EXPERIMENTING WITH EFFICIENCY:
Reducing Energy Use in Laboratories on University Campuses

Team First Fuel

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The situation

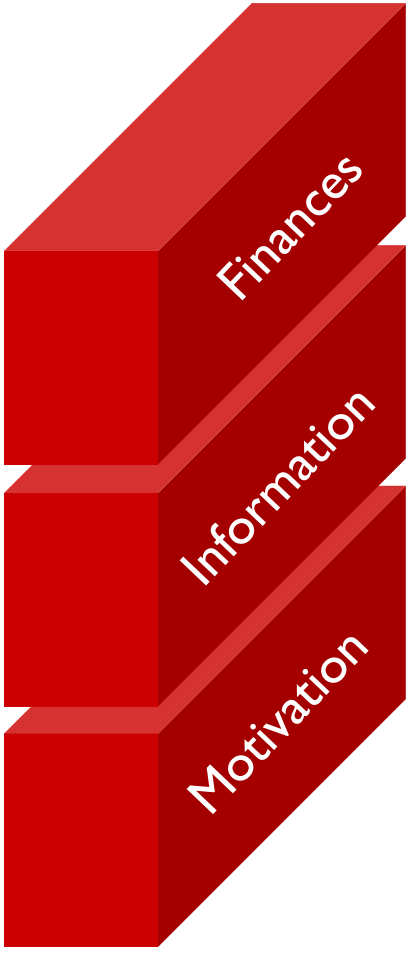
- **Growing interest** in energy efficiency among granting agencies, universities, and researchers

- **Growing need** with rising energy prices and climate change

The barriers

- **Growing interest** in energy efficiency among granting agencies, universities, and researchers
- **Growing need** with rising energy prices and climate change

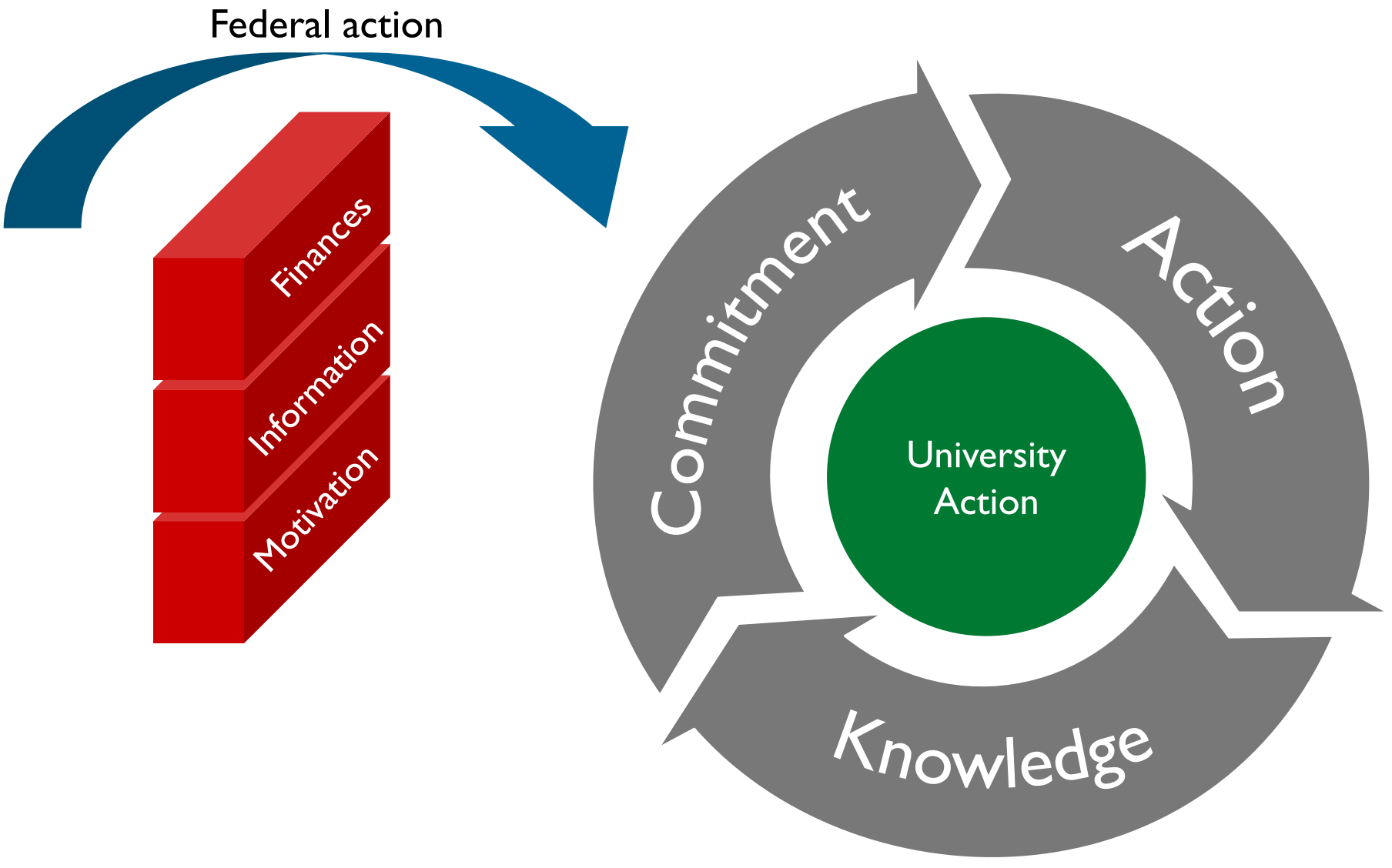
HOWEVER…



- Competing priorities
- Energy not charged to labs
- Complex environments
- Limited accountability
- No incentives

Barriers to change

Our solution



Recommendations

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Federal Action

1. Set Equipment Standards
2. Reform Energy Cost Recovery
3. Train Researchers

University Action

4. Commit to Sustainability
5. Plan Energy Management
6. Facilitate Peer Learning

Set Equipment Standards

- Start with the biggest consumers
- Include performance in addition to energy
- Only reimburse purchases of equipment meeting these standards

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Requiring one year's worth of **new** freezers to meet standards:

- like taking **1,000 homes** off the grid

Reducing air volume through all **existing** hoods:

- like taking **130,000 homes** off the grid

Recommendations

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Reform Energy Cost Recovery

Federal Agencies

Money received from granting agencies

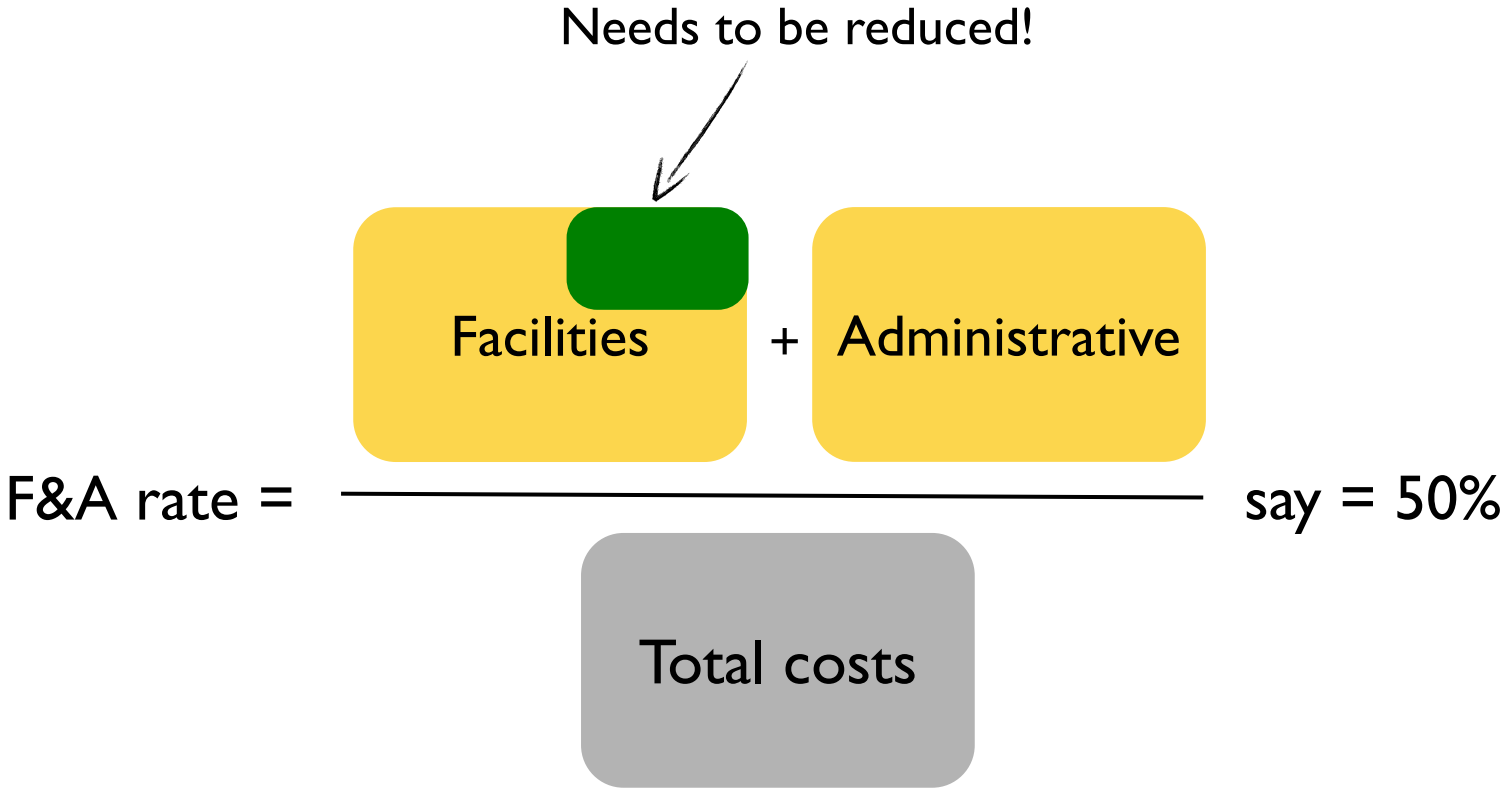
University X

Reform Energy Cost Recovery

Facilities & Administrative (F&A)

Grant for research

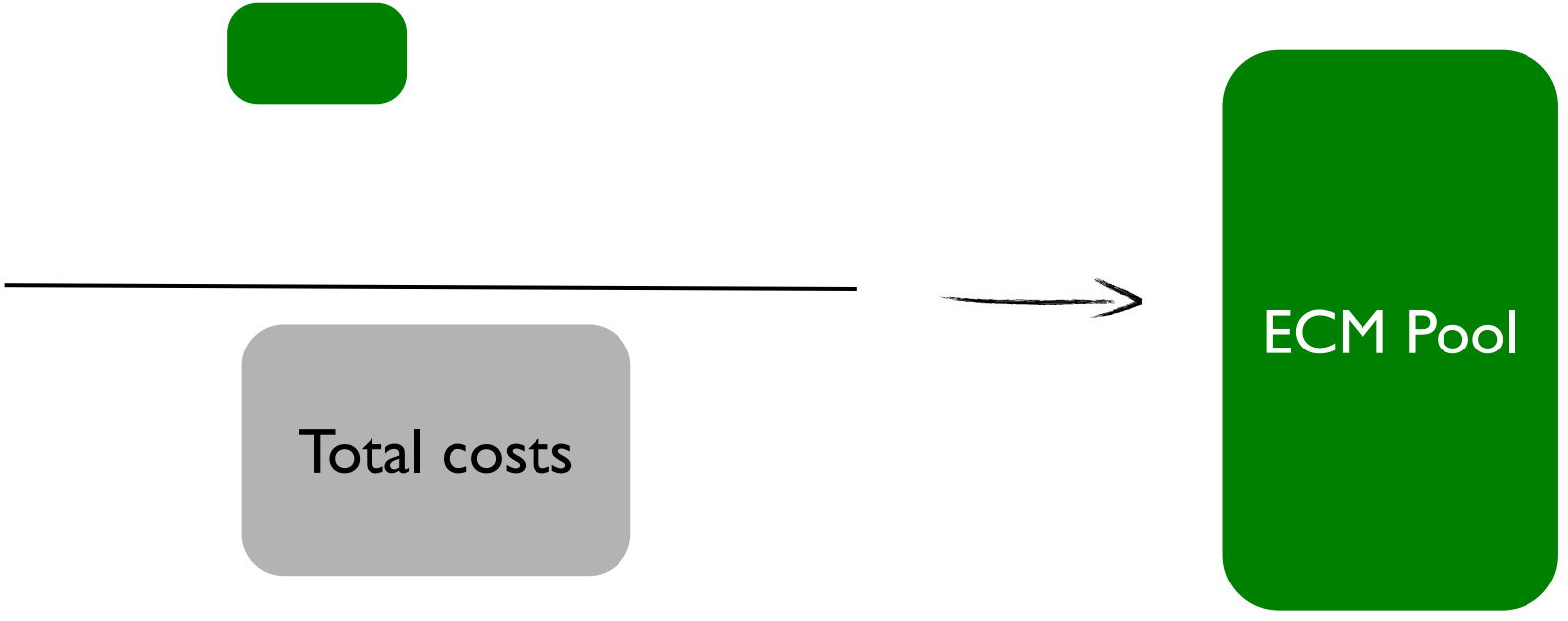
Reform Energy Cost Recovery



Reform Energy Cost Recovery

$$\text{F\&A rate} = \frac{\text{Facilities} + \text{Administrative}}{\text{Total costs}}$$

Reform Energy Cost Recovery



- Funds set aside for energy conservation

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Reform Energy Cost Recovery

ECM Pool

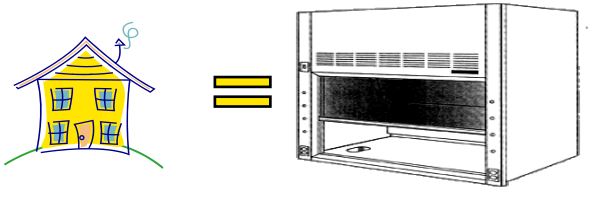
- Funds set aside for energy conservation
- University applies to withdraw ECM funds

Recommendations

Train Researchers: Online Training

TRAINING PRINCIPLES

- Take advantage of social sciences research and community based social marketing
- Frame it in terms that resonate with people



- Include commitment opportunities

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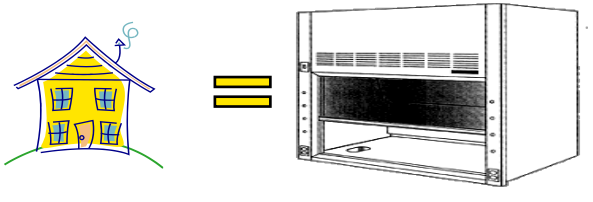

- Include commitment opportunities

SAMPLE TRAINING CONTENT

- General energy conservation
- Wet lab best practices
- Procurement
- Resources for more information

Recommendations

Commit to Sustainability

- Develop tangible goals and publicize them
- Hold facilities staff accountable
- Celebrate all stakeholders' achievements

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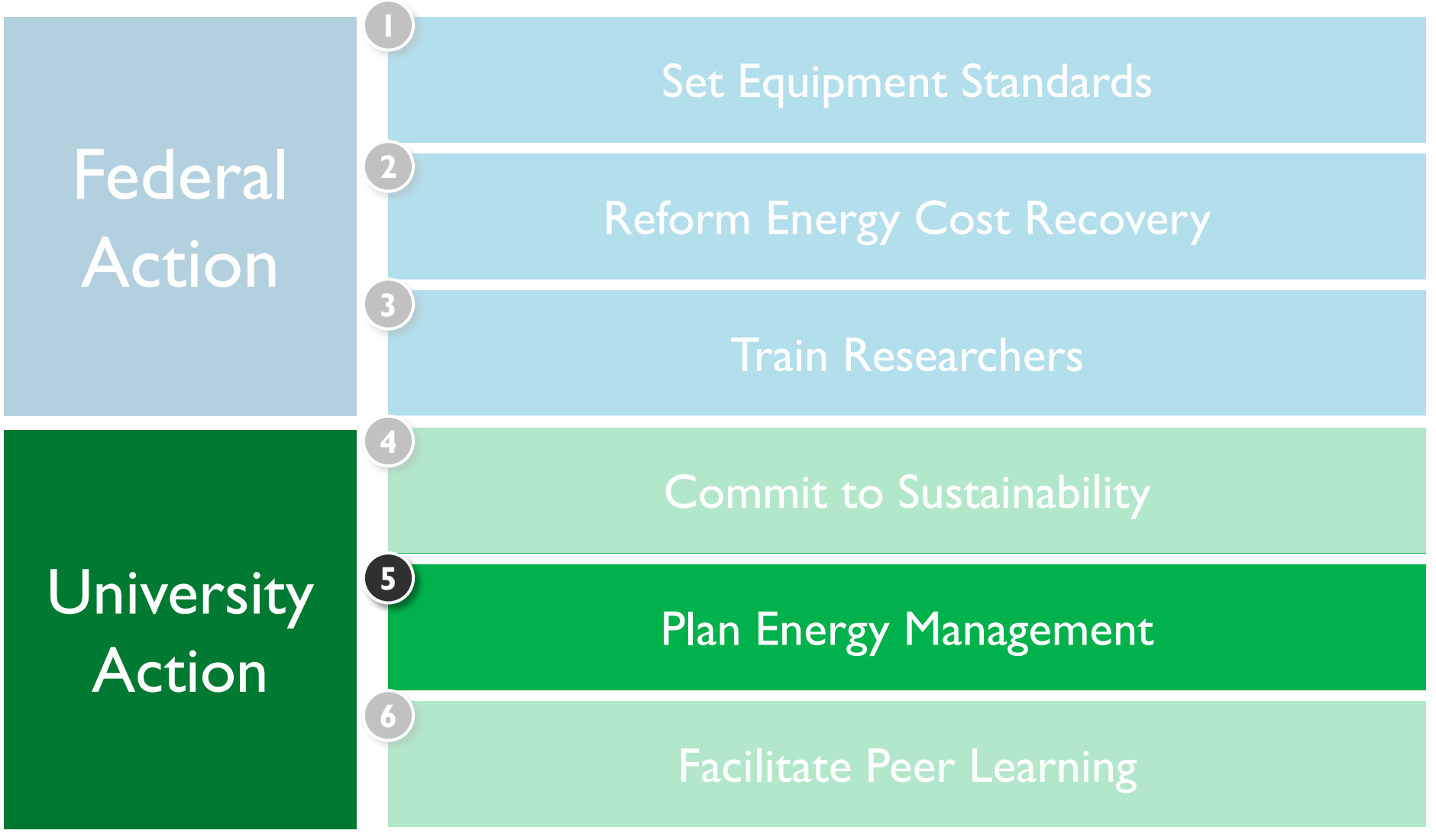
Visible support from leaders and **incentives** for all stakeholders can embed sustainability in university's **culture and identity**

Recommendations



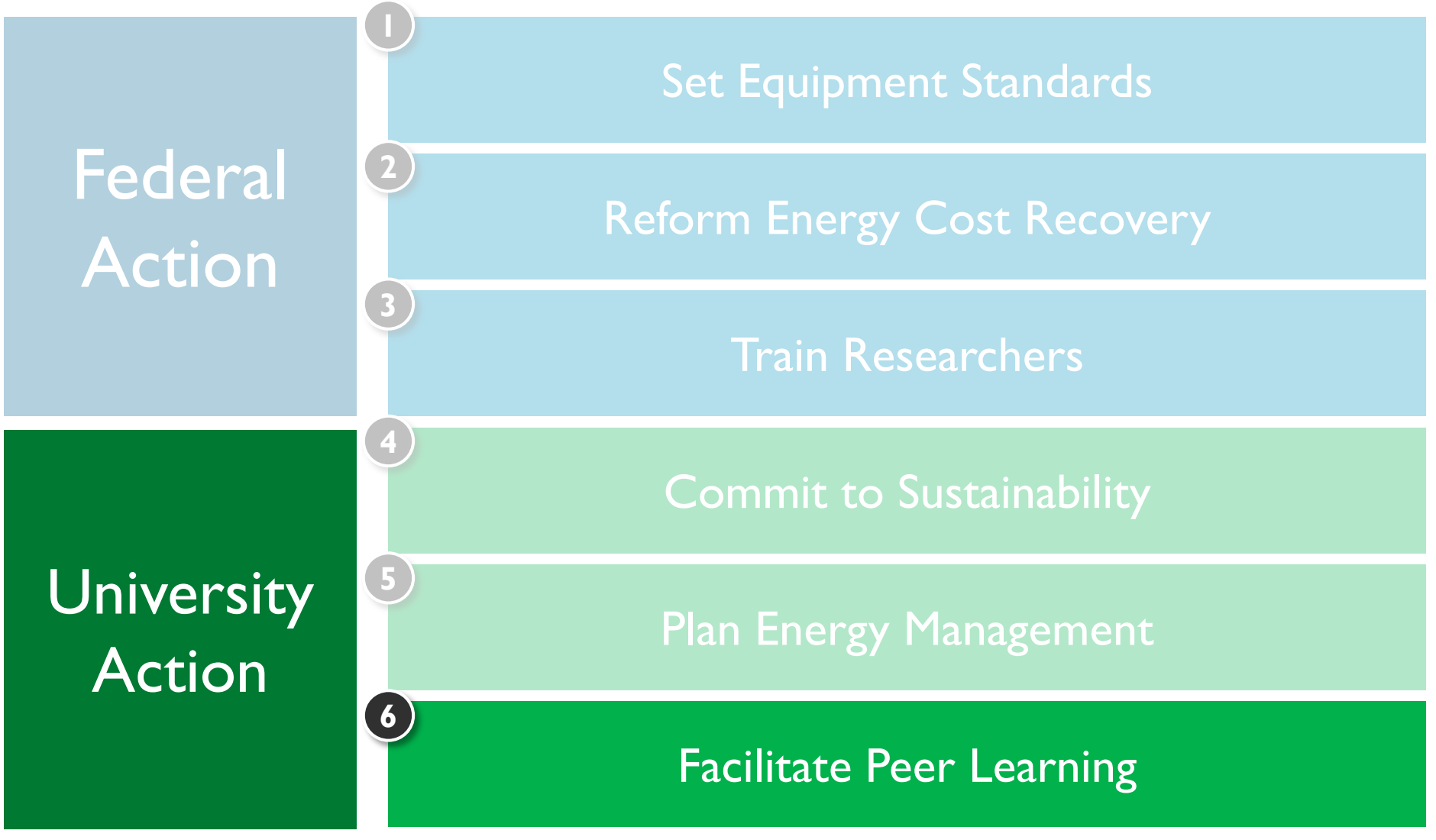
Plan Energy Management

Plan Energy Management

	POLICY	FINANCING	IMPLEMENT-ATION	REFLECTION
***Example*: Renovation of a lab**	• Decide on green building standard (e.g. LEED Gold)	• Use ECM pool held by federal government	• Implement renovation • Measure savings	• Publicize and iterate

Goal: build trust and relationships that can enable tackling the most difficult and rewarding projects

Recommendations



Facilitate Peer Learning

- Researchers know the lab best
  - Diverse lab needs and cultures
  - Unexpected energy loads
- Peers are trusted messengers
- Researchers feel ownership over improvements they participate in

Harvard Shut the Sash celebration

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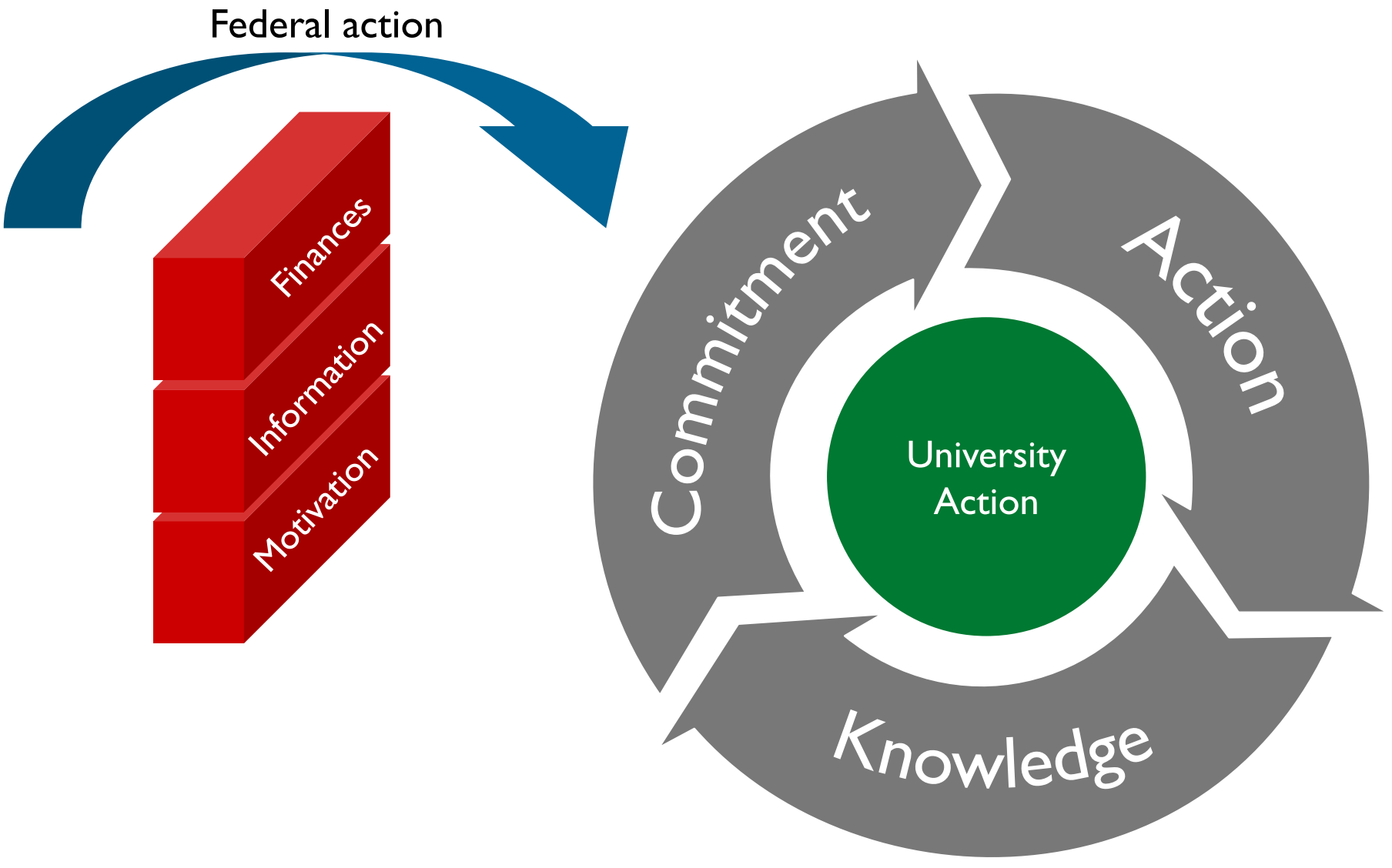
Ideas diffuse widely when backed by researchers

Recommendations

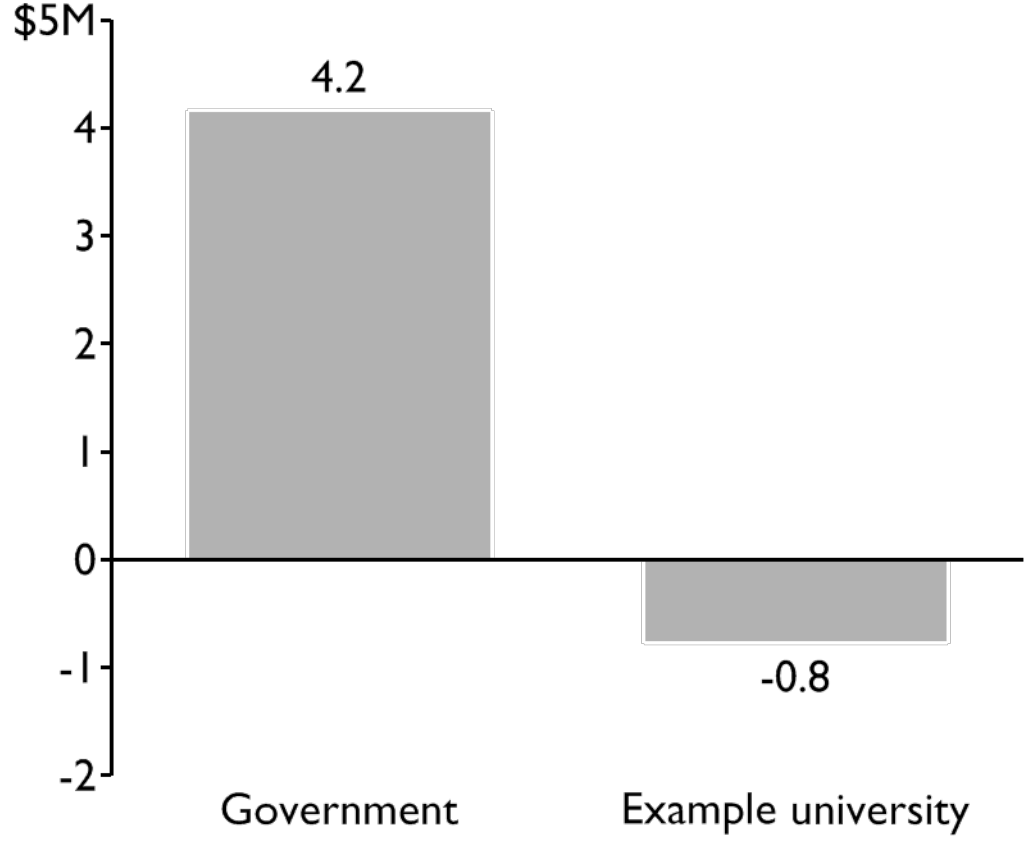
Our Solution



BACKUP

ECM funding pool: assumptions for base case

Net present value
(20 year timeframe)



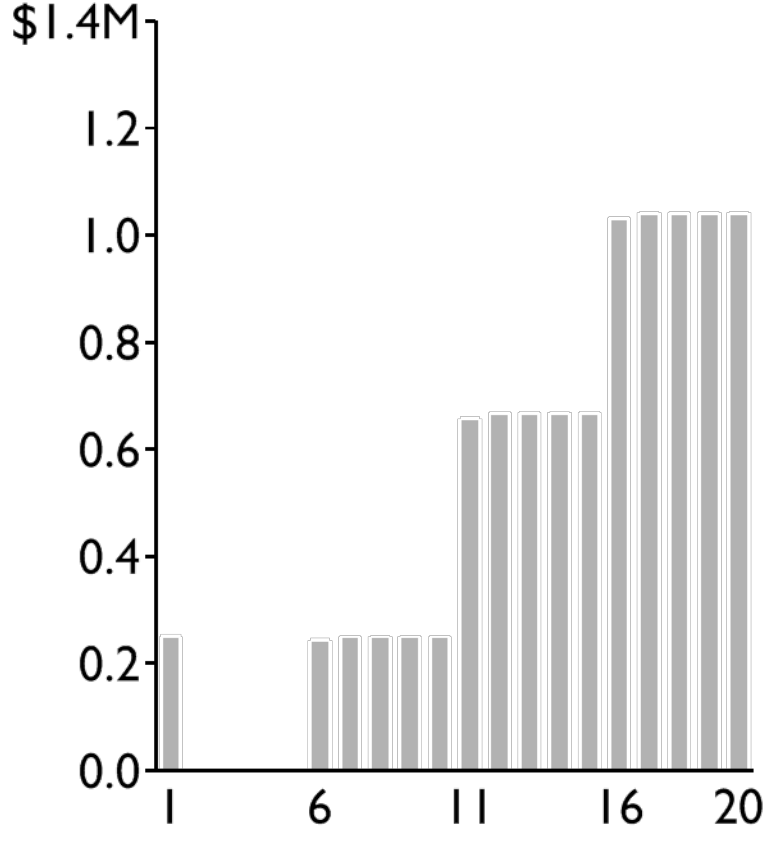
ASSUMPTIONS

- *University*:
  - $10M annual lab energy spend
  - Constant level of grant spending
  - No baseline growth in energy usage
  - 5-year F&A recalculation cycle
  - Discount rate of 7%
- *ECMs*:
  - Based on actual ECM list for an example research university
  - Excludes projects with paybacks >5 years, and projects with negligible upfront costs (i.e. control changes or setbacks)
- *Overall timing*:
  - 1st year: No activity as initial funds are accrued
  - 2nd year: ECM reimbursement begins
  - 3rd+ year: Savings begin to be realized, ECM reimbursements continue

ECM funding pool: year-by-year cash impacts

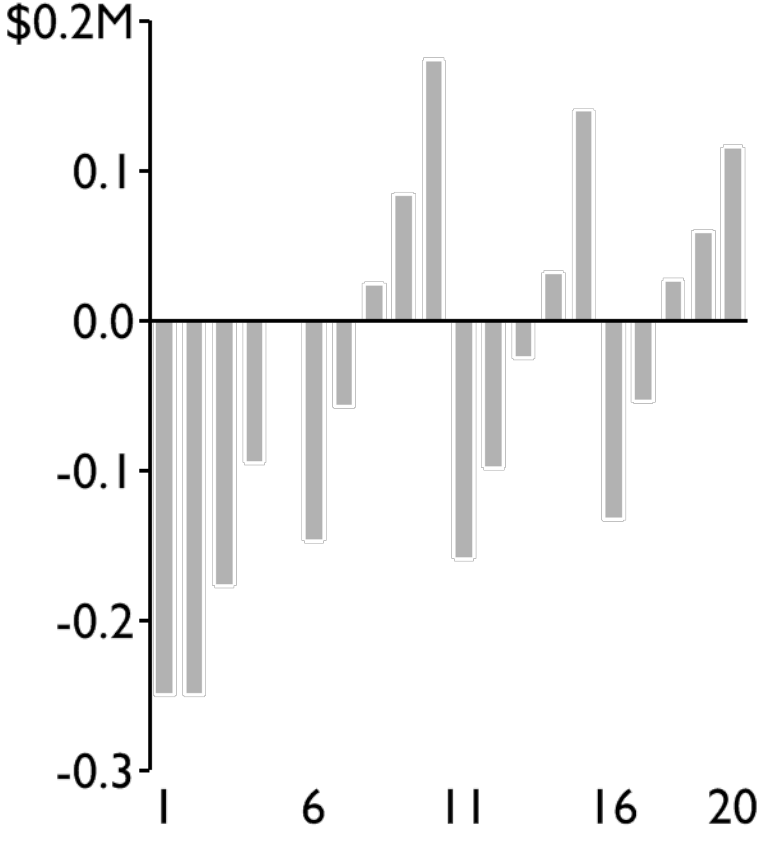
GOVERNMENT

Annual net cash benefit/cost



EXAMPLE UNIVERSITY

Annual net cash benefit/cost



ECM funding pool is financially viable

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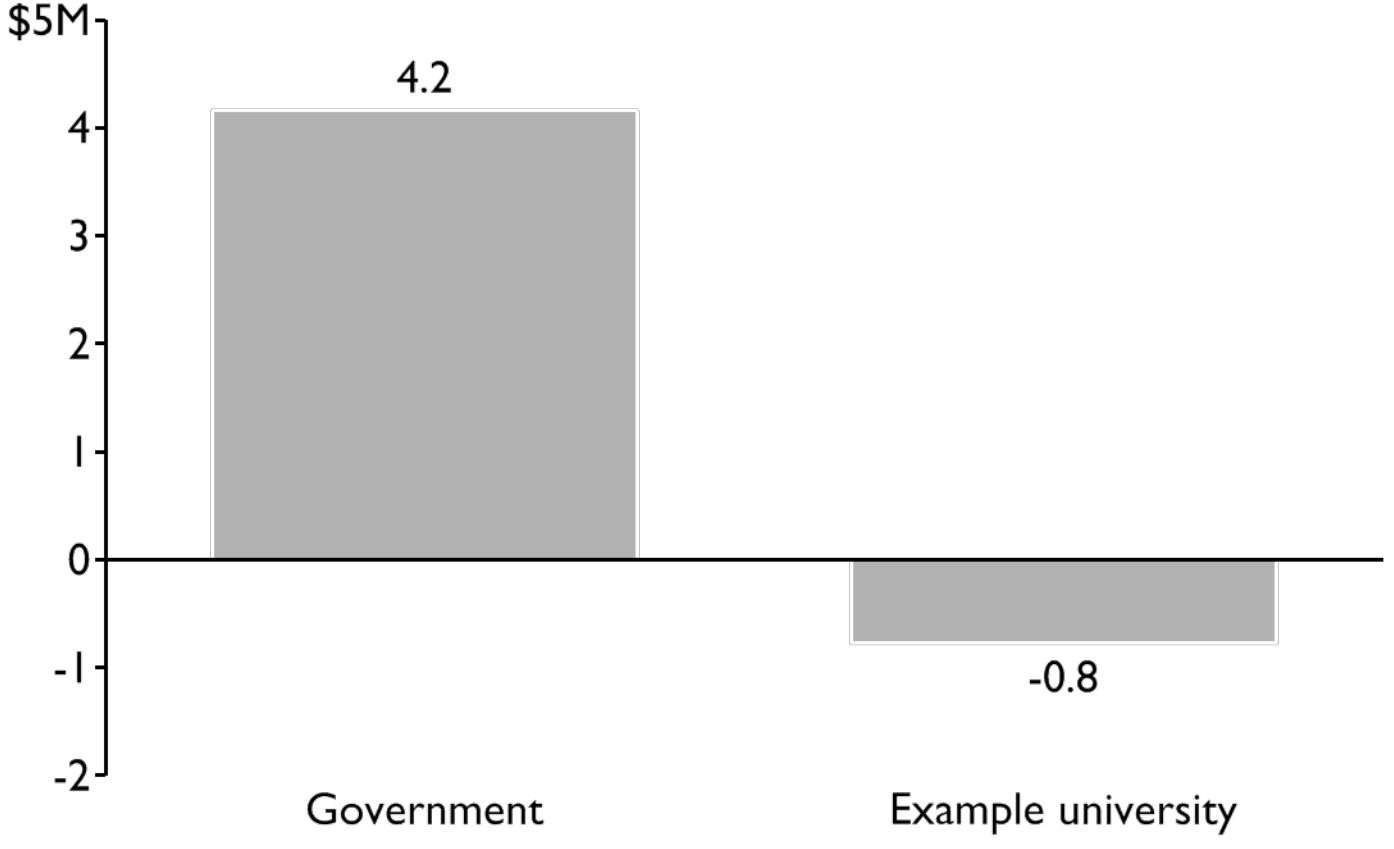
(20 year timeframe)



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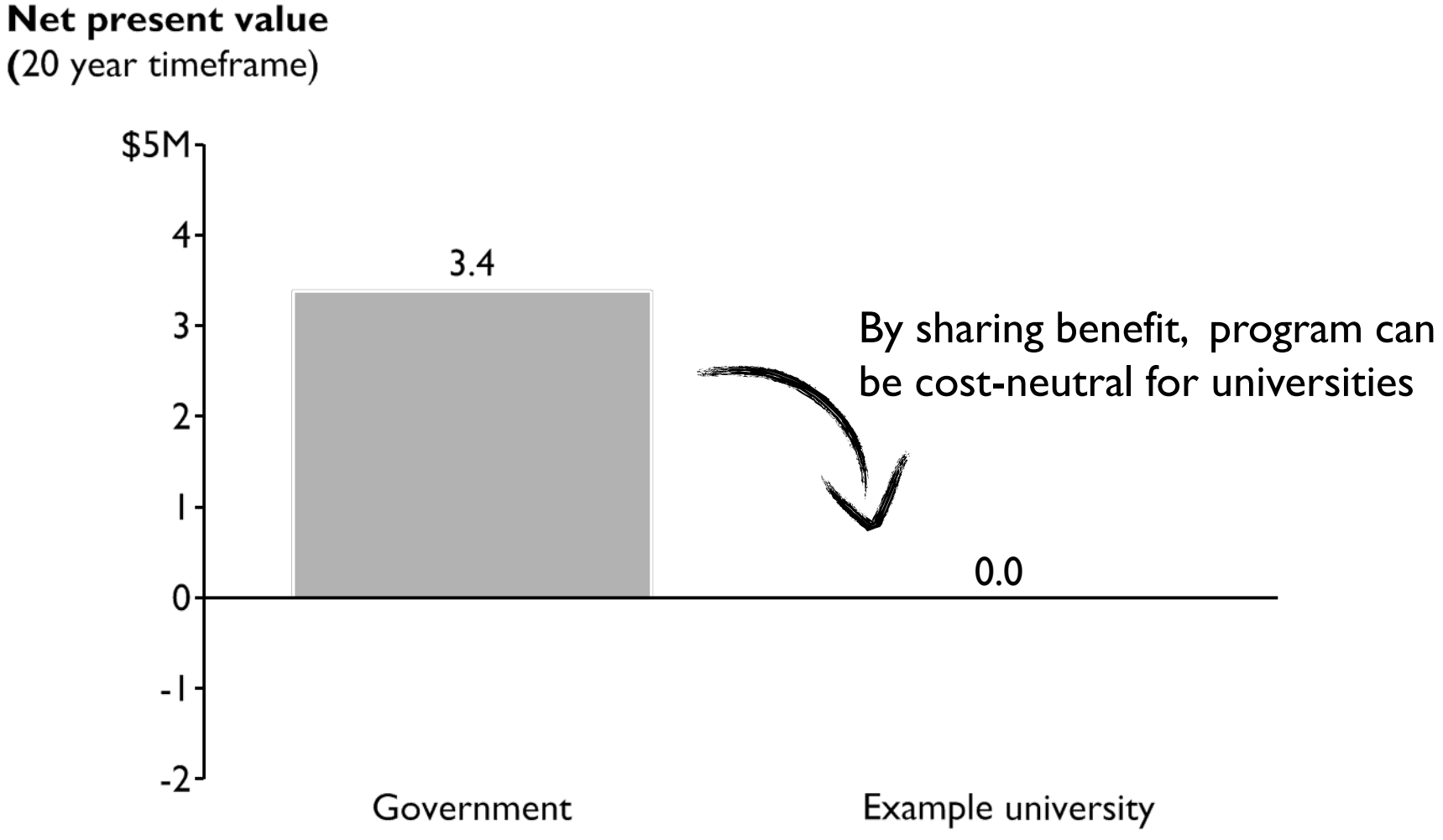

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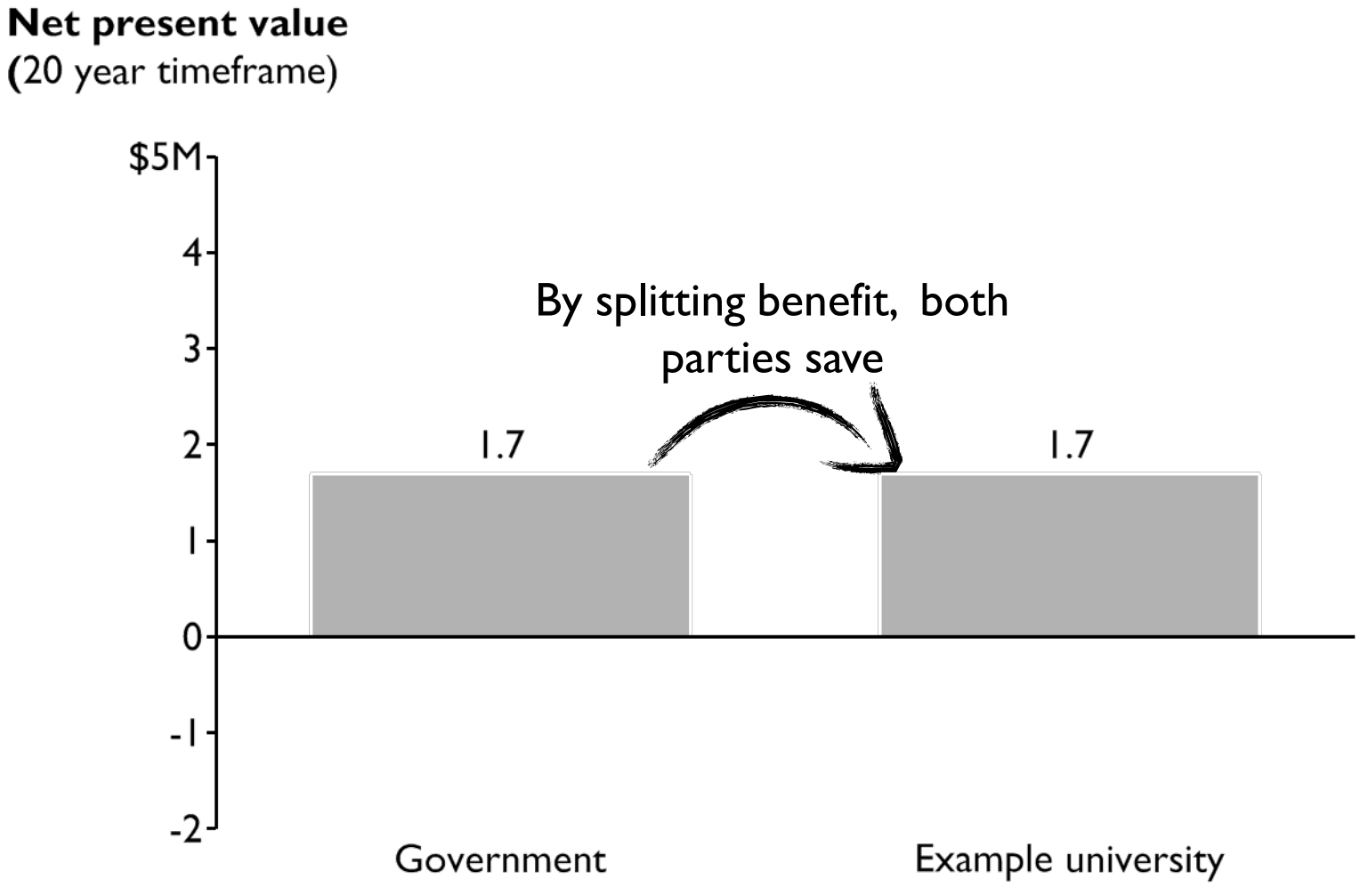

Fume hood savings: All hoods run at 80fpm instead of 100fpm

Location	Boston, Massachusetts, United States	Boston, Massachusetts, United States

ASSUMPTIONS	Hood 1	Hood 2	
Energy Prices [1]			
Electricity	0.15	.15	$/kWh
Electricity Demand	170	170	$/kW-yr
Fuel	9	9	$/million BTU
Operation [2]	24	24	hr/day
Hood Opening (Horizontal)	62	62	inches
Hood Opening (Vertical)	12	12	inches
Face Velocity	100	80	ft/min
Fan Power (supply/exhaust) [3]	1.80	1.80	W/CFM
Cooling Plant Efficiency	1.00	1.00	kW/ton
Heating System Efficiency	70	70	percent
HVAC Supply Air Setpoints			
Heating	55	55	°F
Cooling	45	45	°F
Reheat Energy [4]			
Delivery Air Temp.	65	65	°F
Energy Type	Fuel	Fuel	

ANALYSIS	Hood 1	Hood 2	Difference
Flow Rate	517	413	103 CFM
Cooling & Air-handling			
Chiller Energy [5]	7,146	5,716	1,429 kWh/year
Fan Energy	8,147	6,517	1,629 kWh/year
Total	15,292	12,234	3,058 kWh/year
Total Power	2.8	2.2	0.6 kW/hood
of which Fan	0.9	0.7	0.2 kW/hood
of which Chiller	1.9	1.5	0.4 kW/hood
Heating			
Supply Load [5]	47	38	9 million BTU
Reheat Load	48	39	9 million BTU
Total Load	96	77	19 million BTU
Energy (fuel)	137	110	27 million BTU
Energy (electric)	0	0	0 kWh
Average Reheat Power	0.0	0.0	0.0 kW
Total Per Hood Costs	**4,008**	**3,206**	**802 $/year**
Cost Per CFM	7.76	7.76	-0.00 $

Single hood

x 750,000 hoods in the US → EPA GHG Calculator (online) → Equivalent emissions of 134,500 houses

Disclaimer: Some hoods would not meet performance standards at 80fpm. Hoods that fail containment at 80fpm may be candidates for replacement.

Freezer savings: New freezers meet an 11kWh/ft^3 standard

	Savings/year from purchasing freezers as efficient as today's efficiency leaders[a]				
	Energy (kWh)[b]	$[c]	CO2 (metric tons)[f]	Equivalent to energy demand of:	
Per 27.5 ft^3 freezer:	3,285	$493	2.3	0.1	houses
Annual savings if 90% of all freezers purchased in a year met the standard[d]:	29,565,000	$4,434,750	20,860	1,042	houses
5-year savings if 90% of all freezers purchased in 5 years met the standard[e]:	369,562,500	$55,434,375	260,745	13,025	houses

Notes and Assumptions:

[a]Current 27.5ft^3 freezers from Stirling Ultracold achieve performance at 11kWh/ft^3, while the typical freezer today uses about 20kWh/ft^3.

[b]Calculations do not include the sizeable energy savings associated with reduced HVAC load. In much of the country, the savings will be doubled by reducing the amount of space cooling required.

[c]Energy costs of $0.15/kWh.

[d]10,000 freezers are purchased in the US per year (DOE).

[e]Each year with the purchase of 9,000 new and energy efficient ULTs, we see additional annual savings that persist for the lifetime of the freeer. Therefore, the 5-year savings is not simply five times the annual savings.

[f]National average marginal CO2/kWh = 7.06x10^{-4} metric tons/kWh (EPA).