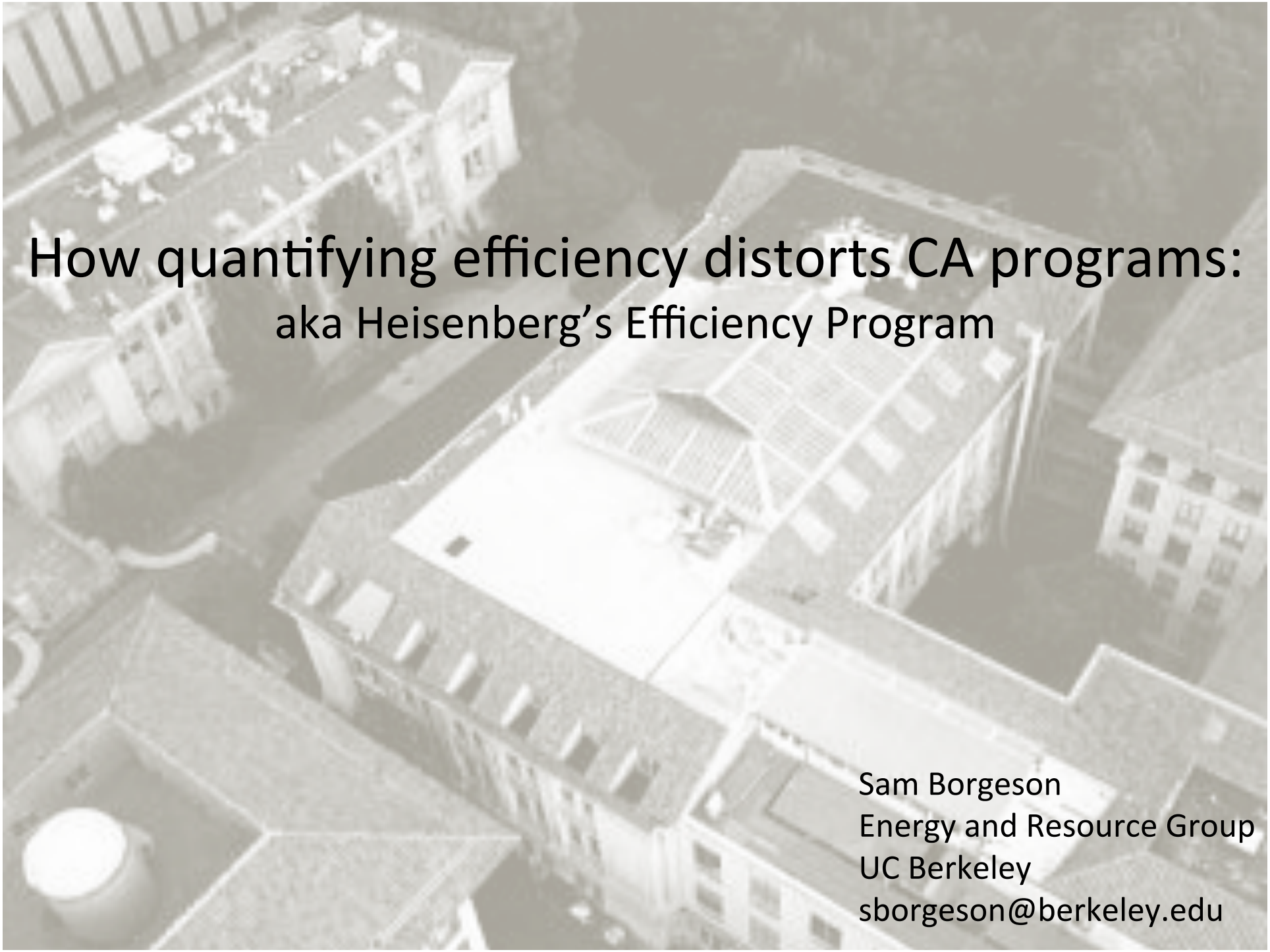

How quantifying efficiency distorts CA programs:
aka Heisenberg's Efficiency Program

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Summary

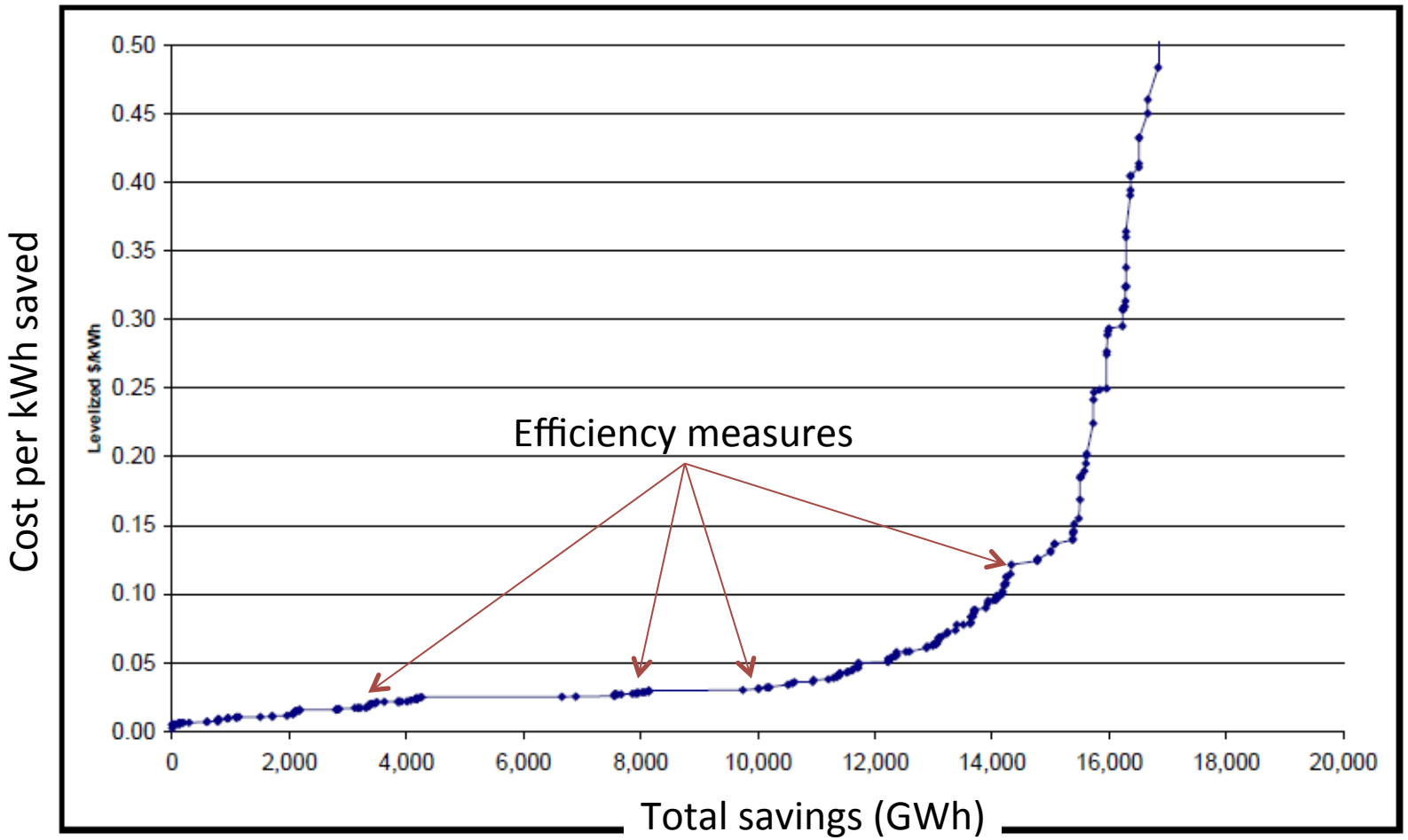
- Neither costs nor kWh savings can be measured precisely
- Different interventions are measured using different standards and some are more forgiving than others
- Too great an emphasis on quantified efficiency outcomes conceals the failures required to learn and innovate
- This dynamic appears to be developing in carbon markets as well

Building science view of EE

Study	EE resource contribution
Twin Rivers (1977)	Shell tightness; **defects**; PRISM; info/**feedback**; price inelasticity; **occupants** matter
Vital Signs (1996)	"lack of **knowledge** usually means wasted power and energy"; "**instrumented** diagnostic examination rarely fails to identify energy conservation opportunities"
PROBE (2001)	"Monitoring, feedback, and effective motion are what create **continuous improvement** – but are sadly rare…"; "… seeking where possible to use **information** rather than energy to achieve the required conditions with minimum waste."
LBNL Cx (2004,2009)	Major potential in tuning buildings to work as designed – much of what is found is the results of mistakes or neglect. Significant savings from **tweaks** to **controls** and hardware.
TIAX controls (2005)	Three **faults**, "HVAC Left on When Space Unoccupied," "Lights Left on When Space Unoccupied," and "Duct Leakage," appear to account for about two-thirds of a quad of waste.
NREL case studies (2006)	"All six buildings showed that they used more energy and produced less energy than predicted in the design/simulation stage"; "lack of **control**"; "too optimistic about the **behavior** of the **occupants**"
NBI / LEED (2008)	"Projects with more aggressive energy performance goals seem to generate overly **optimistic predictions** of actual energy use."

Economic view of EE: Supply curves

Figure 4-13: PG&E Supply Curve Technical Energy Efficiency Potential – 2007-2016 (GWh)

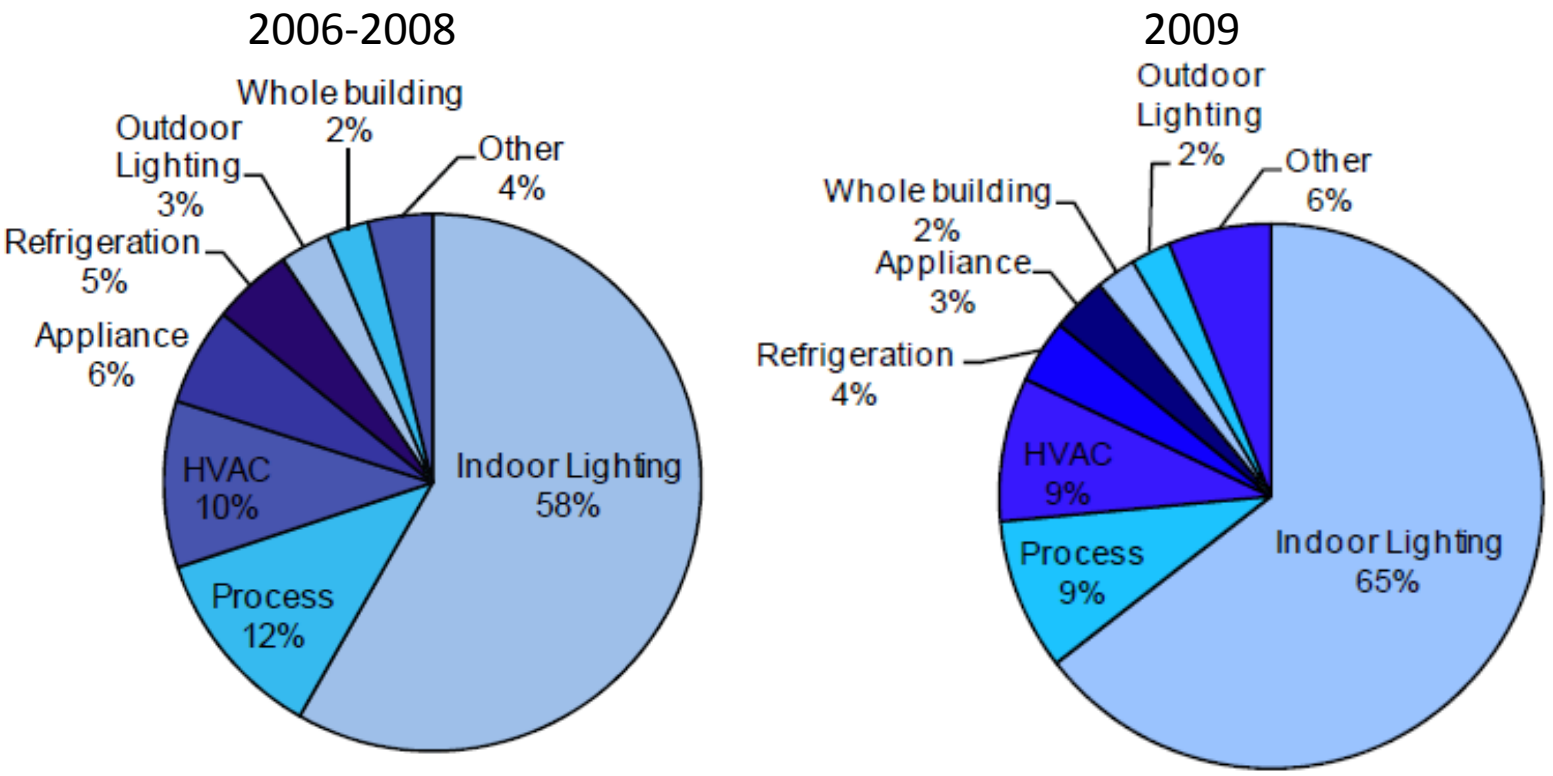


Source: ITRON 2008 EE potential study

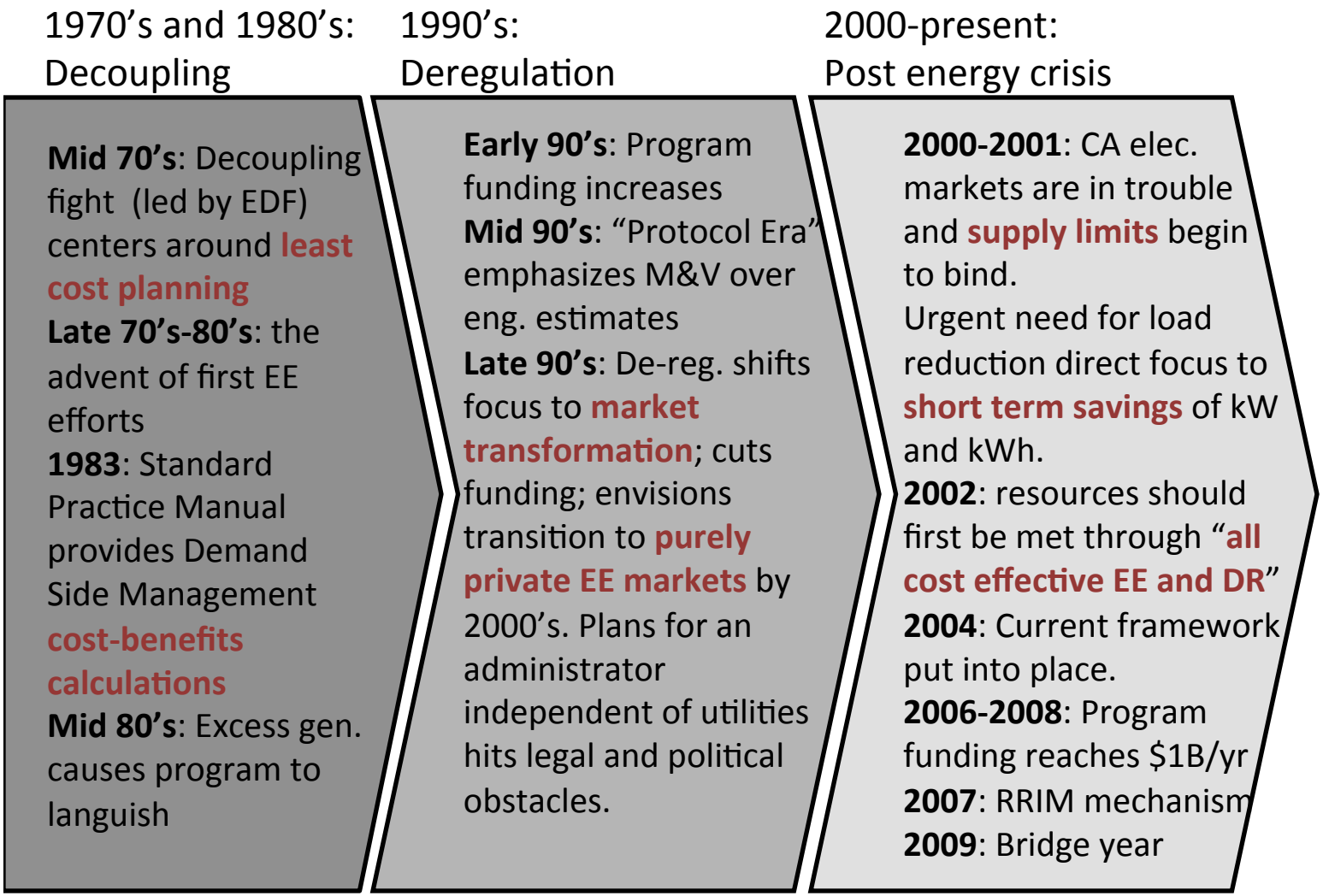
Diversity of methods

- In CA, in different contexts, evaluations can use:
  - rules of thumb, professional estimates, manufacturer's rated performance, deemed savings, temporary sub-metered data logging, billing data, whole building interval meter data, engineering models, building and system simulation, calibrated simulation, etc.
- All codified in the Technical Resource Manual (the rulebook for EE savings)
  - Including massive DEER database of "deemed savings"

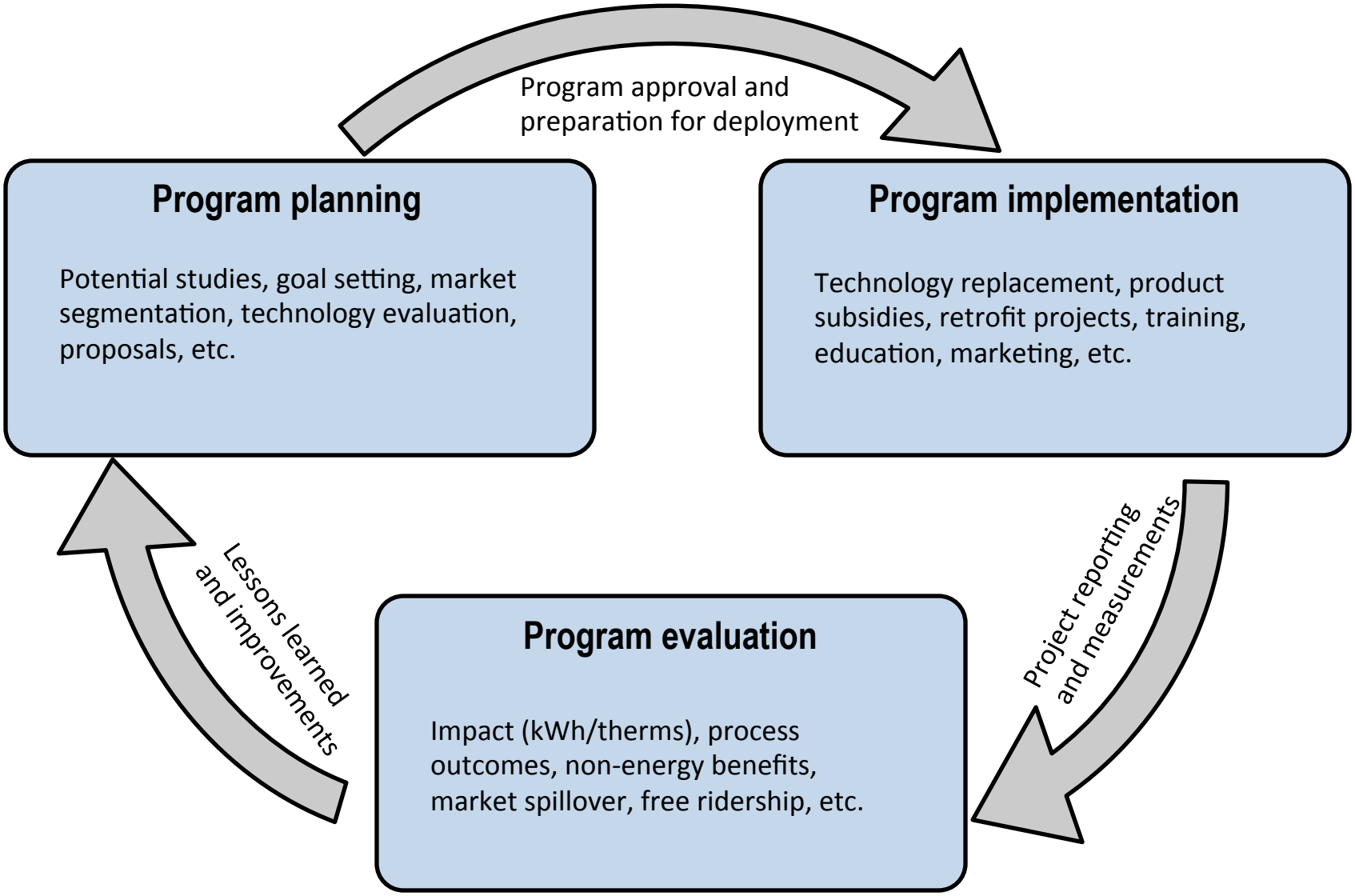
CA evaluated savings



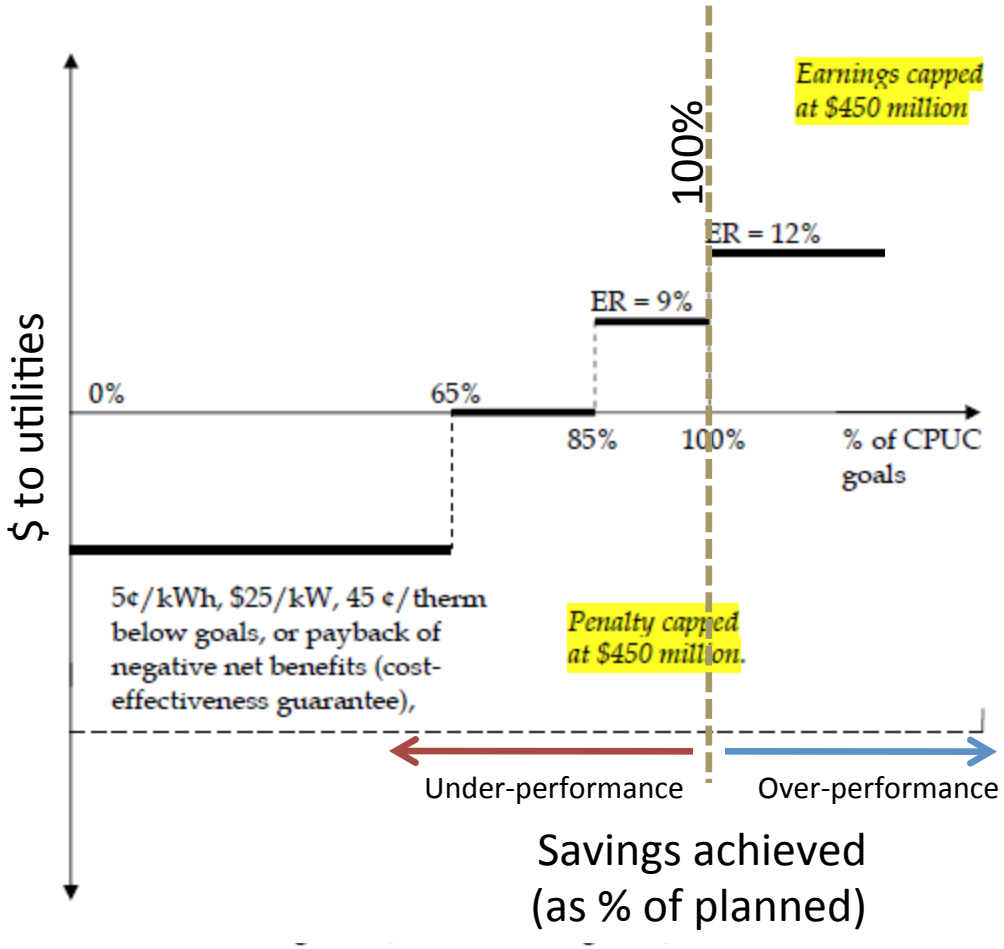
CA EE program history



Idealized EE program work flow

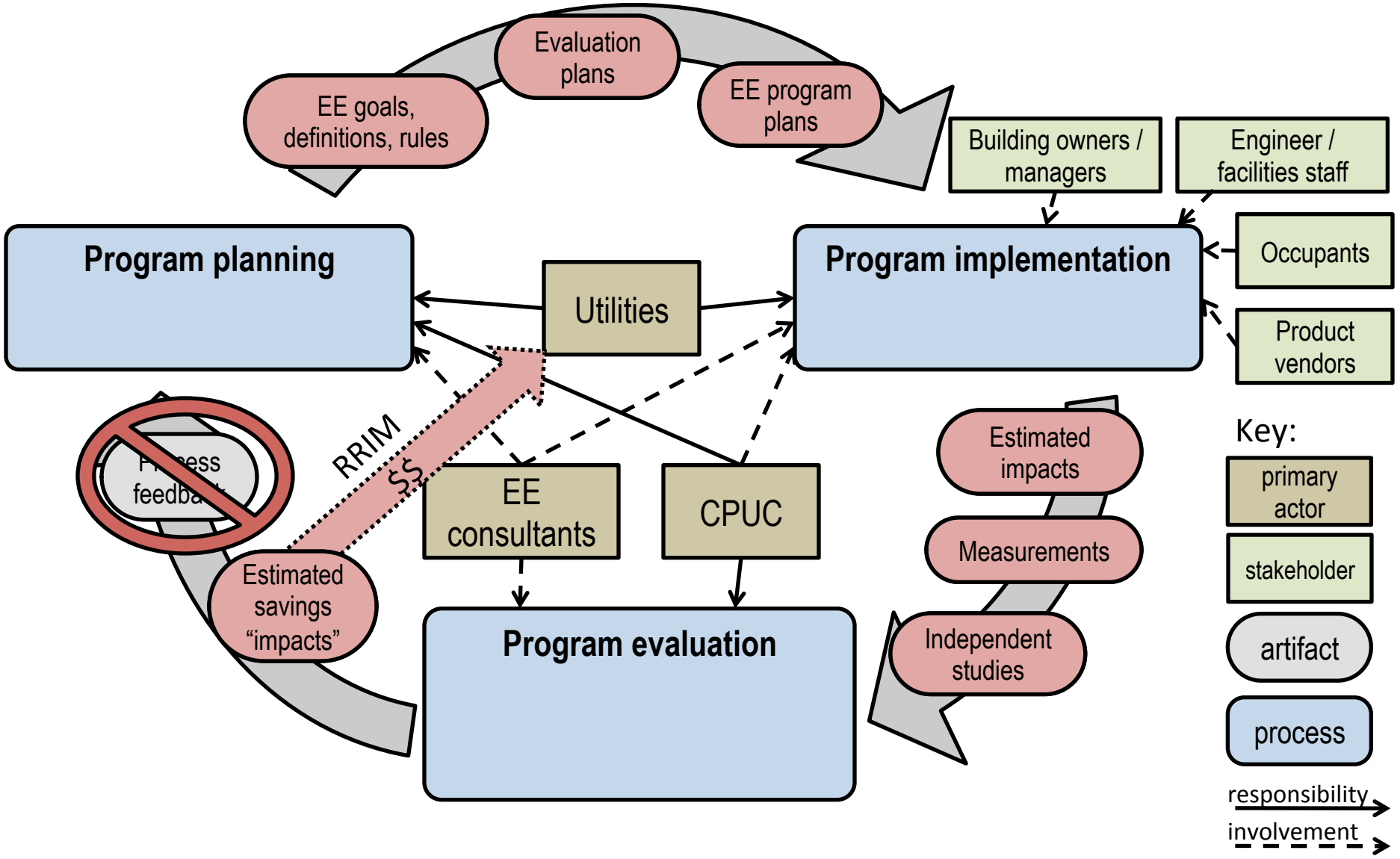


Risk/reward incentive mechanism (RRIM)



CPUC: D.07-09-043: RRIM established

CA EE program work flow



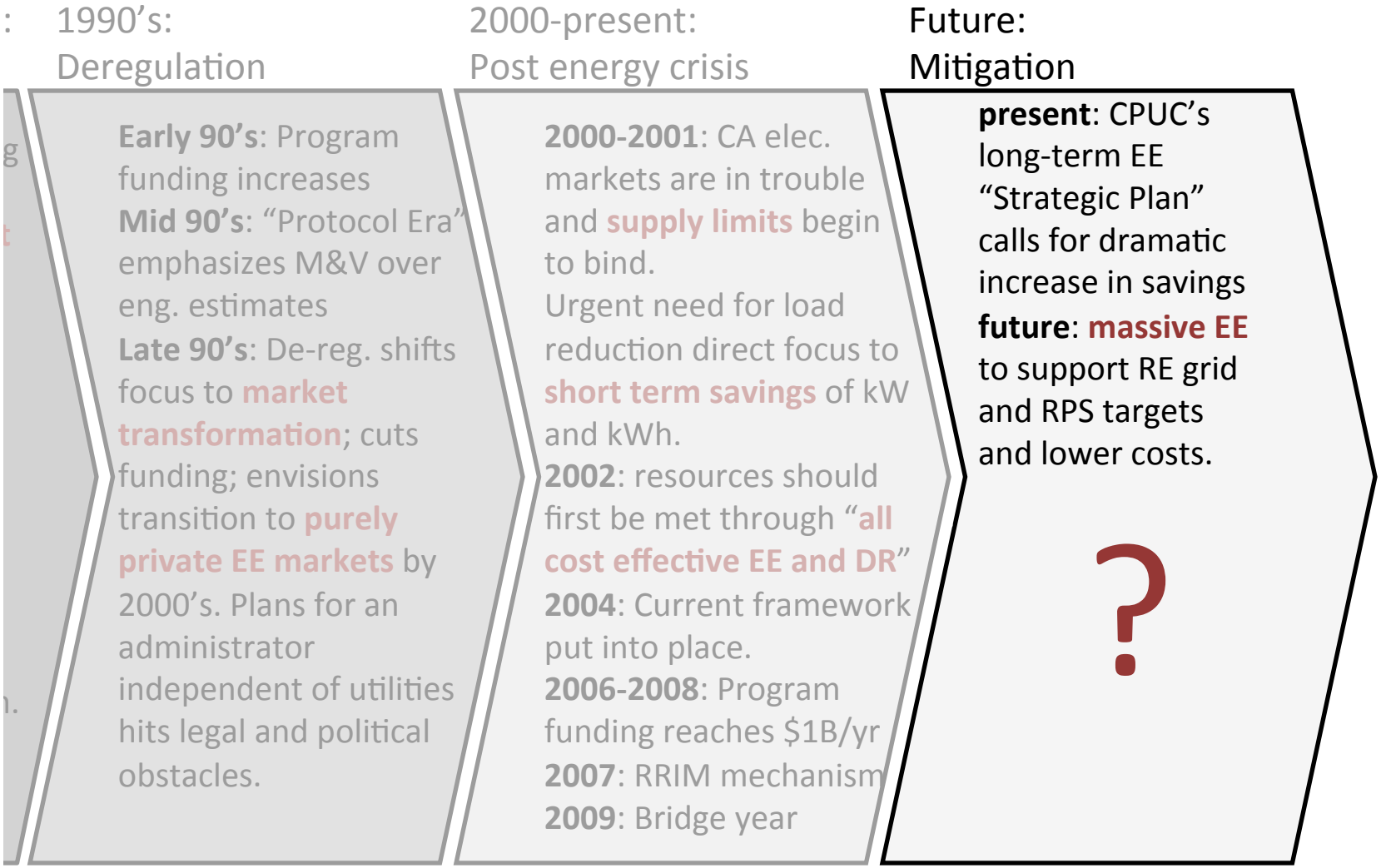
Mechanism confirmed

"One of the 'unintended consequences' of [the Risk/Reward Incentive Mechanism] is that utilities were encouraged to place greater emphasis on **measures with high annual savings** levels even if their design lives were relatively short, with the result that the majority of 2006-2009 portfolio savings (and a significant portion of projected 2010-2012 program savings) derived from one measure – **basic Compact Fluorescent Lamps**.

While flooding the California lighting market with deeply discounted Compact Fluorescent Lamps achieved a significant amount of short-term savings, it was **not the intention of the incentive mechanism**. The goal of the incentive mechanism is to foster greater **innovation and creativity** within the utilities' engineering and management and to ensure that energy efficiency savings (**not merely savings accounting**) became a **top priority for the utilities**."

Source: CPUC D.09-11-014 draft (http://docs.cpuc.ca.gov/efile/PD/162141.pdf)

CA EE program history



FIN

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Measurement of savings

- Two main schools:
  - If we understand the systems and how they were modified, we can estimate changes from first principles (**bottom-up / engineering**)
  - The proof is in the pudding: if we can control for other factors that influence energy consumption, we can isolate the impact of EE programs in empirical data statistically (**top-down / econometric**)

Savings example: Lighting

Type	Lm/W
Incandescent	15
CFL	60
Tube FL	80
LED	80-100 (limit 260-300)

1. Control for equal lumens (light output) between measure and its baseline alternative
2. kWh = lumens x **lifetime** / efficacy x 1/1000 (lifetime is total hours of operation; efficacy is lumens/watt)
3. cost = **purchase price** + NPV(kWh)
4. Measure lifetime *impact* = $kWh_{measure} - kWh_{baseline}$
5. Savings = $cost_{baseline} - cost_{measure}$

3) How do we measure savings in practice?

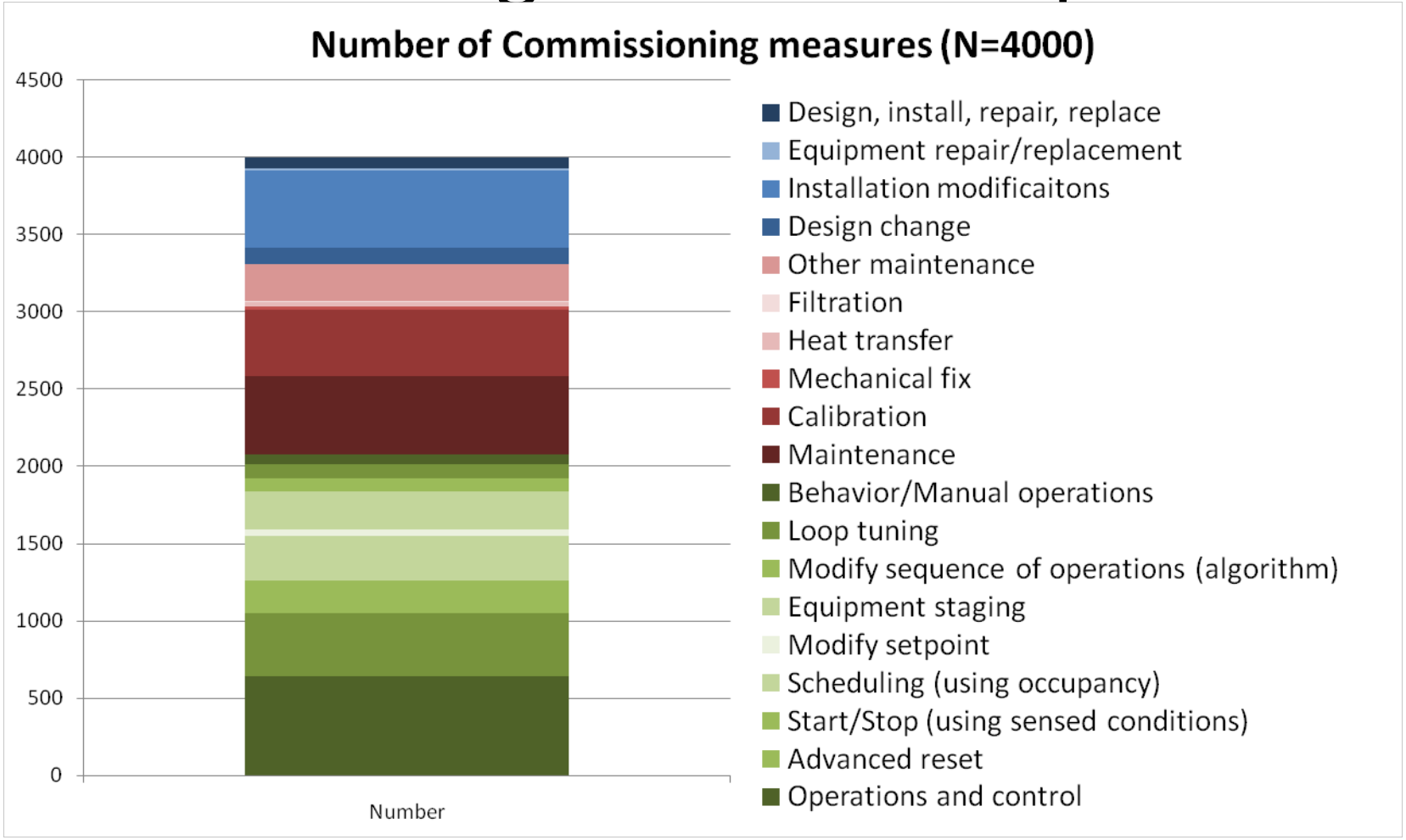
Problems measuring EE

- We are trying to quantify a change away from an outcome that we can never observe.
  - A baseline to compare against must be estimated. **counterfactual**
- Even if we have reason to believe an estimate, we must still ask:
  - Would some portion of savings have happened anyway? **free ridership**
  - What about adoption by non-participants inspired by programs? **spillover**
  - How do we measure or account for longer term purchasing, behavioral and ultimately cultural change? **market transformation**

Putting a stake in the ground

- These are existential questions. Good fodder for philosophy class.
- However, we must run EE programs in the real world with real consequences.
- The CPUC has to operationalize a framework that sets rules by which EE savings are quantified.
  - Ensure public money is well spent
  - Trust but verify
  - Balance costs of evaluation against importance of details
  - Make rules that allow the system to function
- This talk is about the difficulties inherent in this task and the surprising nature of some of the unforeseen outcomes.

Commissioning: measures implemented



Data Source: Figure 7, Mills 2009

CA EE program history

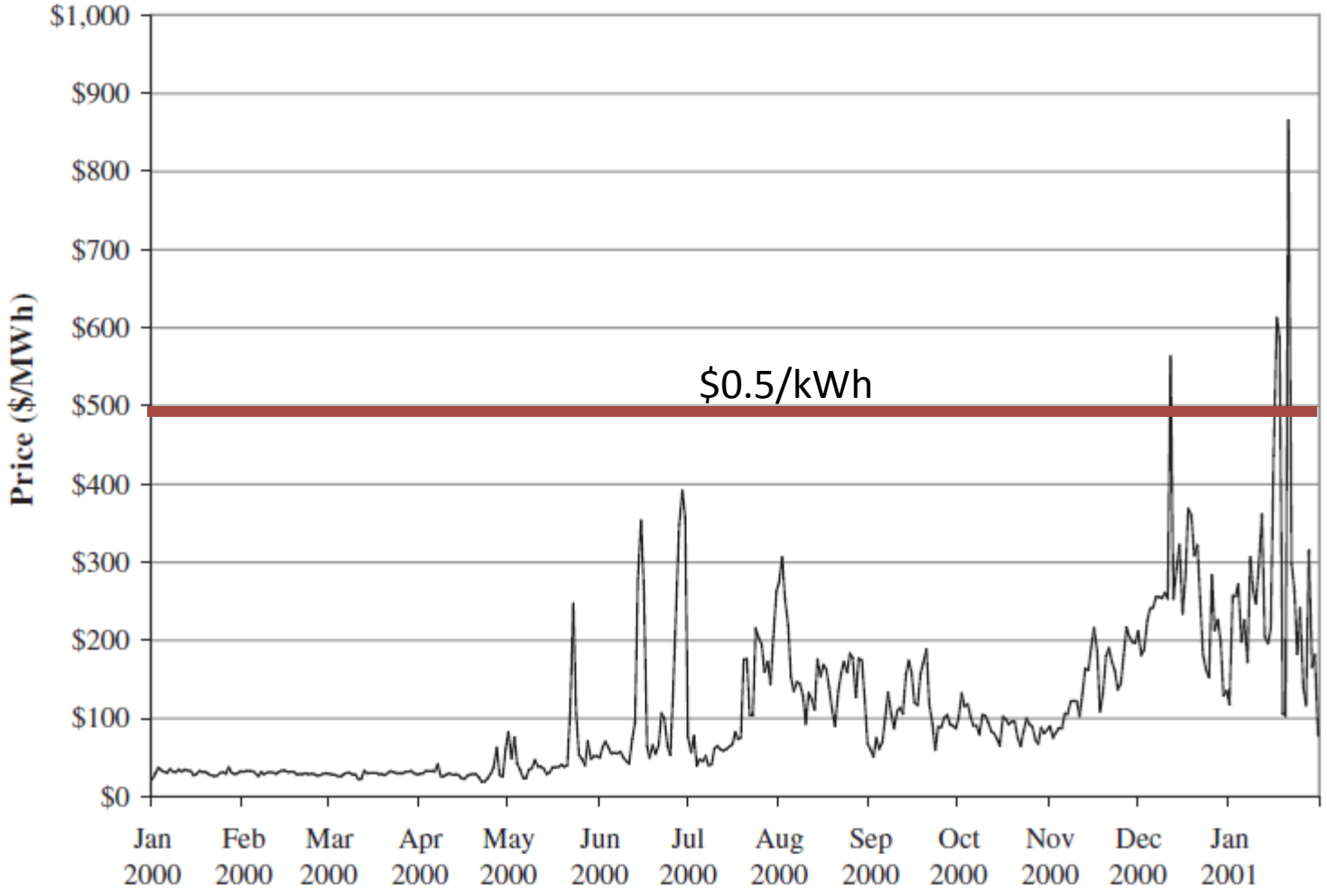
1970's and 1980's: Decoupling

Mid 70's: Decoupling fight (led by EDF) centers around **least cost planning**
Late 70's-80's: the advent of first EE efforts
1983: Standard Practice Manual provides Demand Side Management **cost-benefits calculations**
Mid 80's: Excess gen. causes program to languish

1990's: Deregulation

Early 90's: Program funding increases
Mid 90's: "Protocol Era" emphasizes M&V over eng. estimates
Late 90's: De-reg. shifts focus to **market transformation**; cuts funding; envisions transition to **purely private EE markets** by 2000's. Plans for an administrator independent of utilities hits legal and political obstacles.

CA's 2001 energy crisis: wholesale prices



Source: University of California Energy Institute(2006).