Shareholder Incentives for Utility-based Energy Efficiency Programs in California

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Motivation

How can we deliver energy efficiency programs in the most efficient manner, while ensuring ratepayers' support for the programs?

Outline

1. **The economics of utility-based EE programs**

   Introduction

   Model structure and assumptions

   Analysis of program implementation

2. **Utility-based EE programs in California**

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Energy Efficiency

- **A heightened awareness of EE**

  Energy costs reflected in the economy

  Global warming

  Energy dependency on politically unstable regions

- **Potentials for EE**

  Technical EE potentials: 33% of electricity and 40% of natural gas (Nadel, et al., 2004)

  More than $250 billion net benefits with widespread EE programs over the next 10-15 yrs (National Action Plan for EE, 2006).

Shareholder Incentives for EE

- **Investor-owned utilities (IOUs)**

  Serve 68% of electricity consumers and reap 66% of sales in the U.S.

  Have conflicting interests with ratepayers

- **IOUs' Financial barriers to EE Programs**

  ✓ **Hidden costs not reimbursed**

  Opportunity costs associated with reallocating limited resources to EE

  ✓ **Foregone supply-side earnings** (Stoft, et al., 1995)

  Earnings are based primarily on supply-side investments.

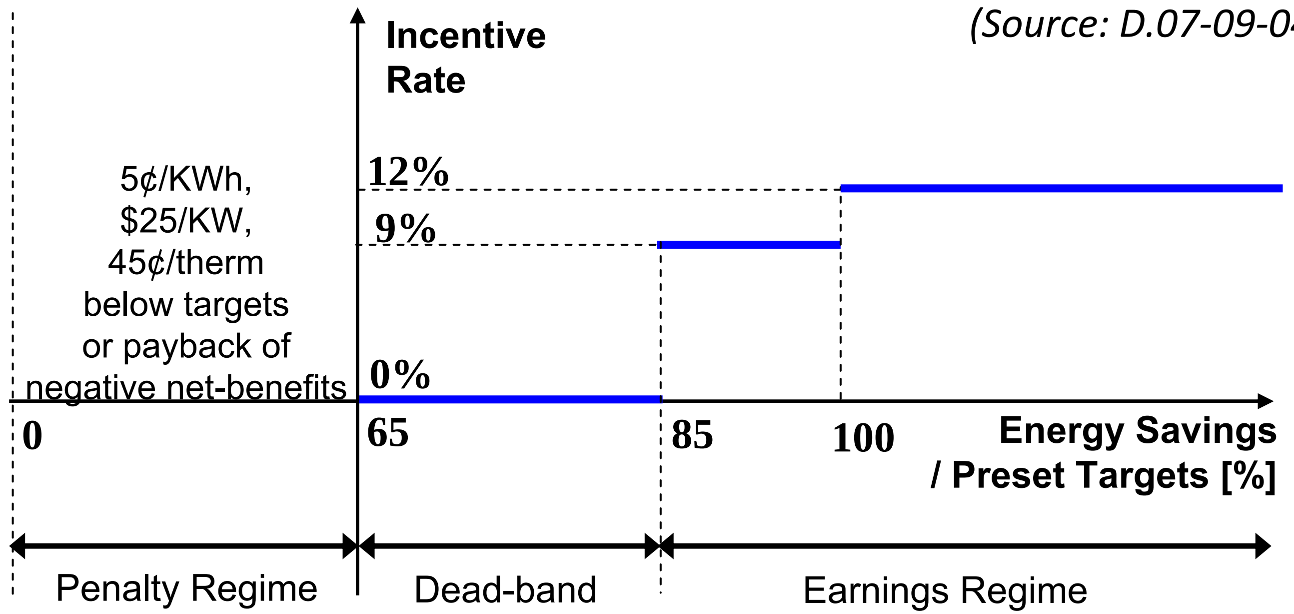
  → **Shareholder incentives for EE are required.**

Shared-Savings Incentive Mechanism

- **Provide utility shareholders with a share of a *net program benefit***

The shared-savings incentive mechanism adopted by the CPUC

(Source: D.07-09-043)



- **Dual-goals approach to Utility-based EE programs:**
  Maximizing net benefits while ensuring the achievement of preset energy savings targets

Research Questions

- **How would the welfare allocation to utilities and their customers vary with the specifications of the incentive mechanism?**

- **Would the shared-savings incentive mechanism encourage utilities to accomplish the dual goals of EE programs, and what reforms, if any, could be proposed?**

Related Work

- Loeb and Magat (1979) and Stoft, Eto, Kito (1995) discussed the efficient sharing rule for utility programs.
- Hurwicz and Shapiro (1978) and Holmstrom (1979) discussed the landlord-worker relationship under the “sharecropping model.”

➢ **This research investigates the efficient design of a shared-savings incentive mechanism for public-funded utility programs that are in place to accomplish the dual regulatory goals.**

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Model Structure

Stage 1: The regulator's choice

- **Adopts an energy savings target of *t*.**
- **Sets an incentive rate of *r* 2 (0,1].**

Stage 2: The utility firm's funding proposal

- **The firm proposes funding *K*.**
- **The proposal is authorized as long as *K* is no greater than the funding level that the regulator estimates in order for the firm to achieve *t*.**[y]

yConsistent with Decision 04-09-060

Stage 3: The utility firm's program management

- **Once *K* is authorized, the firm manages the programs with an energy savings productivity of *e*.**

Key Functions

- **The sharing rule:**

$$R = \begin{cases} r, & \text{if } x \geq t \\ 0, & \text{if } x < t \end{cases}$$

x : Achieved energy savings [GWh annual savings]

t : Energy savings target [GWh annual savings]

r : An incentive rate for the mechanism

- **Gross benefit of energy savings:**

$$B(x;\eta) = \eta\, x$$

x : Achieved energy savings [GWh annual savings]

η : Marginal energy savings benefit [$ million / GWh annual savings]

Key functions (continued)

- **Energy savings:**

$$x(K; e) = e\,K$$

x : Achieved energy savings [GWh annual savings]

e : Energy savings productivity [GWh annual savings / $ million]

K : Program funding [$ million]

- **Opportunity costs of managing EE programs:**

Hidden managerial costs and **foregone supply-side earnings**

$$\psi(e; \beta, \theta) = \frac{\beta}{2\theta} e^2$$

e : Energy savings productivity [GWh annual savings / $ million]

β : The size of the customer base

θ : Program management efficiency

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Requirement for incentive rate *r*

❖ Problem: What is the range of incentive rate *r* that encourages the firm to achieve its energy savings target *t* ?

> **PROPOSITION:**
>
> **The regulator's choice of *r* must fulfill the jointly sufficing constraint, so that the firm's program management will make both the firm and its customers weakly better off.**
>
> ***The jointly sufficing constraint:**
>
> **Minimum sufficing rate r_{min}**
>
> $$\frac{4^{-}}{t\,'\,{}^{3}\mu} \cdot \; r \; \cdot \; 1$$

Inverse

✓ **Definition: Design flexibility**

$$»(t;\,';\,^{-};\,\mu)\;'\;\frac{t\,'\,{}^{3}\mu}{4^{-}}$$

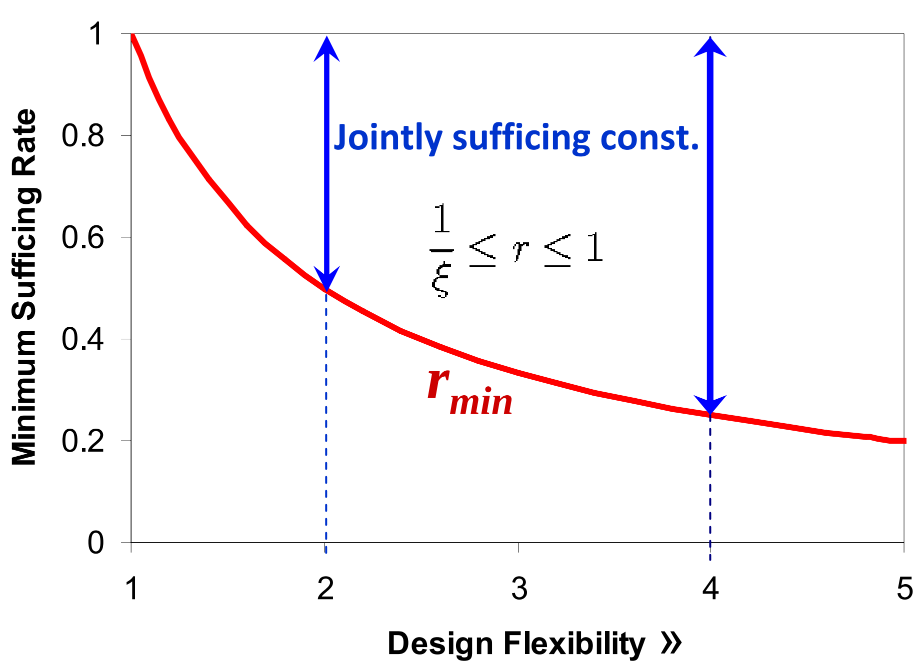
t : Energy savings target
η : Marginal energy savings benefit
β : The size of the customer base
θ : Program management efficiency

Design Flexibility » ´ t´ ³µ=4¯

✓ **Design flexibility » is *higher* for EE programs**

provided with a *higher* per-customer energy savings target,
managed by a firm with *higher* program management efficiency, and
implemented in areas with a *higher* marginal energy savings benefit.

- ➢ ***Greater* earnings opportunities for the firm**
- ➢ **A *more complete* set of design choices for the regulator**



t : Energy savings target
η : Marginal energy savings benefit
β : The size of the customer base
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Joint Welfare Maximization

- Problem: How can we set incentive rate *r* to accomplish the greatest possible joint welfare, while ensuring the achievement of target *t* ?

> - **PROPOSITION:**
>
> **The socially efficient incentive rate is**
>
> $$r^{S*} = \begin{cases} (1/4\lambda)^{1/3}; & \text{if } \lambda > 2 \\ 1/\lambda; & \text{if } 1 \le \lambda \le 2 \end{cases}$$
>
> **where** λ **is the design flexibility defined as** $\lambda \equiv t(\eta/4\beta).$

Note: the jointly sufficing constraint, $1/\lambda \le r \le 1$.

t : Energy savings target
η : Marginal energy savings benefit
β : The size of the customer base
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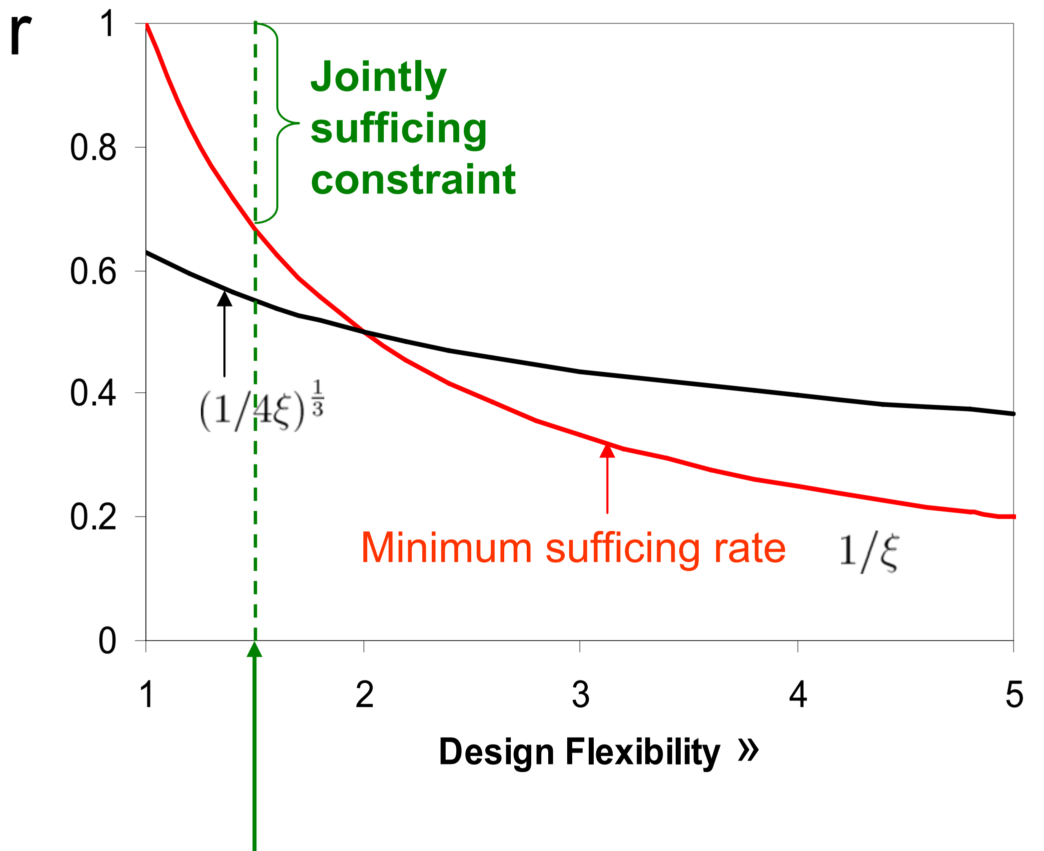
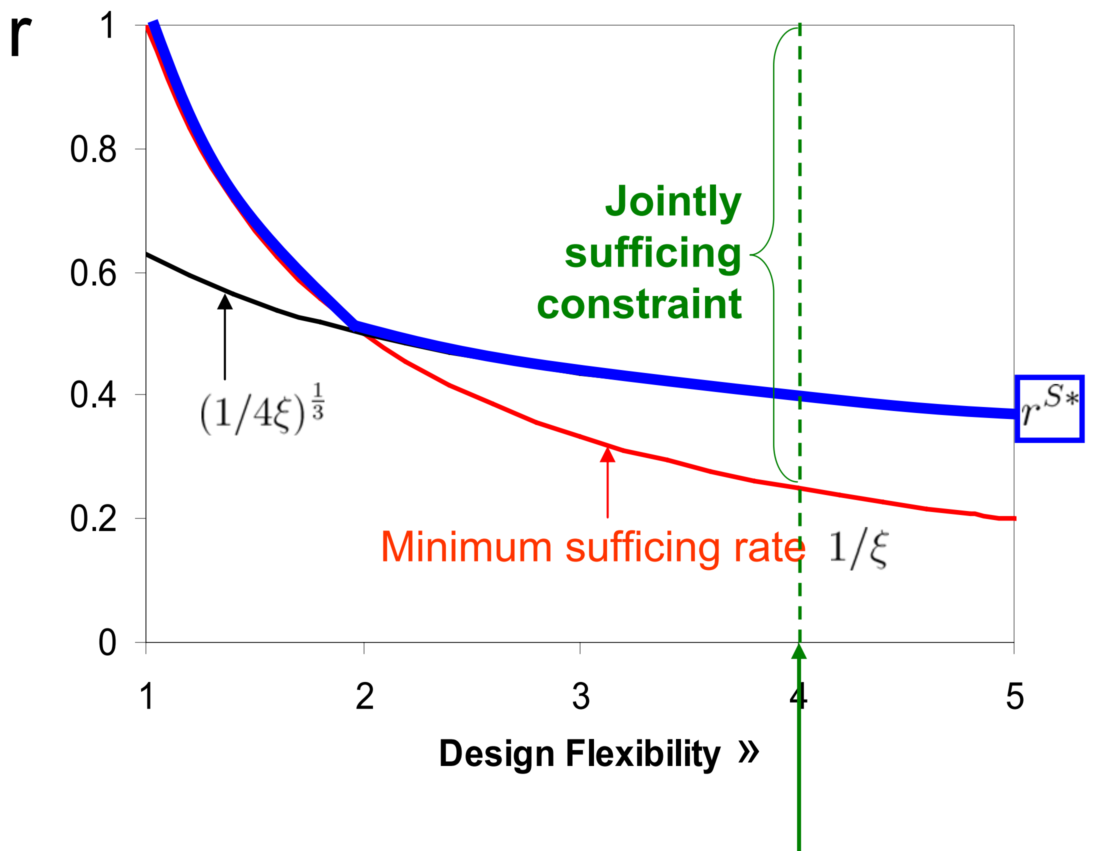
Intuition for the Proposition



EE programs with a limited level of ξ

- The **minimum sufficing rate** is efficient.
- The firm gains **zero** net earnings.

Intuition for the Proposition



EE programs with a sizeable level of »

- A **higher-than-minimum** incentive rate is efficient.
- The firm gains **positive** net earnings.

Preferences of the stakeholders

❖ Problem: What are the implications of an adopted incentive rate for the utility firm, its customers, and society as a whole?

➢ **PROPOSITION:**

When there exists any jointly sufficing incentive rate, the socially efficient incentive rate r S¤ **lies between the customers' preferred incentive rate** r C¤ **and the firm's preferred incentive rate** r F¤**, which is represented by**

$$\frac{1}{»} \cdot r^{C¤} \cdot r^{S¤} \cdot r^{F¤} = 1;$$

where the strict inequality $r^{S¤} < r^{F¤}$ **holds if** $» > 1;$

$r^{C¤} < r^{S¤}$ **holds if** $» > 2;$ **and**

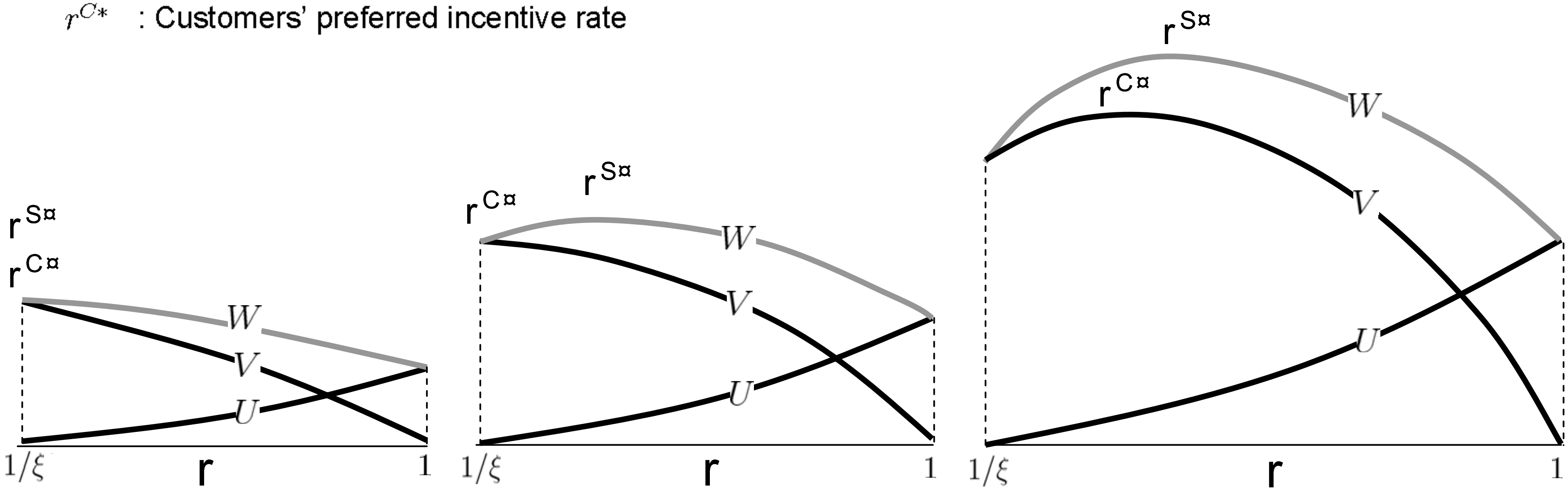
$1 = » < r^{C¤}$ **holds if** $» > 3:$

Design flexibility » ´ t´ ³μ=4¯

Intuition for the Proposition

Impacts of incentive rate r on utility welfare U, customer welfare V, and joint welfare W under different ranges of design flexibility »

$1/\xi$: Minimum sufficing rate
r^{S*} : Socially efficient incentive rate
r^{C*} : Customers' preferred incentive rate



1 < » < 2   2 < » < 3   » > 3

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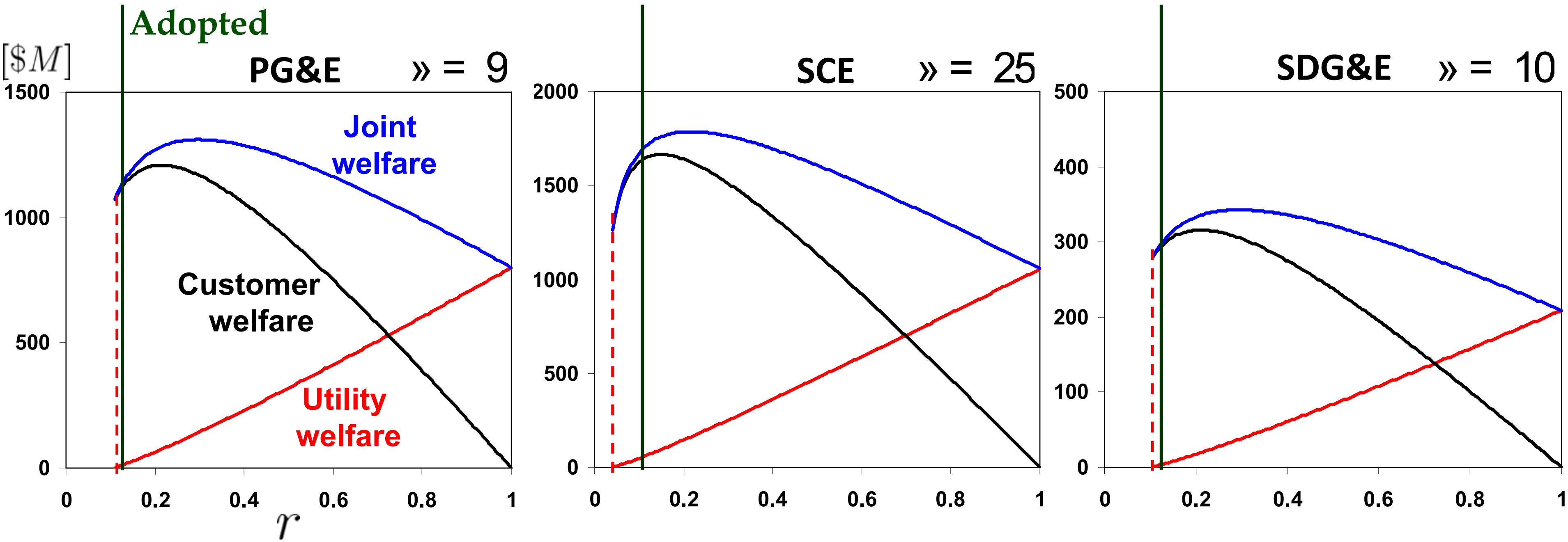
Base Predictions for the 2009-2011 EE programs

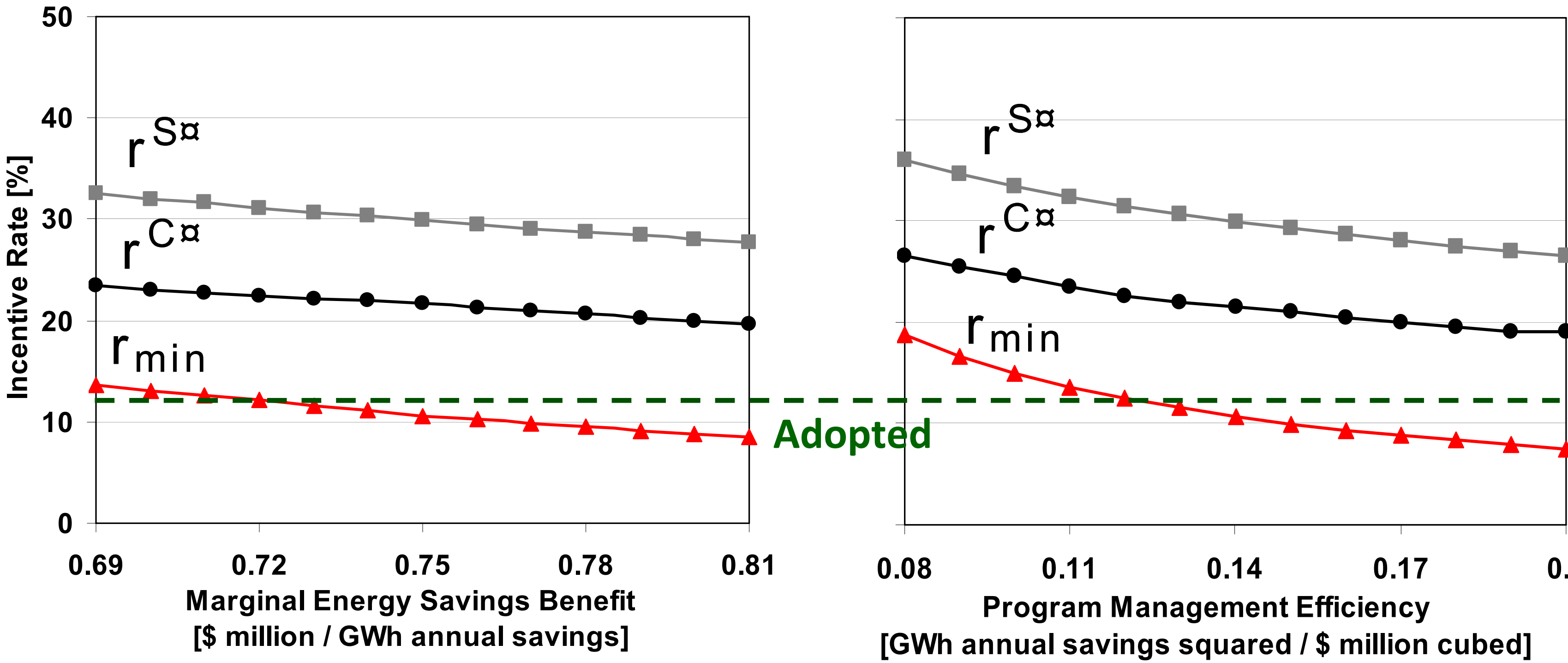


Targets [GWh annual savings]: 3,169 for PG&E, 3,528 for SCE, and 818 for SDG&E
Customer base [million]: 5.0 for PG&E, 4.67 for SCE, and 1.32 for SDG&E
Program management efficiency: 0.14 for PG&E, 0.31 for SCE, and 0.15 for SDG&E (based on 2006-2008 programs)
Marginal energy savings benefit [$million/GWh annual savings]: 0.75 for all the programs

- **The adopted incentive rate** (12%) **would encourage all utilities to achieve their energy savings targets.**
- **A higher-than-adopted incentive rate can be warranted.**
- **Customized deployment of incentive rates for individual utilities can enhance social efficiency.**

Sensitivity Analysis for PG&E's EE programs

❖ Problem: What are the problems with the CPUC's order (Decision 07-09-043) to keep the adopted mechanism in effect for subsequent program cycles as well?



- **Regular updates of the incentive mechanism can enhance social efficiency.**

Conclusions

1. **Each utility firm requires a certain minimum level of incentive rate in order for the shared-savings mechanism to encourage the firm to achieve an energy savings target, eventually bringing non-negative bill savings to customers.**

2. **With sizeable design flexibility, a higher-than-minimum incentive rate could achieve not only greater joint welfare but also greater customer welfare.**

3. **Model-based analysis of California EE programs suggests**

- The CPUC-adopted incentive rate may not suffice to produce not only the greatest possible joint welfare but also the greatest possible customer welfare. A higher-than-adopted incentive rate can be established.
- Social efficiency can be improved by customizing incentive mechanisms for individual utilities and updating them on a regular basis.

Thank you for your attention

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Dual-goals Approach to Utility-based EE

- **Implement a series of EE programs, guided by particular energy savings targets for each program cycle, such that**
  each program cycle produces the greatest possible net benefit, while ensuring the achievement of the preset targets.

"The commission's overriding goal is to pursue all cost-effective EE opportunities over both the short- and long-term…The Commission translated this policy into specific annual and cumulative numerical goals for electricity and natural gas savings" (CPUC Decision 05-04-051).

"The program administrators shall demonstrate that their proposed level of EE program activities and funding is consistent with the Commission's-adopted electric and natural gas savings goals" (CPUC Decision 04-09-060).

Impacts of EE Program Implementation

- **The utility firm's net earnings (*U*):**

$$U = \max_{e} \; r\{\eta x - K\}^{+} - \psi$$

Net program benefit ($\eta x - K$) — Opportunity costs (ψ)

- **The customers' bill savings (*V*):**

$$V = (1 - r)(\eta x - K)|_{e = e^{*}}$$

- **Net social benefit (*W*):**

$$W \equiv U + V = (\eta x - K - \psi)|_{e = e^{*}}$$

x : Achieved energy savings
t : Energy savings target
r : Incentive rate for the mechanism
e : Energy savings productivity
η : Marginal energy savings benefit
K : Program funding
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EE Program Implementation at Equilibrium

❖ Problem: Then how will the EE programs be implemented?

Stage 1: The regulator adopts incentive rate *r* fulfilling the jointly sufficing constraint.

Stage 2: The utility firm proposes $K^* = (\beta t / \eta r \theta)^{\frac{1}{2}}$ **and the regulator authorizes the proposal.**

Stage 3: The utility firm achieves target *t* , no more or less, with the energy savings productivity of $e^* = (\eta r t \theta / \beta)^{\frac{1}{2}}$**, incurring the opportunity costs of** $\psi^* = \eta r t / 2.$

x : Achieved energy savings
t : Energy savings target
r : Incentive rate for the mechanism
e : Energy savings productivity
η : Marginal energy savings benefit
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Predicted Impacts of EE Programs

Predicted impacts of average EE measures of the 2006-2008 programs
(Calculated from D.04-09-060 and D.05-09-043)

	Benefits / MWh annual savings	y PACs / MWh annual savings	Net program benefits / MWh annual savings
PG&E	$760	$340	$420
SCE	$750	$210	$540
SDG&E	$680	$310	$370

y Program Administration Costs (PACs): customer incentives and rebates, installation costs, operating costs, and marketing and outreach costs

- SCE is believed to exhibit the *greatest* energy savings productivity.

✓ *Suppose* that, in the funding authorization, the CPUC accounts for energy savings productivity that each utility will exhibit under the incentive mechanism and its program management efficiency.

  - Rough estimates of program management efficiency: 0.14 for PG&E, 0.31 for SCE, and 0.15 for SDG&E

Appendix

Minimum Earnings Requirement for EE programs

- **Problem: What is the minimum earnings requirement or, equivalently, opportunity costs associated with EE programs, and how some of the earnings requirement can be verified?**

2006-2008 EE programs	Model-based program management efficiency	Model-based opportunity costs [$million]	Supply-side comparable earnings† [$million]		
			‡ TURN's calculation	CPUC's Calculation §	Utilities' calculation §
PG&E	0.20-0.08	106-264	0-36	177-275	272
SCE	0.45-0.17	117-294	0-41	201-312	312
SDG&E	0.21-0.08	32-80	0-10	50-77	62
Total	-	256-638	0-87	428-664	646

?

† Supply-side comparable earnings: foregone shareholder earnings from supply-side projects that are displaced by the 100% achievement of energy savings targets (calculated from D.07-09-043)
‡ TURN: The Utility Reform Network, a ratepayer coalition.
§ Shareholders' alternative investment opportunities were *not* taken into account.

- Inflated supply-side comparable earnings plus missing hidden opportunity costs: the CPUC regarded its comparable earnings estimates as the utilities' minimum earnings requirements for EE programs. → ***the incentive rate of 12%***