Marginal Cost Electricity Pricing and Greenhouse Gas Reductions

By Lee S. Friedman
Professor of Public Policy
Goldman School of Public Policy
University of California
Berkeley, CA 94720-7320
(510) 642-7513
lfried@berkeley.edu

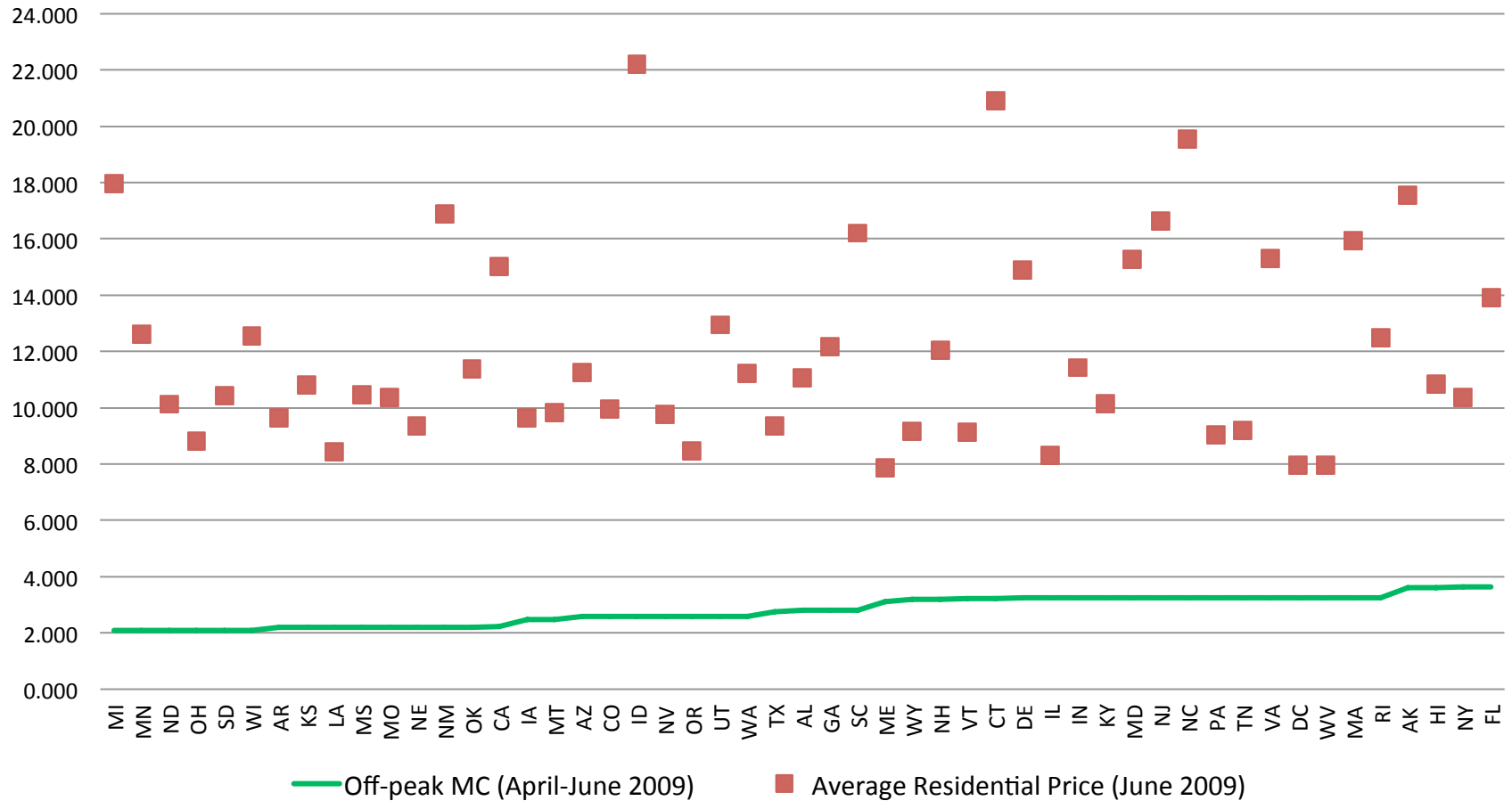
Overview

- Offpeak electricity has the potential to deliver substantial GHG reductions (e.g. vehicle electrification in CA would reduce GHG by 60% and currently vehicles emit > 40% all GHGs)
- Big Problem: substantial mispricing of offpeak electricity. It's average price in U.S. to residential consumers is $.12/kwh, 331% above its ≈$.03 MC. In CA, MC is same but average price is $.15/kWh, and many consumers face rates in the $.38-.44/kWh range.
- Time-of-use (TOU) electricity pricing is a crucial part of the solution.
  - Focus here not on time-shifting electricity use but on substituting electricity for gasoline and diesel fuel consumption. Prior electricity price elasticity estimates do not reflect this possibility.
  - With current battery technology for PHEVs and EVs, a $.03/kWk MC is equivalent to gasoline just under $1.50/gallon—so off-peak electricity compared to current gasoline prices of $4.00/gallon should be a great bargain.
- Only 1% of U.S. residential consumers are on time-of-use (TOU) rates that distinguish peak and off-peak prices. Even existing TOU rates are a big problem: average off-peak TOU price is $.075/kwh, almost 3x MC. CA's special new EV rates may be worse than this, e.g. PG&E E-9 is tiered with offpeak rates that will be $.16-.20 for most users.
- Sources of the Problem: Meters, Rate Design, and Customer Status Quo Bias
- Solutions: Universal smart grid w/smart meters by 2020, MC-based TOU Rate Designs, Mandatory TOU for all electricity customers

What is the MC of Offpeak Electricity?

- In many parts of the country, there are competitive, real-time wholesale markets for electricity. These markets determine "locational marginal prices" (LMPs) that are the prices delivered to the "door" of a receiving electricity distribution company. They vary by hour, day, and year depending primarily on fuel costs at the marginal generating plant. The off-peak LMPs are almost all of the off-peak MC to a residential consumer.
- In addition to the LMPs, there are minor expenses involved in maintaining grid balance and reliability even during off-peak hours (ancillary services). I include these in off-peak MC (≈ 3% of LMP).
- In addition to the off-peak wholesale MC, there is the additional marginal distribution cost of getting the electricity from its grid LMP location to the actual residential consumer. Most of the distribution cost in the U.S. (which averages $.017/kwh) does not actually vary with kwhs—it is a nonmarginal expense (e.g. billing, administration, routine maintenance). But there are minor marginal expenses like line losses (≈6-7% LMP); I add 10% of LMPs for the marginal distribution cost (treating 20% of distribution expenses as marginal).
- 33 states (and DC) served by ISOs, generally good data. For 17 others, have good data on average wholesale price from EIA. Estimate off-peak wholesale cost by using average (off-peak LMP/average EIA) from all ISO states, and then include same factors as above.
- For April-June 2009, off-peak MC in U.S. averages $.02794/kwh.
- From 2003-2010 in PJM (western PA), $.03-$.05 for 7 years, 2008 unusual year $.06

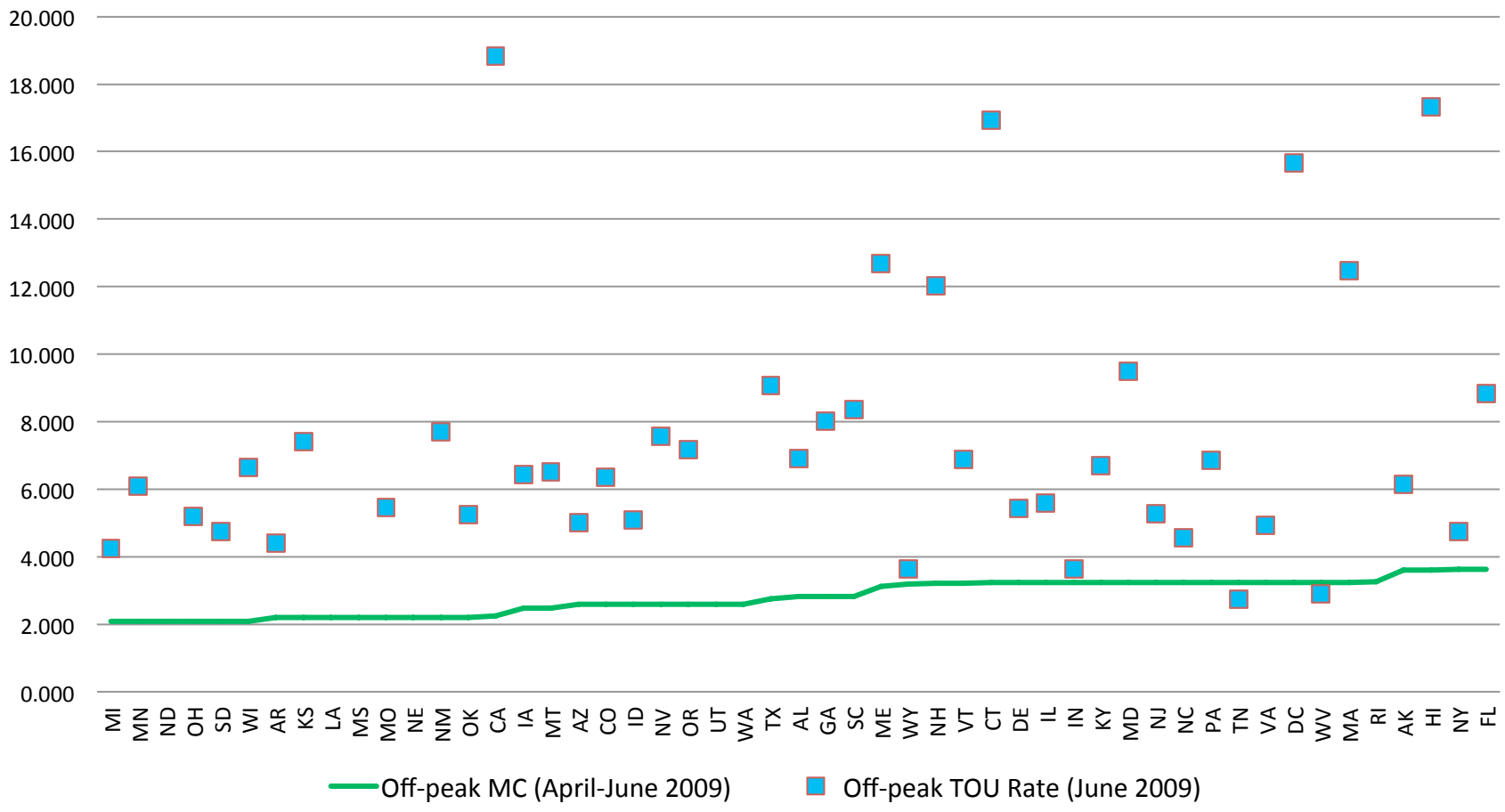
Average Electricity Rates and Offpeak MCs in the U.S.



How close are rates to offpeak MC?

- Since barely more than 1% of U.S. residences are on TOU rates, the average residential rate in each state is the best single measure. For June 2009, the U.S. average of these rates is 12.05 cents/kwh, 331% higher than the 2.79 cent/kwh off-peak MC.
- The average hides the tiered-rate structures that are common, with some consumers on tiers with below-average rates, and some on above-average tiers. In CA, many consumers have tier rates > 1000% above MC.
- For the 1.3% of residences on TOU rates, we chose a sample of one distribution company w/ resdtl TOU from each state, drawn where possible from the respondents to the FERC 2008 Demand Response and Advanced Metering Survey. 7 states had no such entity that FERC or we could identify. We used rates in effect during June 2009. The average off-peak TOU rate in this sample is 7.452 cents/kwh, still almost 3x higher than off-peak MC.
- **Conclusion: off-peak electricity is mispriced and far above its MC**

Offpeak Electricity Rates



Barriers to MC-based Off-peak Rates

- Meters
  - FERC 2010 Survey: 8.9% U.S. residences have smart meters
  - Some states like CA & CT have required full deployment, but takes 5-7 years w/new technology (planning, testing, adaptability)
  - Numerous other states doing something, mostly pilots. FERC thinks BAU will mean < 40% deployment by 2019.
  - This is too slow! A good goal for DOE is to induce 100% by 2020.
- TOU Rate Design
  - Current rates are high because fixed costs, stranded costs, rolled into per kwh charges
  - At least 2 simple ways to have MC rates, same cost recovery, w/minimal bill change
    - Baseline method: only changes from historical consumption pattern assessed at MC (in use by Georgia Power for commercial & industrial real-time pricing customers); gives rebate for conservation
    - Two-part tariff: MC rates w/ constant "infrastructure" charge per customer to raise revenues to appropriate total, group customers by historic consumption and have higher "infrastructure" charge for each group.

Standard Two-Part Tariff:

$$FC = (RR - MCR)/n \qquad (1)$$

where FC = Fixed Cost, RR = Revenue Requirement, and MCR = Marginal Cost Revenue

Friedman-Weare (1993) Two-Part Tariff:

For *k* groups, set FC_1, FC_2, …, FC_k such that

$$FC_i = (RR - MCR - (\sum_{j \neq i} n_j FC_j))/n_i \text{ for } i = 1,2,\ldots k \qquad (2)$$

where n_i is the number of customers in group *i*.

The Proportionality Rule: the fixed fee for each group *i* rises proportionately with its average consumption $\overline{Q}_i$. Then the following relation will hold:

$$FC_i/FC_j = \overline{Q}_i/\overline{Q}_j \qquad \text{for all } i, j \qquad (3)$$

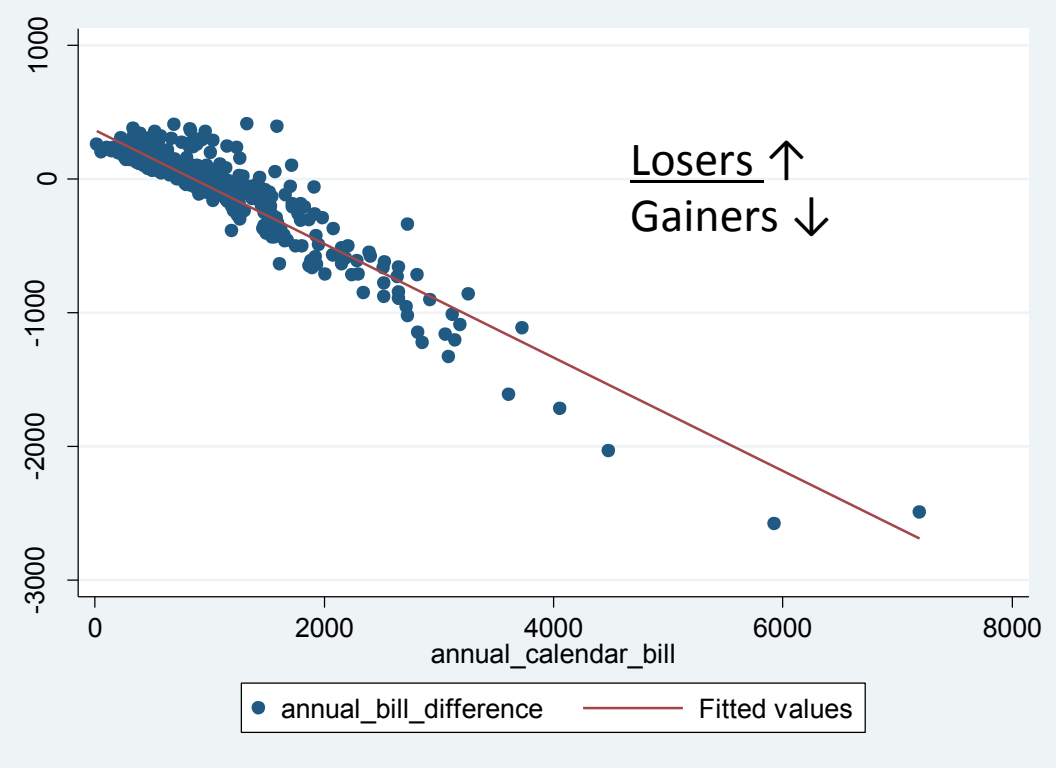
Equations (2) and (3) will solve for the FC_i for any group definitions given values of the other parameters (n_i, $\overline{Q}_i$, *RR*, *MCR*).

Status Quo Equity Rule: the fixed fee assigned to each group *i* holds that group's contribution to the revenue requirement RR_i constant, with $\sum_i RR_i = RR$. Then

$$FC_i = RR_i/n_i - MCR(\overline{Q}_i) \qquad \text{for all } i \qquad (4)$$

where $MCR(\overline{Q}_i)$ is the marginal cost revenue at the average consumption level in group *i*. Since *MCR*(*Q*) is linear in *Q*, equation (4) for all *i* ensures that equation (2) holds.

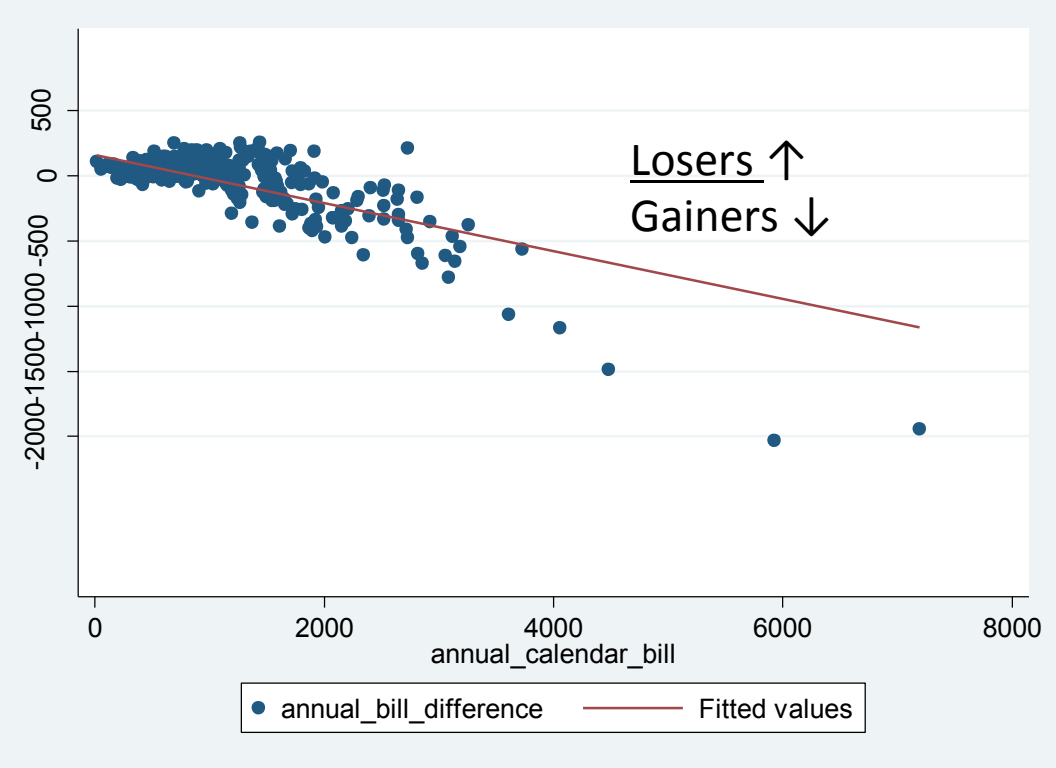
TOU 2-7PM Peak Plan ($.30/kWh peak, $.05/kWh offpeak)
Applied to Representative California Residential Population
Regressive TOU27 Bill Differences with **Standard Two-Part Tariff Fixed Fee**
$249.12 annually or $20.76 monthly
(Bill difference is positive if TOU27 Bill > Original Bill)



Difference = 366.0315 - .4252*Bill R^2 = .86
(10.49) (.01)

Less Regressive TOU27 Bill Differences with **Proportionality Rule** applied to quintiles

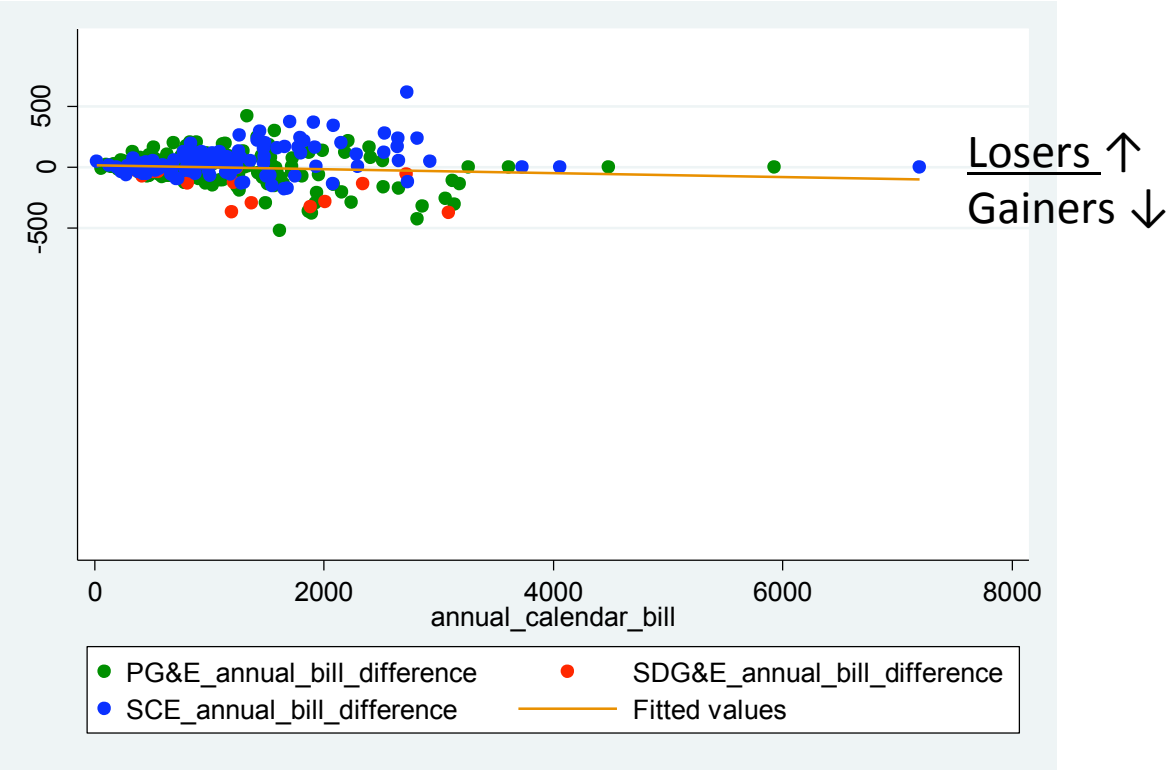
(Bill difference is positive if TOU27 Bill > Original Bill)



Difference = 158.6407 - .1838761Bill R^2 = .50

(11.06) (.01)

The **Status Quo Equity Rule** is neutral with respect to small and large users in terms of bill differences caused by a switch to a TOU27 plan



Difference = 14.5227 - .0159069Bill R^2=.01
(9.42) (.01)

Barriers to MC-based Offpeak Rates

- Getting Customers on TOU: Nudge or Shove?
  - Now, customers must "opt-in" if they want TOU
  - If TOU made the default (customers can "opt-out"), huge difference because of "status quo" bias
    - 401k contributions after 3-years employment: 65% when opt-in, 98% when opt-out
    - Organ donations: 12% in Germany under opt-in, 99.98% in Austria under opt-out
    - Messenger, CA Energy Commsn based on statewide pilot of critical peak pricing for which very high (90%) reported satisfaction of customers: 10-15% if opt-in, 60-75% if opt-out
    - CA only state so far to have adopted TOU as the default, restricted by SB695 to be after 2012, after one year's smart meter data showing a comparison of TOU and nonTOU bills, and with customer "bill protection" for one year (annual bill <= the time-invariant plan).
  - Does retail competition solve this? Not yet
    - "price to beat" standard offer always put as time-invariant rate
    - The competing retailers often don't control meters: e.g. in Texas, all meters controlled by Oncor Electric Delivery
  - What about mandatory TOU?
    - CT is only state to have this so far, effective when its smart meters are deployed
    - Economists generally dislike "mandatory", respect for consumer preference
    - But time-invariant rates are egregious mispricing just as most agricultural commodity subsidy programs: they subsidize very costly, environmentally challenging peak consumption and they penalize off-peak consumption to our environmental detriment. Continued use will cause great social harm
    - Time-invariant rates are a historical anachronism, no longer necessary, and not affordable
  - Answer: CT is correct, TOU rates should be made mandatory

Summary

- Big problem of mispriced, overly expensive off-peak electricity throughout the U.S. It is more than 4x MC for most residences, and more than 2x MC for the 1% on TOU rates.
- This is huge impediment to efficient GHG reductions as it wrongly discourages vehicle electrification and other GHG-reducing options
- Barriers: lack of smart meters, poor TOU rate design, and "status quo" bias of consumers
- Solutions: speed up smart meters to 100% deployment by 2020, use consumer-friendly MC-based rate designs for TOU, and make them mandatory.