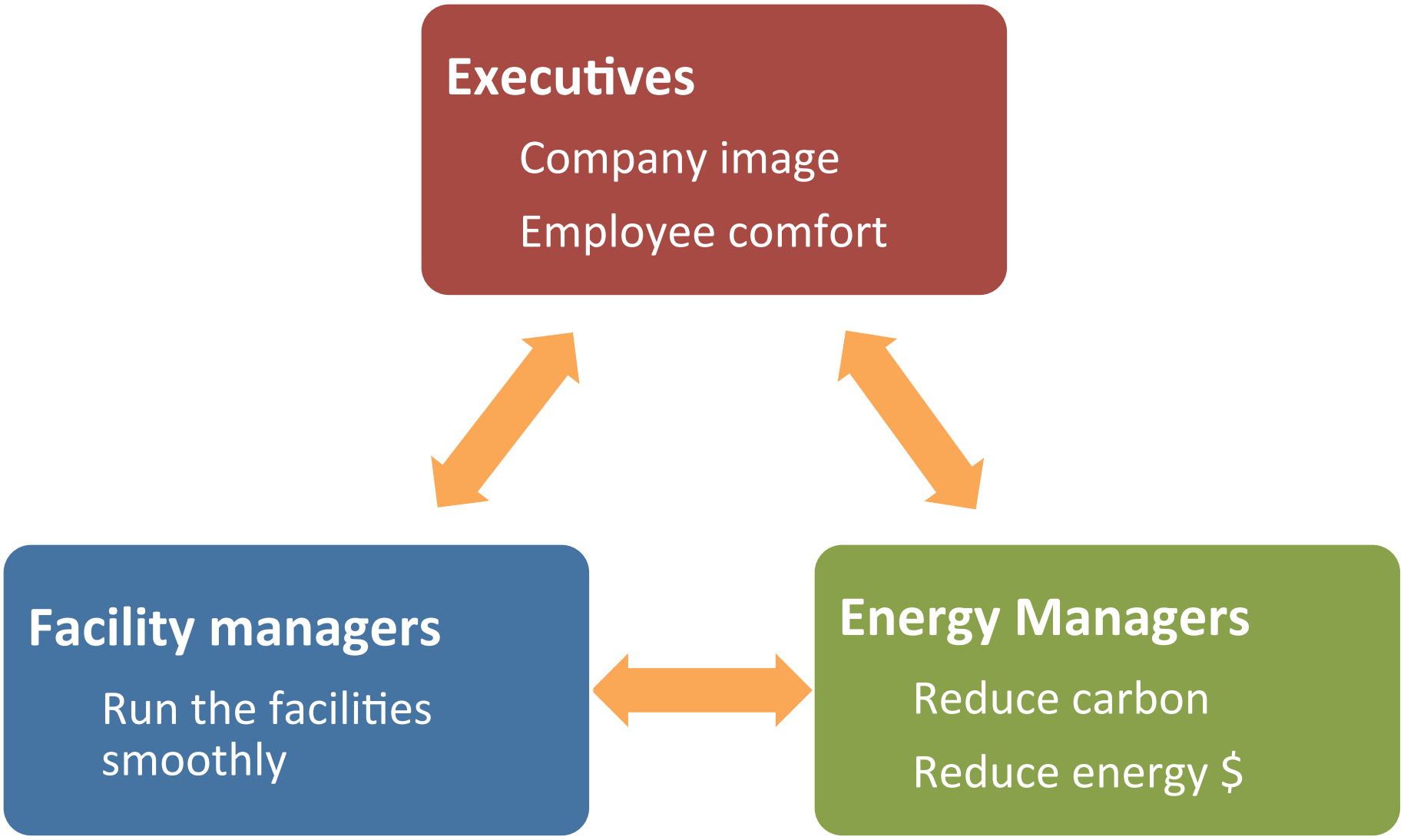
- Lack of a verified business case

"We can't get the company to pull the trigger on putting in LED parking lot lights because they're **not sure […] how our customers are going to feel** about those types of parking lights.“

- Retail Executive

Peterman et al. (2012)

(3/3) Split incentives (internal)



Policy role

- Technical guidance
  - DOE Buildings Performance Database
- Codes & standards
  - ASHRAE's *Procedures for Commercial Building Energy Audits*
- Align incentives
  - Codes, standards, and mandates to bring fundamental ECMs into day-to-day decision making across all organizational levels (NYC, SF mandates for RCx and audit).
  - Building performance transparency to bring efficiency to senior management's attention.

Aligning incentives across all levels of organizations

"We are now investing in energy efficiency because our customers and shareholders want it."

Commercial bank executive

Peer groups and network effect

“I can’t wait for your analysis to be done so we can sit down and you guys tell me how we are doing compared to […].”

Photo: Google/Connie Zhou

Huge potential for energy efficiency – largely untapped

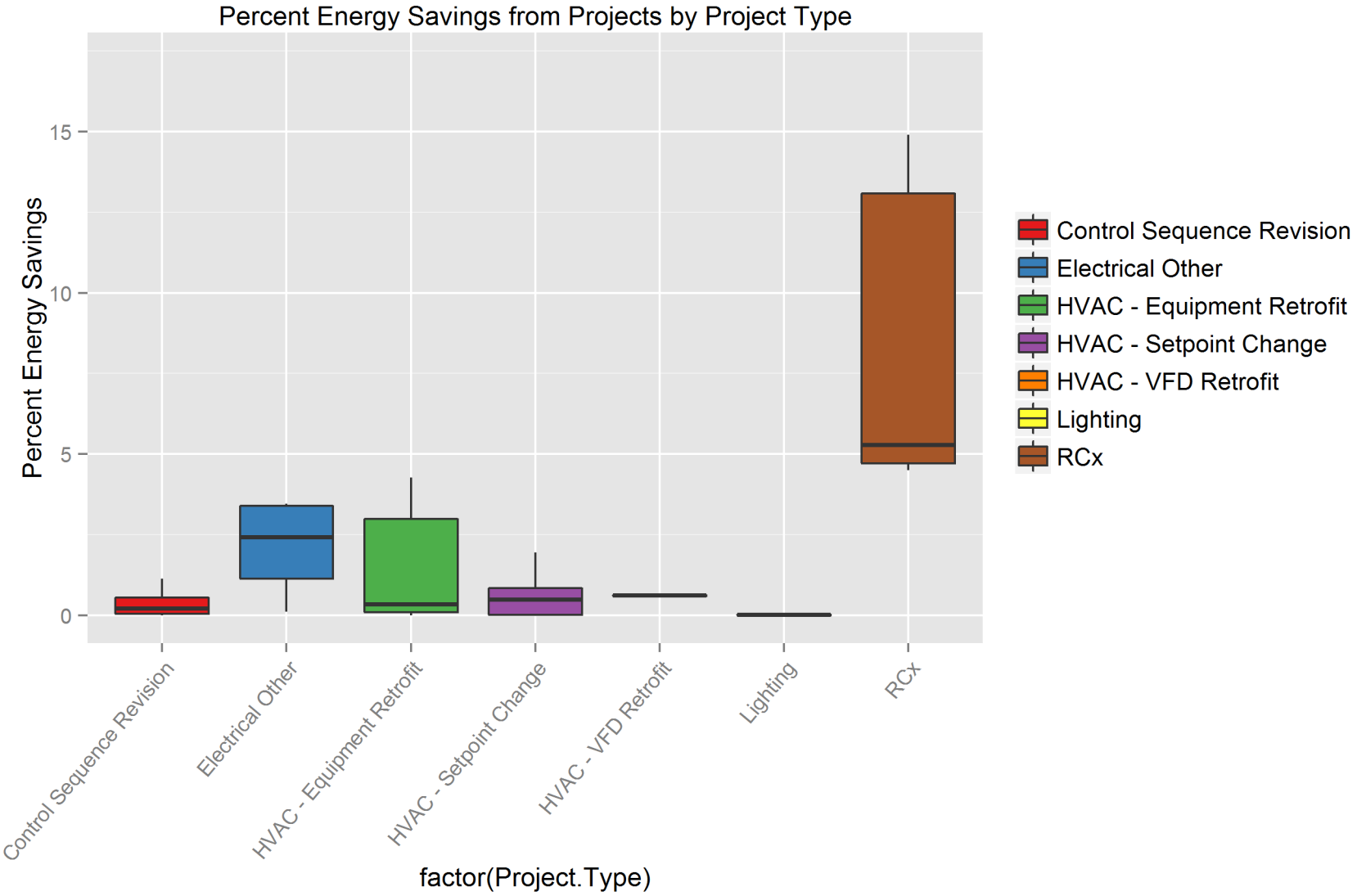
- With existing technologies, it is economically possible to reduce commercial buildings energy consumption by **30%**

- With emerging technologies, by 2020, it will be economically possible to reduce commercial buildings energy consumption by **80%**

Case study

- Interviewing energy managers and facility managers
- Strategies for energy conservation measures

RCx, HVAC Equipment Retrofit, and Electrical Retorfits show the highest savings potential

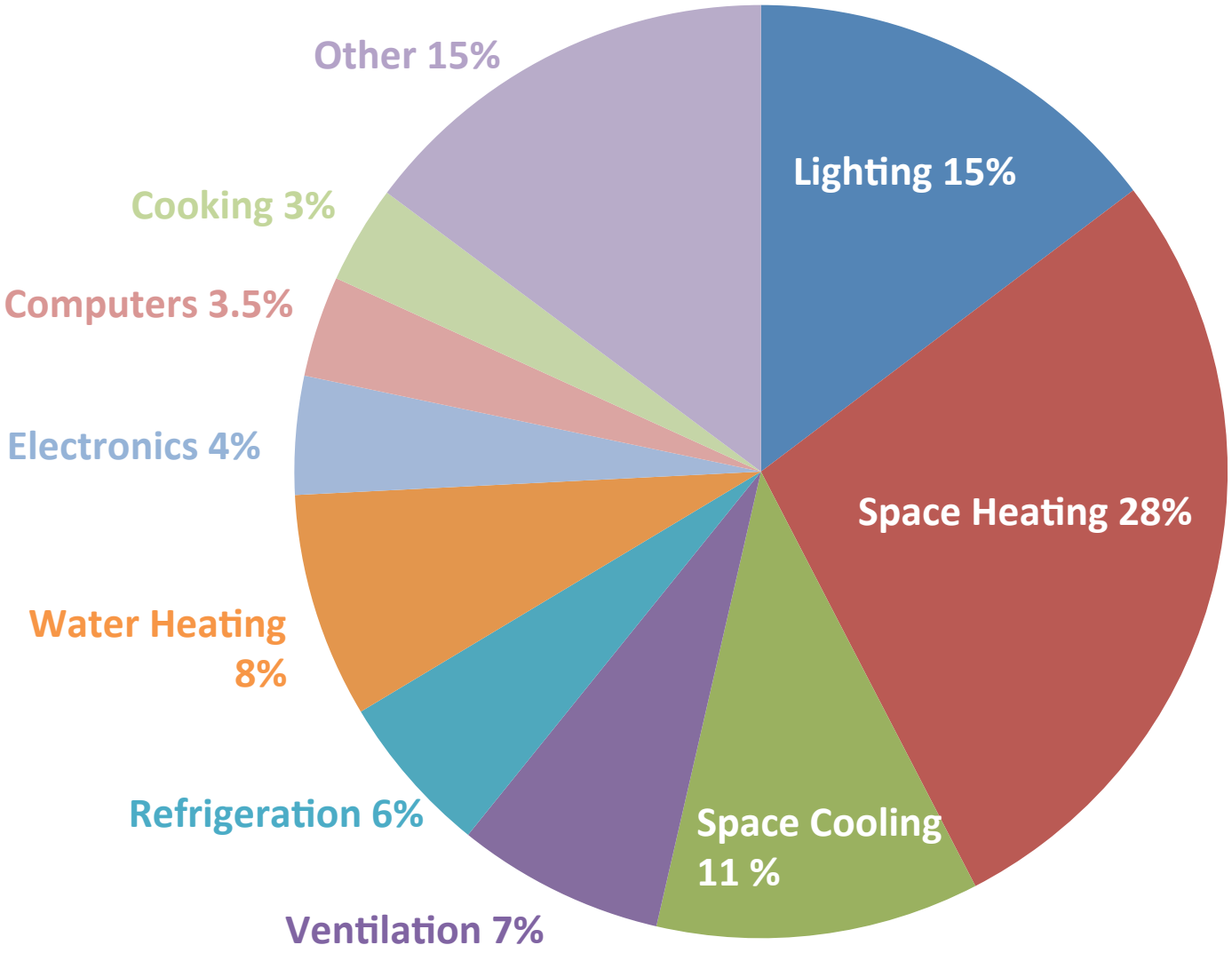


Energy mangers …

- Energy intensity (kWh / sqft) and ROI are useful, but should not be the only metrics to select projects.
  - Total kWh savings from **all** buildings.
  - Include non-energy savings.

- Invest savings from shorter payback projects into a capital planning budget to finance additional improvement projects.

- RCx has great potential but is under-utilized
  - Time and resource intensive if done manually.
  - Utilize continuous commissioning systems and fault detection systems.


Other 15%
Lighting 15%
Cooking 3%
Computers 3.5%
Electronics 4%
Space Heating 28%
Water Heating 8%
Refrigeration 6%
Space Cooling 11 %
Ventilation 7%

Significant amount of energy is lost every year due to factors controllable by better energy management

- **400%** variation in energy use intensity of commercial buildings that is not explained by age, technology, hours, size, climate.

- **$193.9 billion** of annual energy costs in the U.S. are lost as a result.

EPA (2012)

Many EE programs underachieve

- Ex ante models predictions for energy savings:

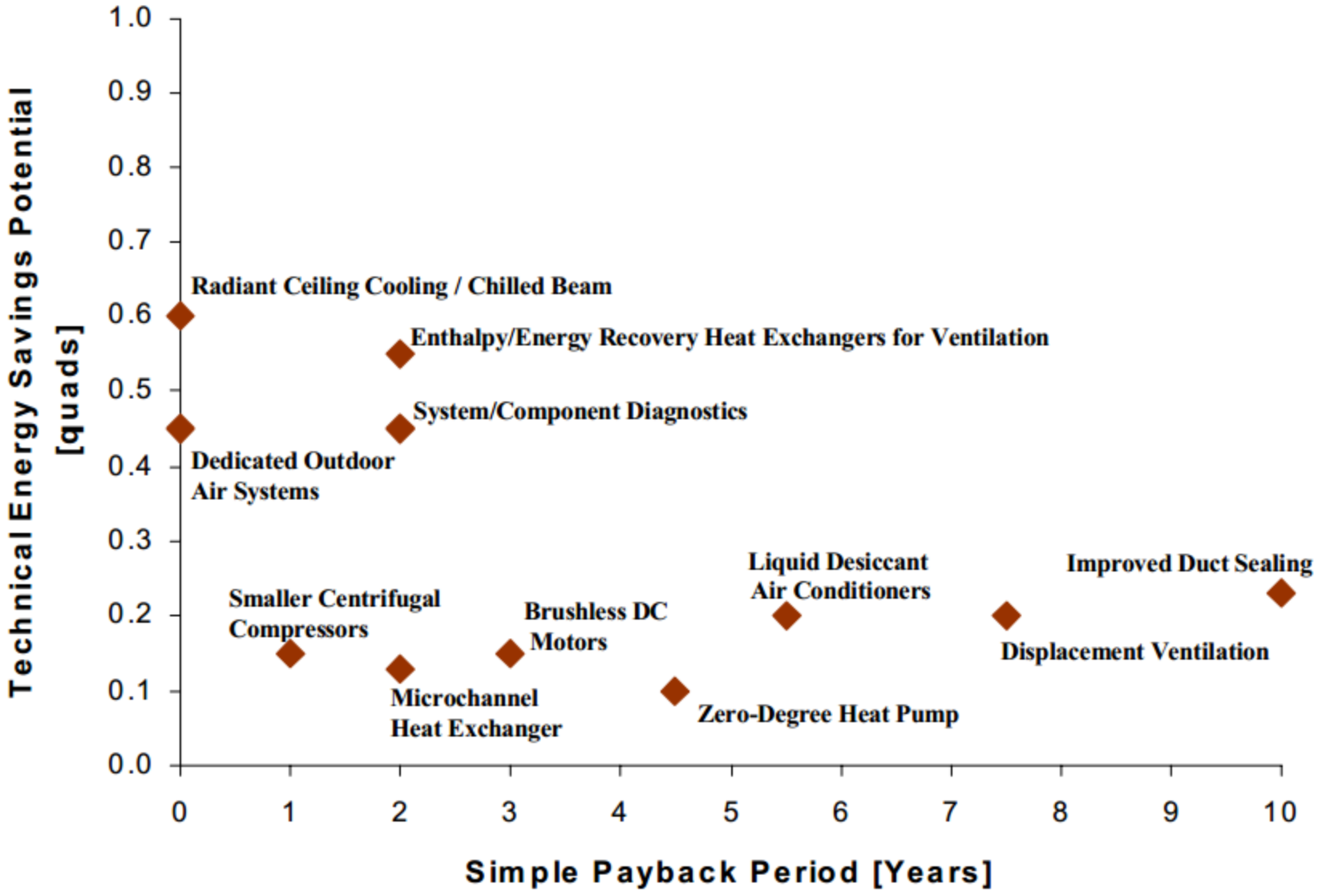
  25% to 50%

- Ex post analyses verified savings:

  10% to 40%*

Deutsche Bank & Living Cities (2011); Shapiro (2011)

Other retrofits suggest even more savings

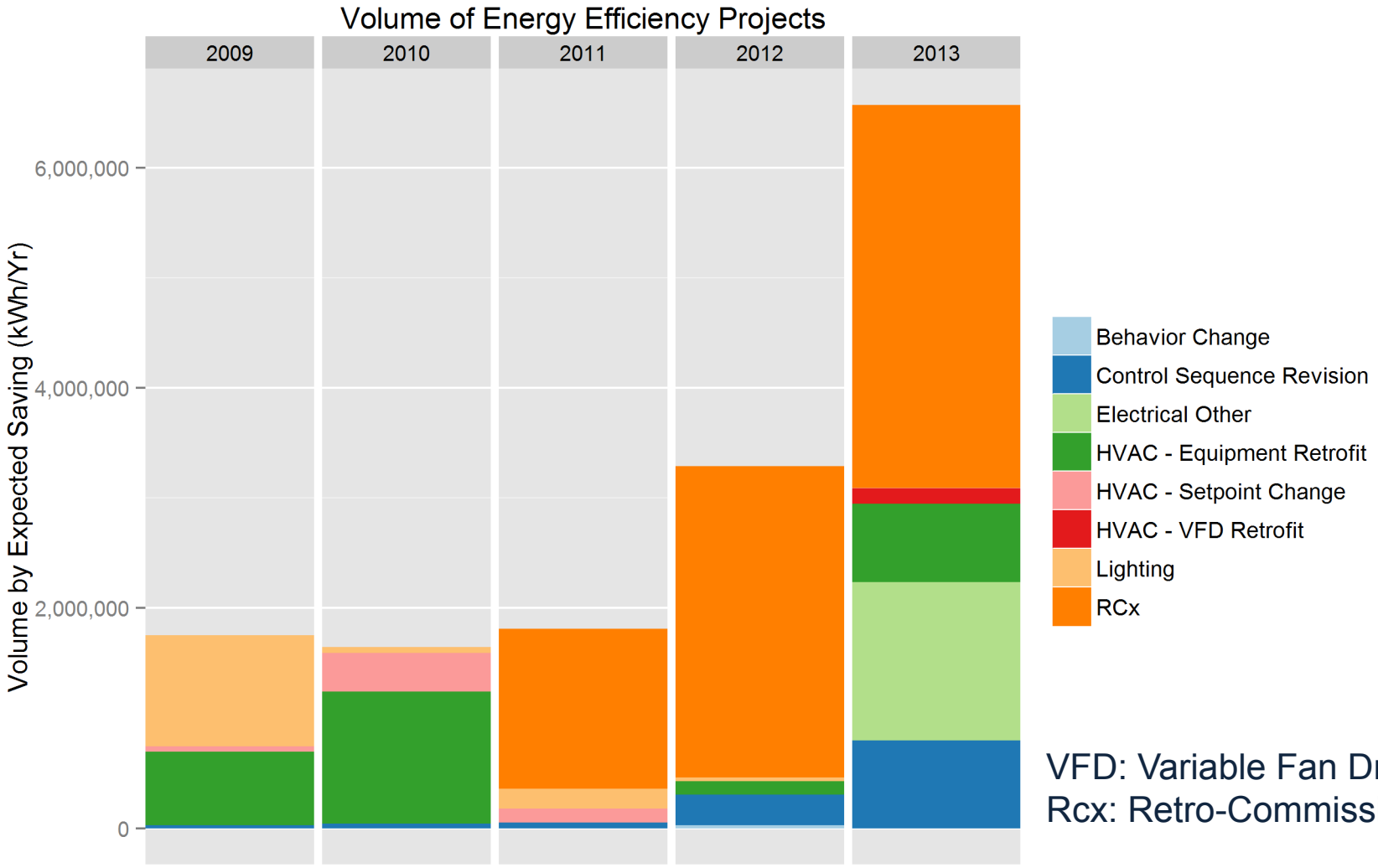


Westphalen & Koszalinksky (2001)

Why EE projects under-achieve?

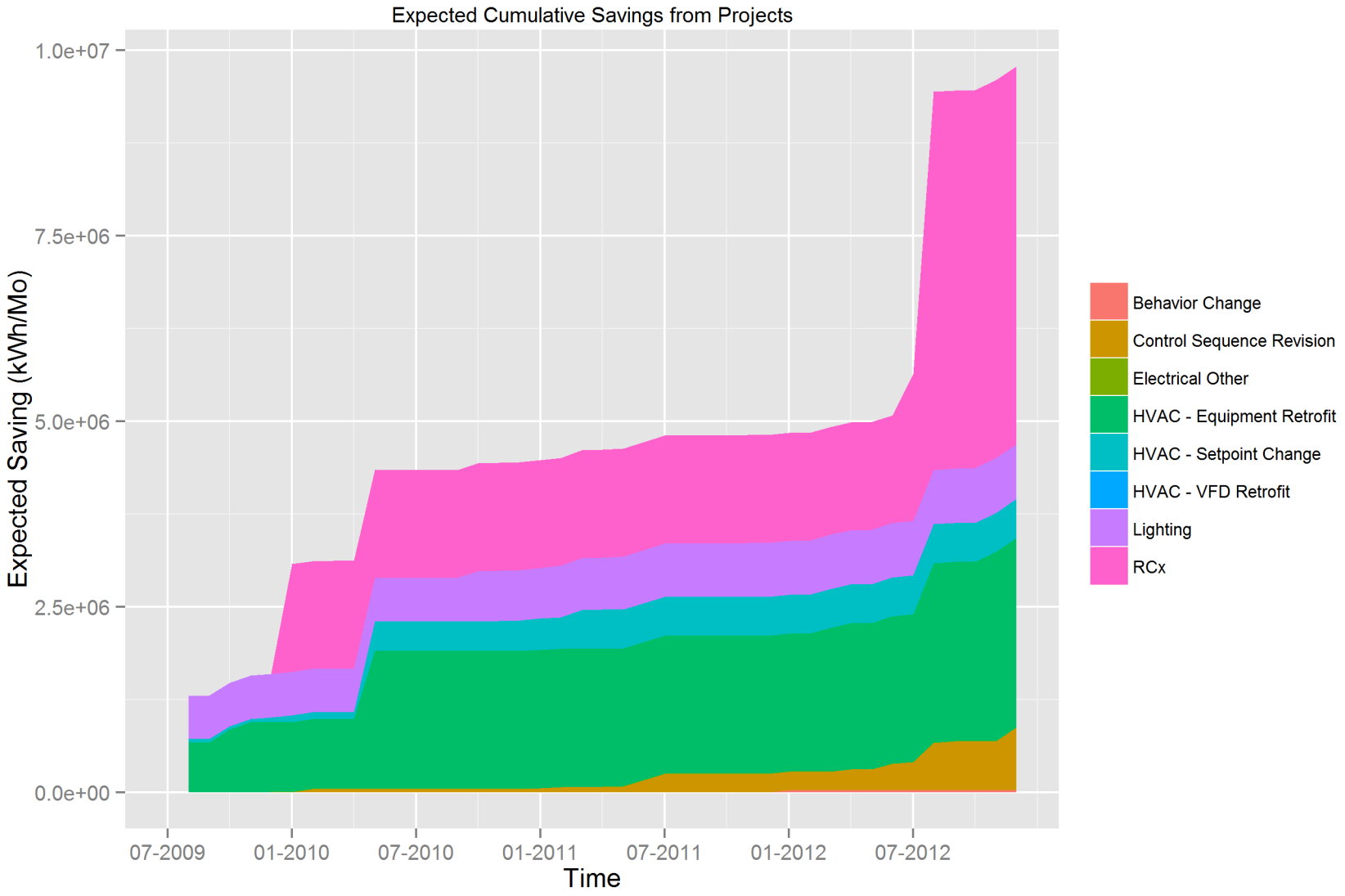
- Design
- Implementation
- Inaccurate estimation of savings potential
- Sub-optimal choice of energy efficiency projects
  - Choice of buildings
  - Choice of projects

Majority of projects are focused on HVAC Equipment Retrofit, Lighting, and RCx.

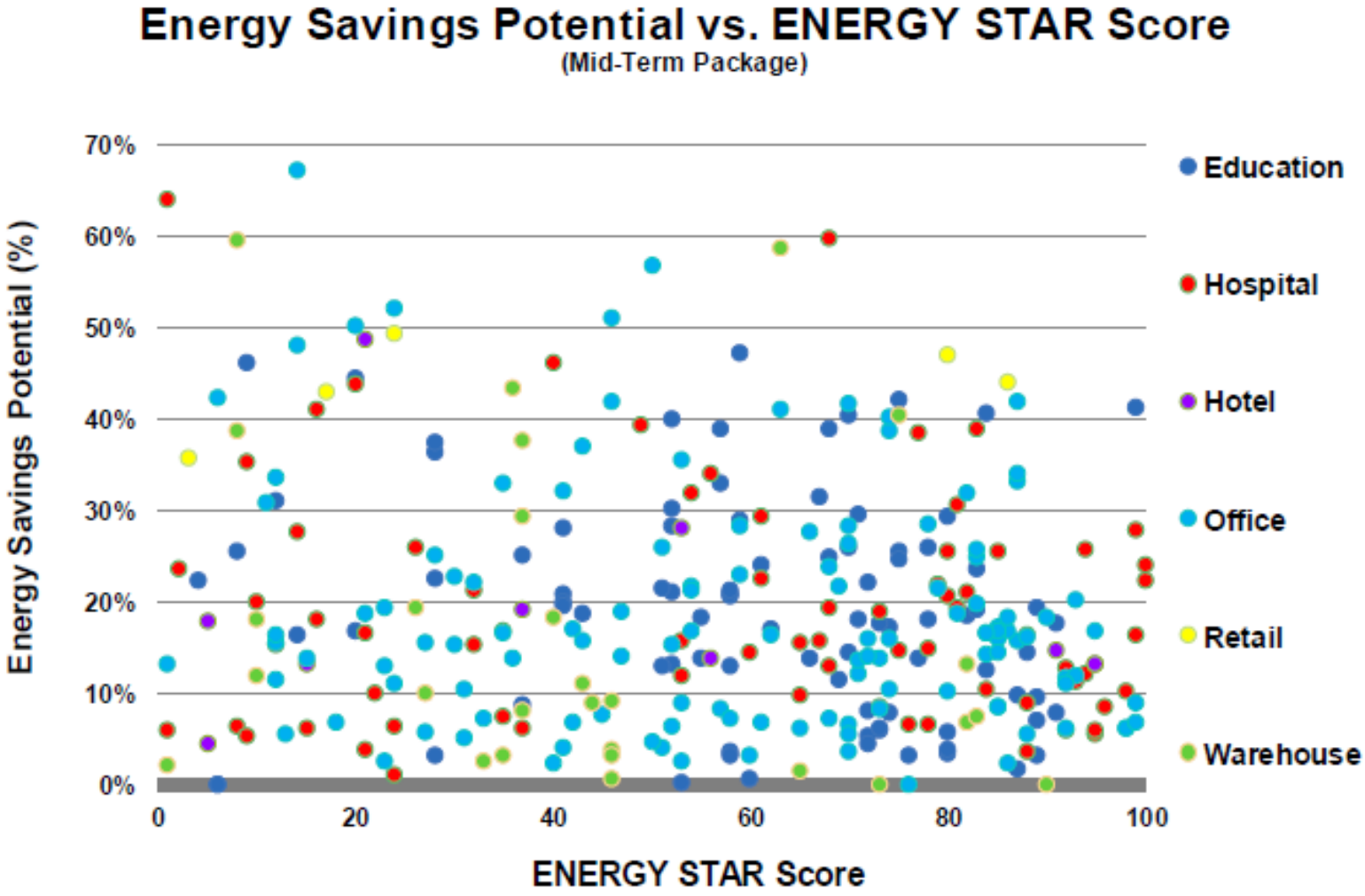


VFD: Variable Fan Drive
Rcx: Retro-Commissioning

Cumulative expected savings from ECMs

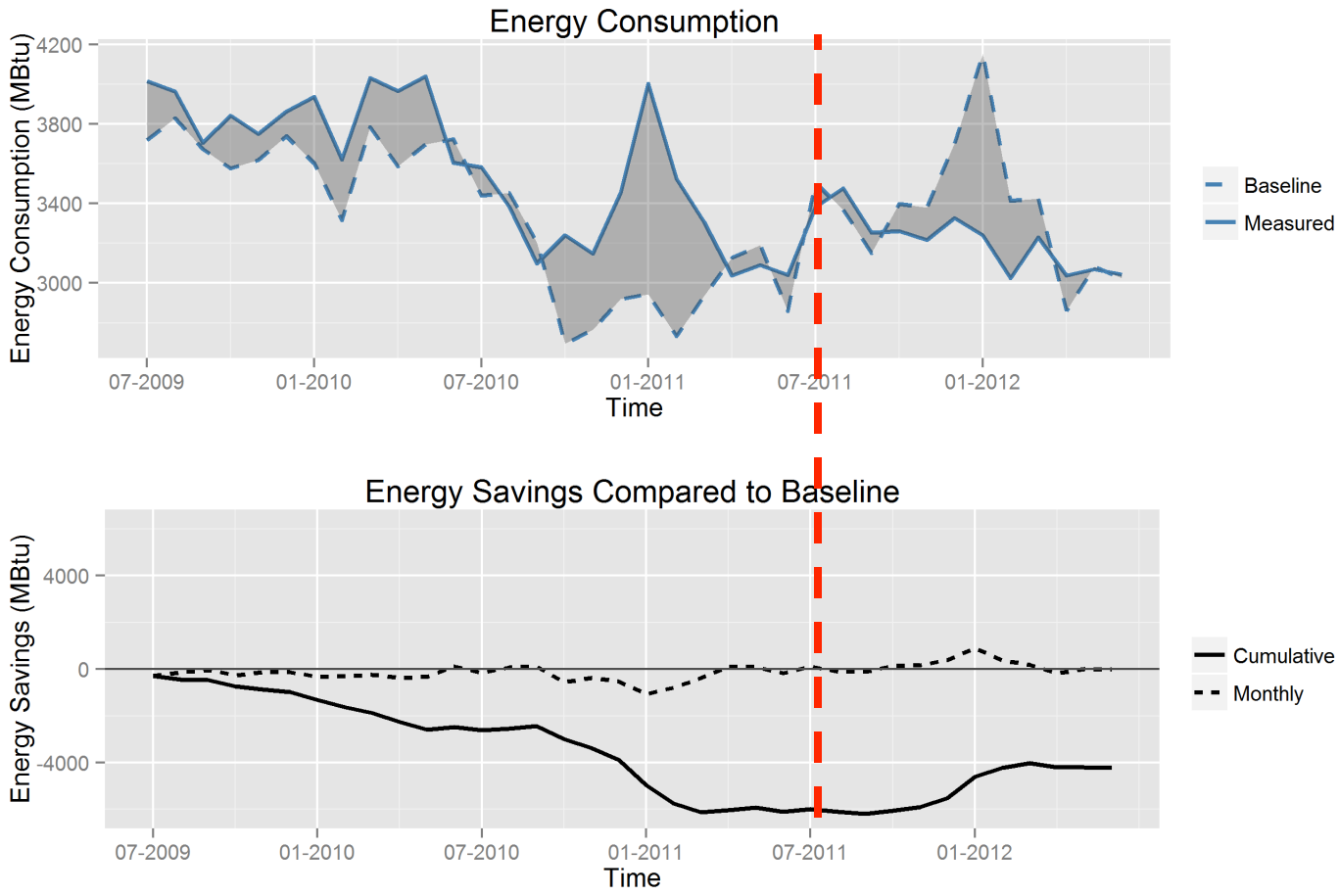


Energy Star score does not correlate with energy savings potential.



Source: Retroficiency's virtual audit of 500 commercial buildings in the US (2013)

Passive strategy for retrofits: “if it’s not broken, don’t fix it”.



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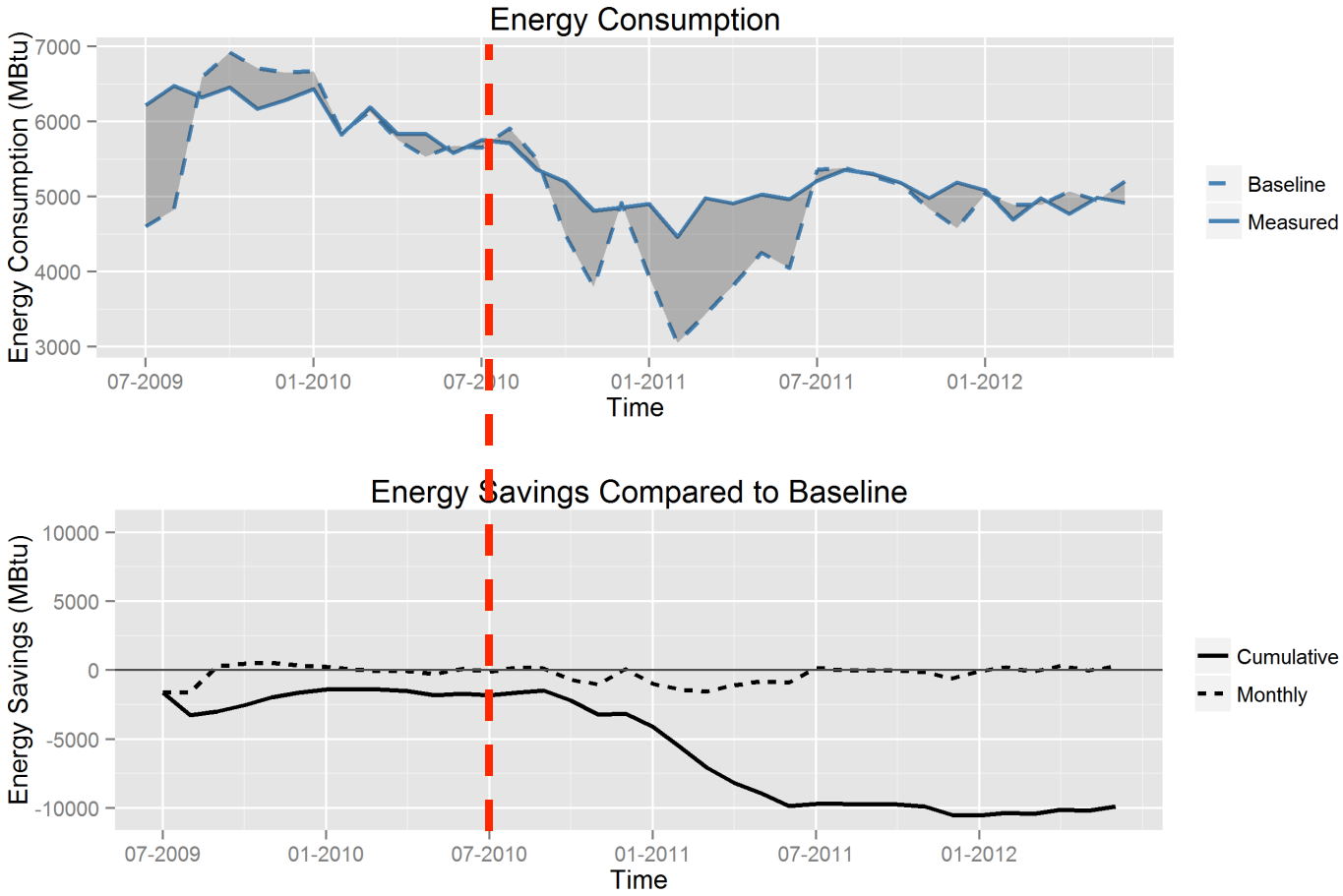

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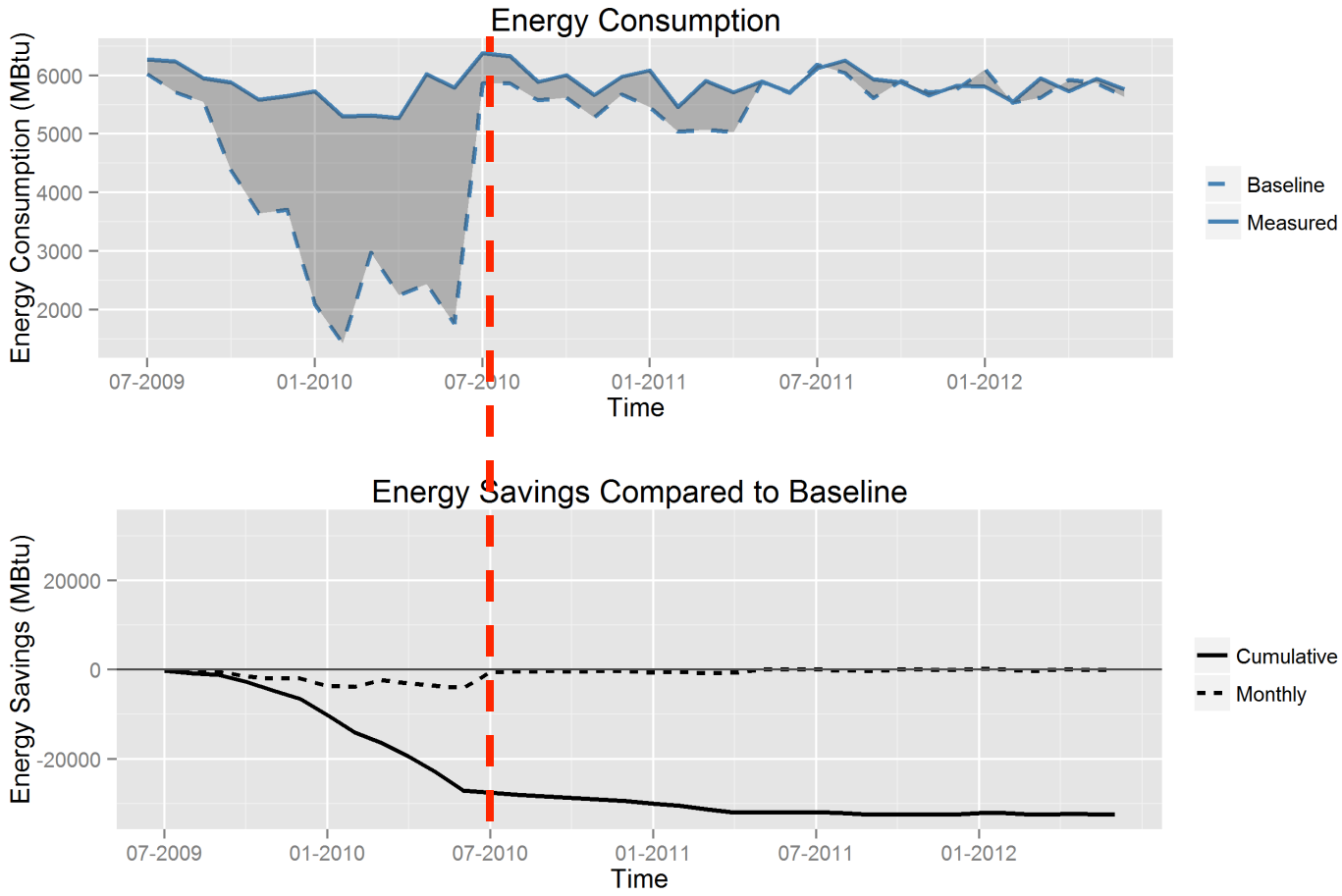
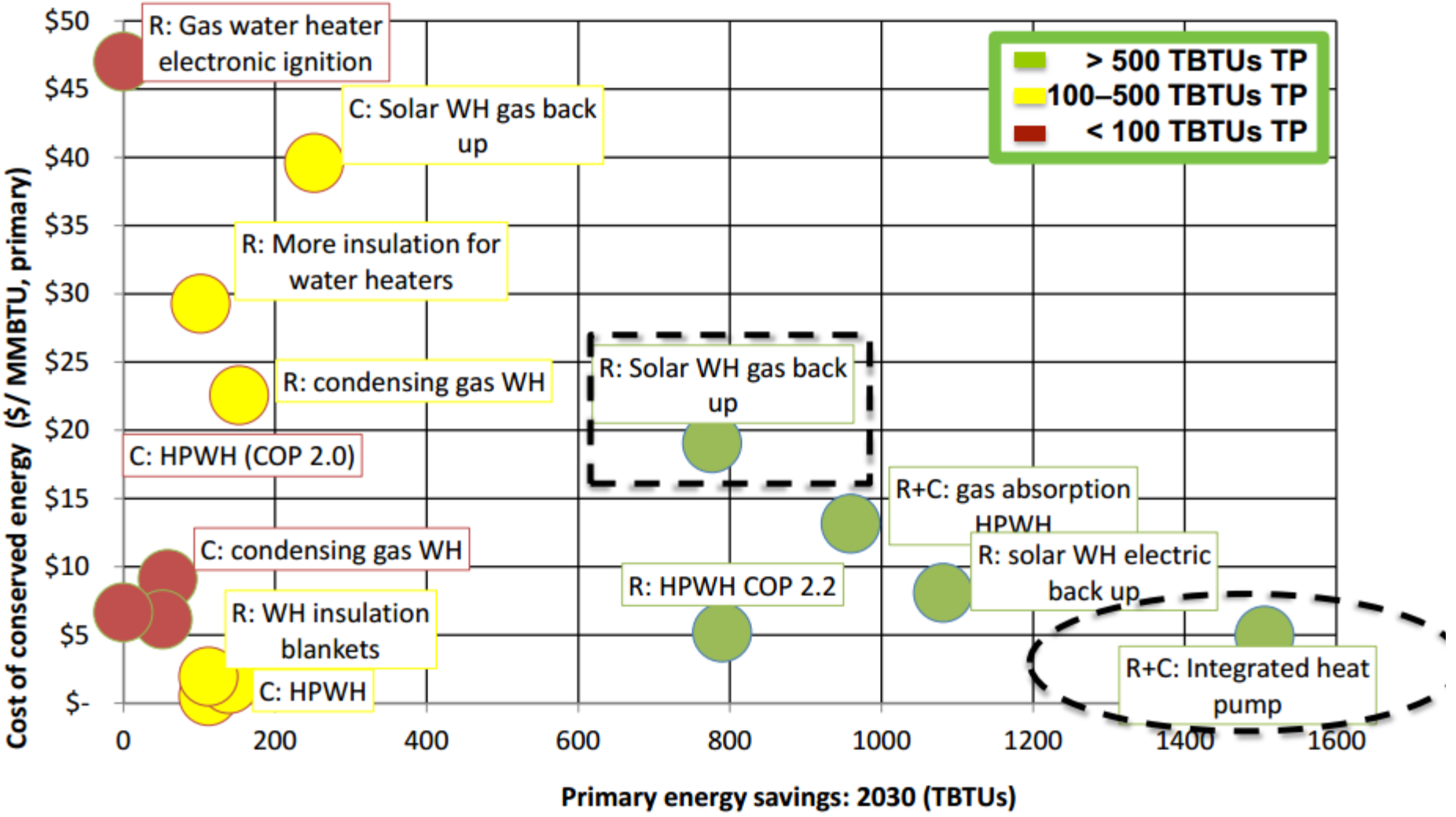
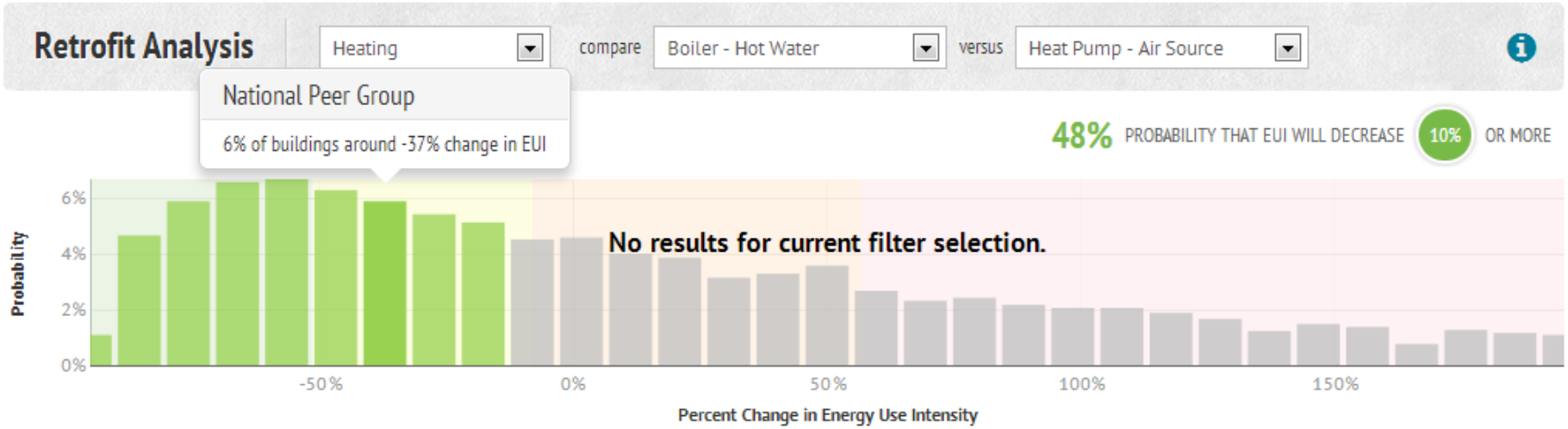


Prioritization tool for energy efficiency investment



DOE Buildings Performance Database



Improve the standards for energy audits

- ASHRAE's *Procedures for Commercial Building Energy Audits*.
- Federal, state, and utility-specific requirements for audits are uneven and partially cover the building stock.
- Better standards, templates, and training are needed.

Aligning organizational incentives (externally and internally)

Commercial Buildings Codes:

- ■■■■ Most efficient: Meets or exceeds American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 – 2007 or equivalent
- ■■■ Meets or exceeds ASHRAE Standard 90.1–2004 or equivalent
- ■■ Meets or exceeds ASHRAE Standard 90.1 – 1999
- ■ No statewide code or precedes ASHRAE Standard 90.1-1999
- ▲ State has adopted a new code to be effective at a later date

Residential Building Codes:

- ✦✦✦✦ More efficient: Meets or exceeds 2009 IECC or equivalent
- ✦✦✦ Meets or exceeds 2006 IECC or equivalent
- ✦✦ Meets or exceeds 1998–2003 IECC or equivalent
- ✦ Least efficient: no statewide code or precedes 1998 IECC

As of July 20, 2010.
Numbers in the table indicate the number of policies in each category.
* Combined EERS/RES
Sources: DSIRE, OCEAN, ACEEE

		Incentives								Rules & Regulations						
		Personal Tax Incentives	Corporate Tax Incentives	Sales Tax Incentives	Property Tax Incentives	Rebates	Grants	Loans	Bonds	Green Building	Appliance/Equipment Standards	Energy Standards Public Buildings	Commercial Building Codes	Residential Building Codes	Public Benefits Funds	Energy Efficient Resource Standard (EERS)	Number of Policies
Alaska & Hawaii	Alaska					2		4					■	✦✦✦			6
	Hawaii					3		1		1		1	■■■	✦✦✦	1	X	7
California	California					1	1	1			1	1	■■■■	✦✦✦✦	1	X	6
Heartland & Texas	Kansas							1					■	✦			1
	Oklahoma	1	1					4				1	■■	✦✦			7
	Texas			1				2				2	■■▲	✦✦▲		X	5
Southeast & Florida	Alabama							1				1	■	✦			2
	Arkansas	1				1		1				1	■■	✦✦			4
	Florida							1				1	■■■■	✦✦✦		X	2
	Georgia		1			1		1				1	■■■	✦✦✦			4
	Kentucky	1	1	1		1		1				2	■■■	✦✦✦			7
	Louisiana					1		2				1	■■■	✦✦✦			4
	Mississippi							1					■	✦			1
	Missouri	1		1		1		2				1	■	✦		X*	6
	North Carolina			1		2	1	3		1		1	■■■	✦✦✦			9
	South Carolina	1		1				1				1	■■■	✦✦✦			4
	Tennessee						1	3				1	■	✦✦			5

Commercial Buildings Codes:

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West	Arizona				1	1					1	2	■	✦		X	5
	Colorado					1	1	1				1	■	✦		X	4
	Idaho	1				1		1				1	■■■	✦✦✦			4
	Montana	1	1			1		1	1			1	■■■■	✦✦✦✦	1		7
	Nevada				1	1		1			1	1	■■■	✦✦✦		X*	5
	New Mexico	1	1			1			1			1	■■■	✦✦✦	1	X	6
	Oregon	1	1			9		3			1	1	■■■■	✦✦✦	1		17
	Utah					1		2				1	■■■	✦✦✦			4
	Washington					1	1			1	1	1	■■■▲	✦✦✦▲		X	5
	Wyoming					1	1	1					■	✦	1		4
Midwest	Iowa							1				1	■■■■	✦✦✦✦		X	2
	Michigan	1				2	1					1	■■	✦✦✦	1	X	6
	Minnesota						1	6				1	■■■	✦✦✦		X	8
	Nebraska							1					■■	✦✦			1
	North Dakota					1	1						■	✦			2
	South Dakota											1	■	✦			1
	Wisconsin					7		2				1	■■■	✦✦✦			10

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Mid-Atlantic	Delaware					4	2					1	■■	✦✦	1	X	8
	DC					1		1			1	2	■■■■	✦✦✦✦	1		6
	Illinois					2	3	2	2			1	■■■■	✦✦✦✦	1	X	11
	Indiana	1	1									1	■■■■	✦		X	3
	Maryland	1	1		2	2		5			1	1	■■■■	✦✦✦✦		X	13
	New Jersey					10	1	2			1	2	■■■▲	✦✦✦▲	1		17
	Ohio					1	1	2				2	■■■	✦✦	1	X	7
	Pennsylvania					1	5	4				1	■■■■	✦✦✦✦	1	X	12
	Virginia			1	1	1		2				1	■■■	✦✦✦			6
	West Virginia			1		1							■■	✦✦			2
New England & New York	Connecticut			1		2		2			1	1	■■■	✦✦✦	1	X	8
	Maine					4		2				1	■■■■	✦✦✦✦	1		8
	Massachusetts					2	1				1	1	■■■■	✦✦✦✦	1	X	6
	New Hampshire					2		5				1	■■■■	✦✦✦✦	1		9
	New York	1	1		1	7	2	3			1	1	■■▲	✦✦▲	1	X	18
	Rhode Island					1					1	1	■■■	✦✦✦	1		4
	Vermont					13		3			1		■■■	✦✦	2	X	19

As of July 20, 2010.
Sources: DSIRE, OCEAN, ACEEE

Encouraging more fundamental retrofits

- Puget Sound Energy Commercial Custom Grant Program
  - Funds up to 70% of most retrofits, up to 50% of lighting retrofits
- RCx and audit mandates
  - New York City “Greener, Greater Buildings Plan)
  - San Francisco “Existing Commercial Buildings Energy Performance Ordinance”

Peer groups and network effect

- economic incentives
- certifications;
- alliances and partnerships;
- internal company programs

Adobe's Net-Net

Multi-Building Retrofit (PEA)

Offices, Data Center -- 620,000 SF – 4 Buildings

ENERGY CONSERVATION MEASURES (ECM) Less Than 4 Years

Analysis: Maintenance, Timing, Life Cycle, Installation Costs, Savings, Future Use

ECM	Electric Savings	Demand Savings	Annual Savings	Est. Cost	Rebates	Simple Payback
1)Lighting as Needed	74,300 kWh		$7,200	$25,500		3.53 Yrs
Lighting Controls Some 32W T8's --to 28W T8's – occupancy sensors, vendingmiser, wattstoppers						
2)Plumbing System	153,500 kWh		$39,400	$143,900		3.65 Yrs
Water and sewer reduce water – restricted flow rates – use low flow control– hands free flush						
3)Chiller Optimization Controls	125,900 kWh		$11,700	$23,800		2.04 Yrs
4)Energy Management Controls System	1,400,000 kWh		$131,100	$121,900		0.93 Yrs
EMCS-new-only big equipment-Extend to full bldg – advanced metering- Co2 air intake, space override switches, occ. sensors, meter major loads –tie back to original EMCS						
5)Permafrost Refrigerant Additive	176,300 kWh		$16,400	$59,800		3.65 Yrs
6) Power Factor Correction		120kW	$8,600	$29,000		3.38 Yrs
Subtotal	1,930,000 kWh	120 kW	$214,000	$403,900		1.88 Yrs

Source: Honeywell Building Solutions

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Adobe's Net-Net

Multi-Building Retrofit (PEA)

ENERGY CONSERVATION MEASURES (ECM) More Than 4 Years

ECM	Electric Savings	Demand Savings	Gas Therms	Annual Savings	Est. Cost	Rebates	Simple Payback
7)Kitchen Dishwasher	16,100 kWh		-378	$1,100	$12,300		11.18Yrs
High Efficiency Heater	--------- Electric booster to gas						
8)Kitchen Dom. Hot Water			1,744	$1,900	$58,600		30.84Yrs
Condensing Boiler	--------replace conventional boiler with high eff. Condensing boiler						
9) Tower-Free Cooling	358,900 kWh			$33,400	$222,400		6.66Yrs
10) Var. Speed Chilled Water Pumping	101,700 kWh			$ 9,450	$70,900		7.50Yrs
11) New High Efficiency** Chiller	144,900 kWh			$13,500	$371,200		27.53Yrs
12) Thermal Storage System		440 kW		$152,830	$1,275.000*	$435,600	8.34Yrs
Sub Total	621,600kWh	440kW	1366	$212,180	$2,010,400*	$0	9.47Yrs

* Includes Rebate ** This ECM was excluded in final totals

Subtotal (Less: 4 Yrs)	1,930,000 kWh	120kW		$214,000	$403,900		1.88Yrs
Subtotal (More: 4 yrs)	476,700 kWh**	440kW	1366	$198,680**	$1,639,200***	$0	8.25Yrs
Selected Total	2,406,700 kWh	560 kW	1366	$412,680	$2,043,100	$0	4.95Yrs

ROI: 20.2% **IRR**: 21.1% (10 Year) **Simple payback**: 4.95 years

(Reduce: Elect 10.2%/yr-- GHG 4.6Mlbs/yr(13.5%) – EStar 67 to 77, or 330 Cars/yr, 238,000 gal/yr Built 2006)

Source: Honeywell Building Solutions

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Summary and recommendations for practitioners

- Investment is limited by availability of funds and the ability to manage multiple projects.

- We are paying too much attention to largest buildings and to “shallow retrofits”.
  - Lighting retrofits high ROI, but low in overall kWh savings.

- RCx works but is under-utilized
  - Time and resource intensive if done manually.
  - Utilize continuous commissioning systems and fault detection systems.

- Invest savings from shorter payback projects into a capital planning budget to finance additional improvement projects.