The Impact of Retail Rate Structure on the Economics of Commercial Photovoltaic Systems in California

Ryan Wiser, Andrew Mills, Galen Barbose & William Golove

State Energy Advisory Board Meeting
Berkeley, CA
August 14, 2007

The Electricity Markets and Policy Group

Conducts research and provides assistance to policy makers on issues related to:

- **Energy Efficiency and Demand Response (Chuck Goldman)**
  - Tracking industry trends
  - Program administration, planning, implementation, and evaluation
  - Rate design and ratemaking
  - National Action Plan for Energy Efficiency support and informational resources
- **Renewable Energy (Ryan Wiser)**
  - Renewable portfolio standard (RPS) design
  - Renewable resource acquisition planning
  - Economic analysis and market assessment of renewable technologies
- **Resource Planning (Goldman, Wiser)**
  - Comparative analyses of utility integrated resource plans (IRP) and practices
- **Electric Reliability (Joe Eto)**
  - CERTS program management, R&D project development and implementation

Other current group members: Galen Barbose, Ranjit Bharvirkar, Mark Bolinger, Pete Cappers, Kristina Hamachi-LaCommare, Nicole Hopper, Nancy Lewis, Andrew Mills, Diana Sexton

PV Rate Analysis Project Overview

Motivation and Context

- Utility bill savings represent a major (if not the primary) financial benefit for customers that install grid-connected photovoltaics
- Retail rate structures – especially for commercial customers – can vary substantially, with potentially significant implications for the value of bill savings from PV

Objective

- Evaluate the impact of retail rate design on the customer-economics of grid-connected PV, focusing on commercial rates in California
- Also examine the value of offering multiple rate options and net metering

Data and Methodology

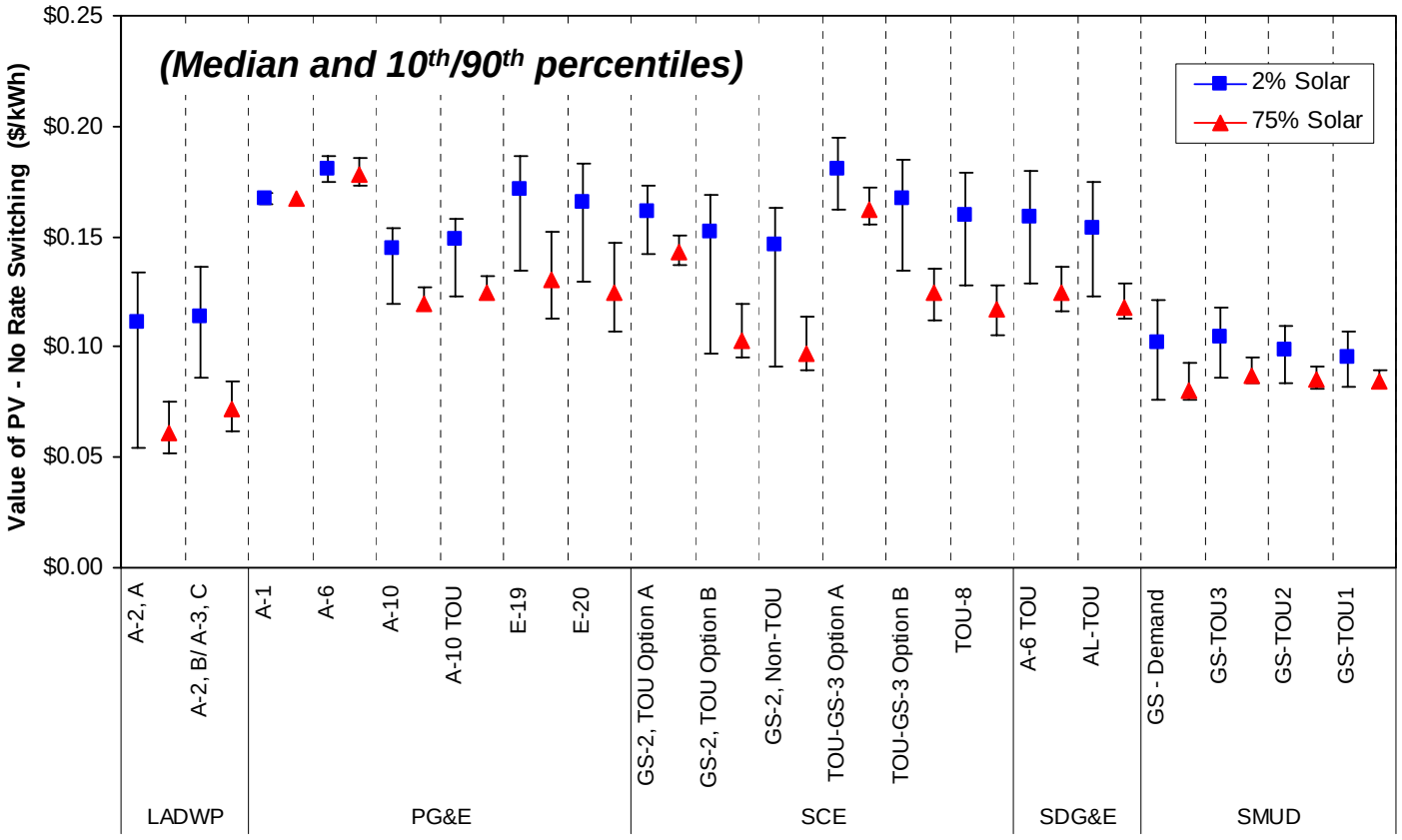
- Computed utility bill savings across 20 commercial rates currently offered by California's five largest electric utilities (PG&E, SCE, SDG&E, LADWP, and SMUD)
- Based on building load and PV production data from 24 actual commercial PV installations in California
- Scale PV data for each site so that annual production is equal to various specific percentages of annual building load ("PV penetration level"), focusing on 2% and 75% boundary cases

Commercial Electricity Rates in CA

- Typically include three main types of charges:
  - Volumetric energy charges
  - Demand charges
  - Fixed, recurring customer charges
- Rates differ in terms of both the allocation of costs among these charges and the structure of the charges themselves
- Volumetric energy charges
  - $/kWh rates may be flat, seasonal, or time-of-use (TOU)
- Demand charges
  - Billing demand may be established on a monthly or rolling annual basis
  - May be based on maximum demand occurring over all hours or during specific time-of-day (TOD) periods
  - $/kW rates may vary by season or remain constant over the year

The Value of Bill Savings Varies Widely Across Rates

The figure shows the distribution in the value of PV across customers, for each rate, at 2% and 75% penetration levels



- Variation across rates reflects differences in rate *structure* and rate *level*
- Drop off from 2% to 75% is quite pronounced for some rates, less so for others
- Variation across customers is much larger for some rates than others

Key Findings: Rate Design

1. Differences in rate design lead to variation in the median value of bill savings of 25-75%
2. Demand charge savings can be substantial at low PV penetration levels, but exhibit steeply diminishing marginal returns with increasing PV penetration
3. Demand charge savings are negligible for customers with flat or inverted load profiles when demand charges are not TOD-based
   - For customers with an afternoon peak load shape, demand charge savings are much greater and are less dependent on the type of demand charge
4. Energy charge savings are approximately 20% greater for TOU rates with a high spread between peak and off-peak prices, compared to rates with seasonal or flat energy charges

Key Findings: Other Rate-Related Issues

Multiple Rate Offerings

- The optimal (i.e., least cost) rate depends on the PV penetration level:
  - If PV penetration > 50%, all customers would minimize their bill by switching to the rate with the lowest demand charges
  - If PV penetration < 50%, the optimal rate depends on the customer's underlying load shape

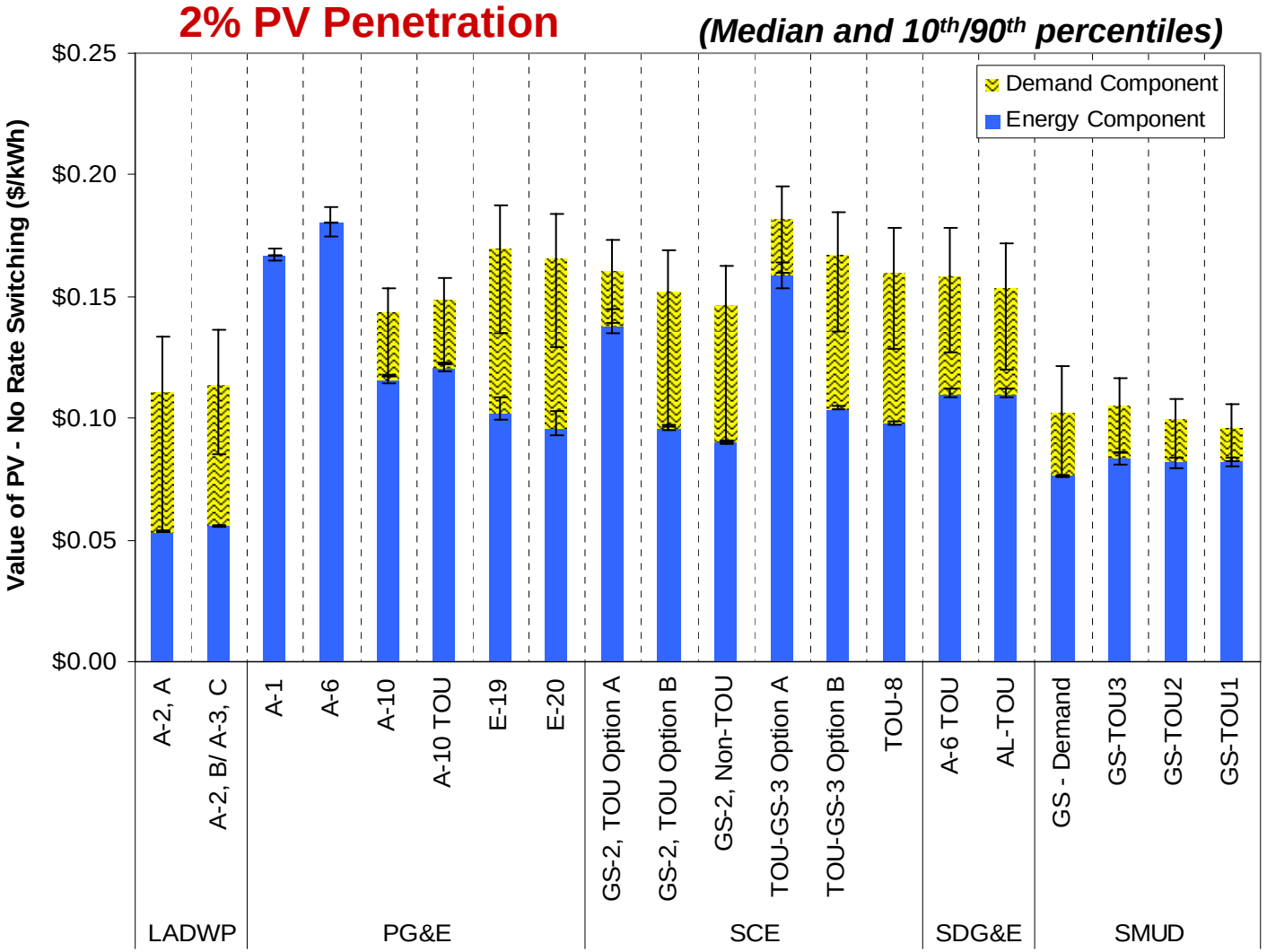
Net Metering

- Net metering provides substantial value at high PV penetration levels, but minimal value if PV penetration ≤ 25%
- Net metering is two-to-three times more valuable for customers with flat or inverted load profiles than for those with afternoon peak load shapes

Policy Implications

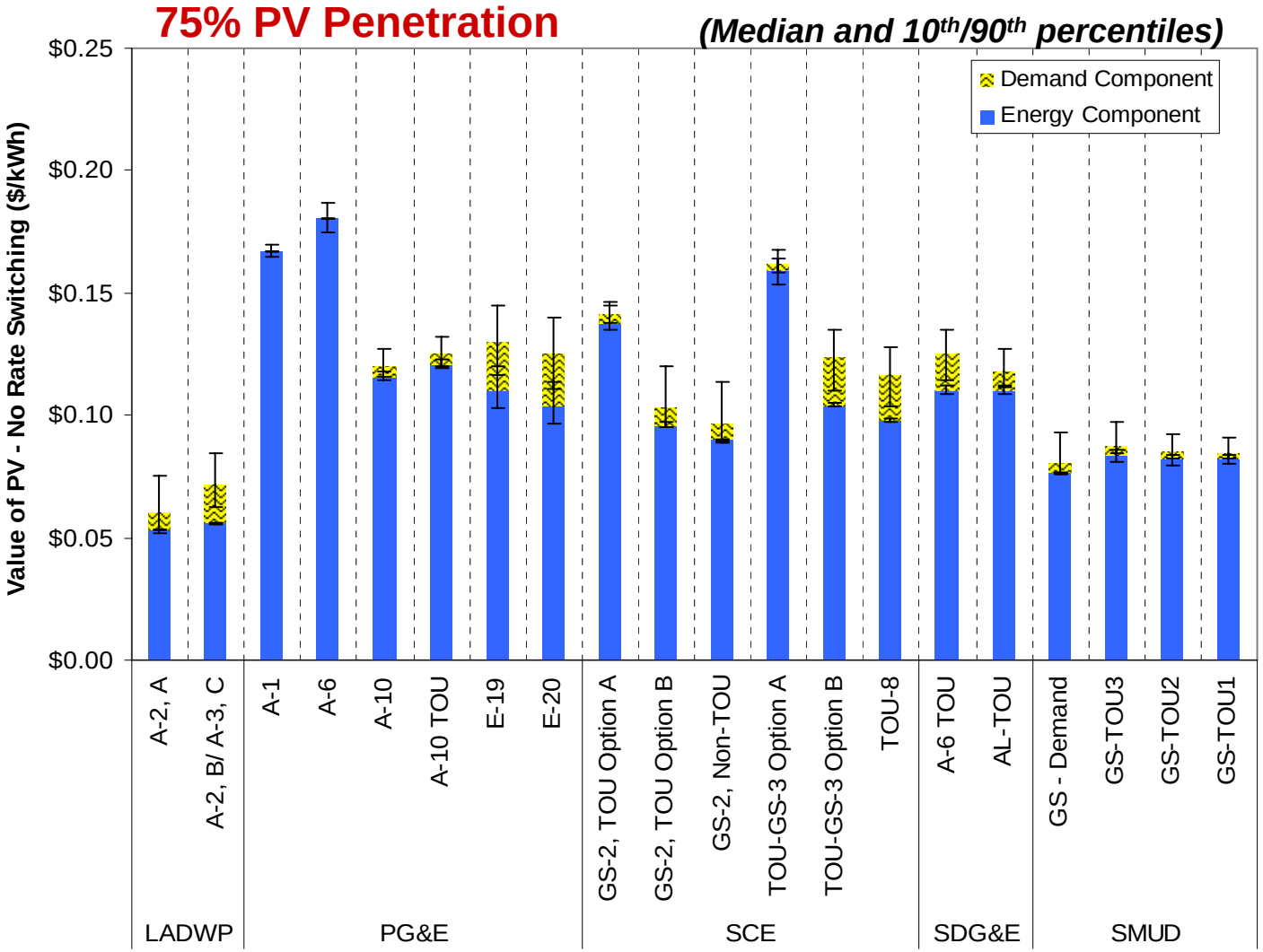
- Rate design is fundamental to the economics of commercial PV
- PV adoption among a diverse range of commercial customers can be supported by offering rates that recover costs primarily through:
  - Volumetric charges
  - Structured as TOU with a large peak to off-peak price spread
- However, requiring that customers with PV switch to such rates could undermine the economics in some circumstances
- Net metering provides significant value for PV systems that serve a large percentage of building load
  - Lack of net metering will tend to discourage large systems, as well as PV adoption by customers with flat or inverted load shapes

Demand Charge Savings Can Be Substantial at Low Levels of PV Penetration



- For some rates, >50% of the value of PV can come from reduction in demand charges at 2% PV penetration
- Demand charge reductions are highly customer-specific, as indicated by wide percentile bands

But Decline Substantially at Higher PV Penetration Levels (per kWh produced)

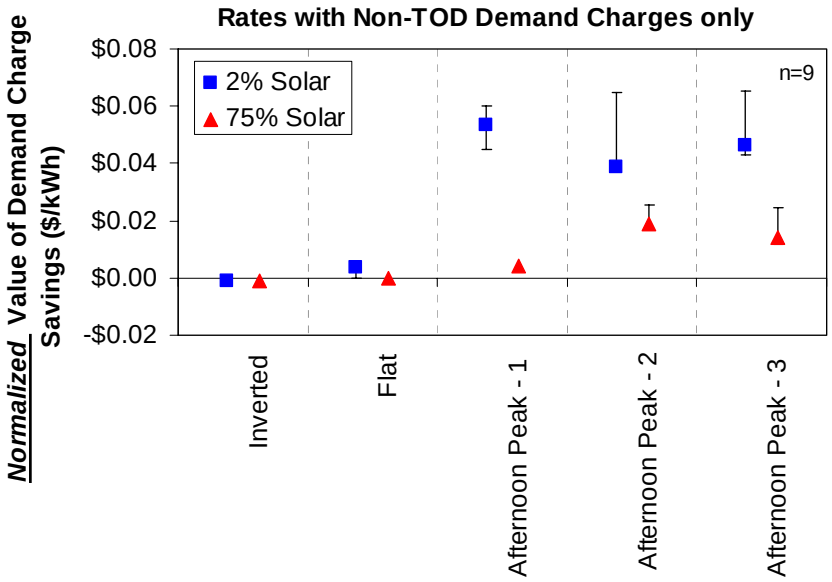


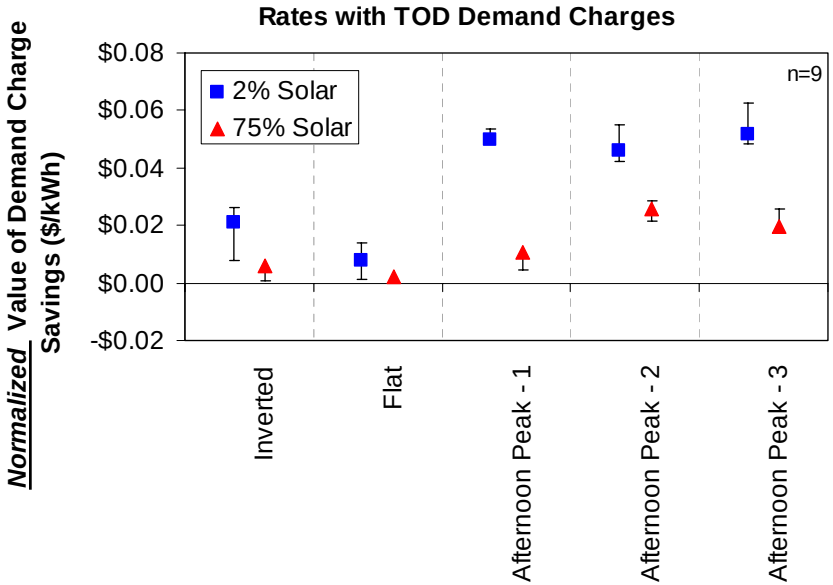
- Rates with high demand charges become significantly less attractive at high PV penetration
- In comparison, energy charge savings vary little across PV penetration levels or customers

Demand Charge Savings Are Much Lower for Facilities With Flat or Inverted Load Profiles

The figures compare demand charge savings for five representative customers across rates with and without TOD-based demand charges

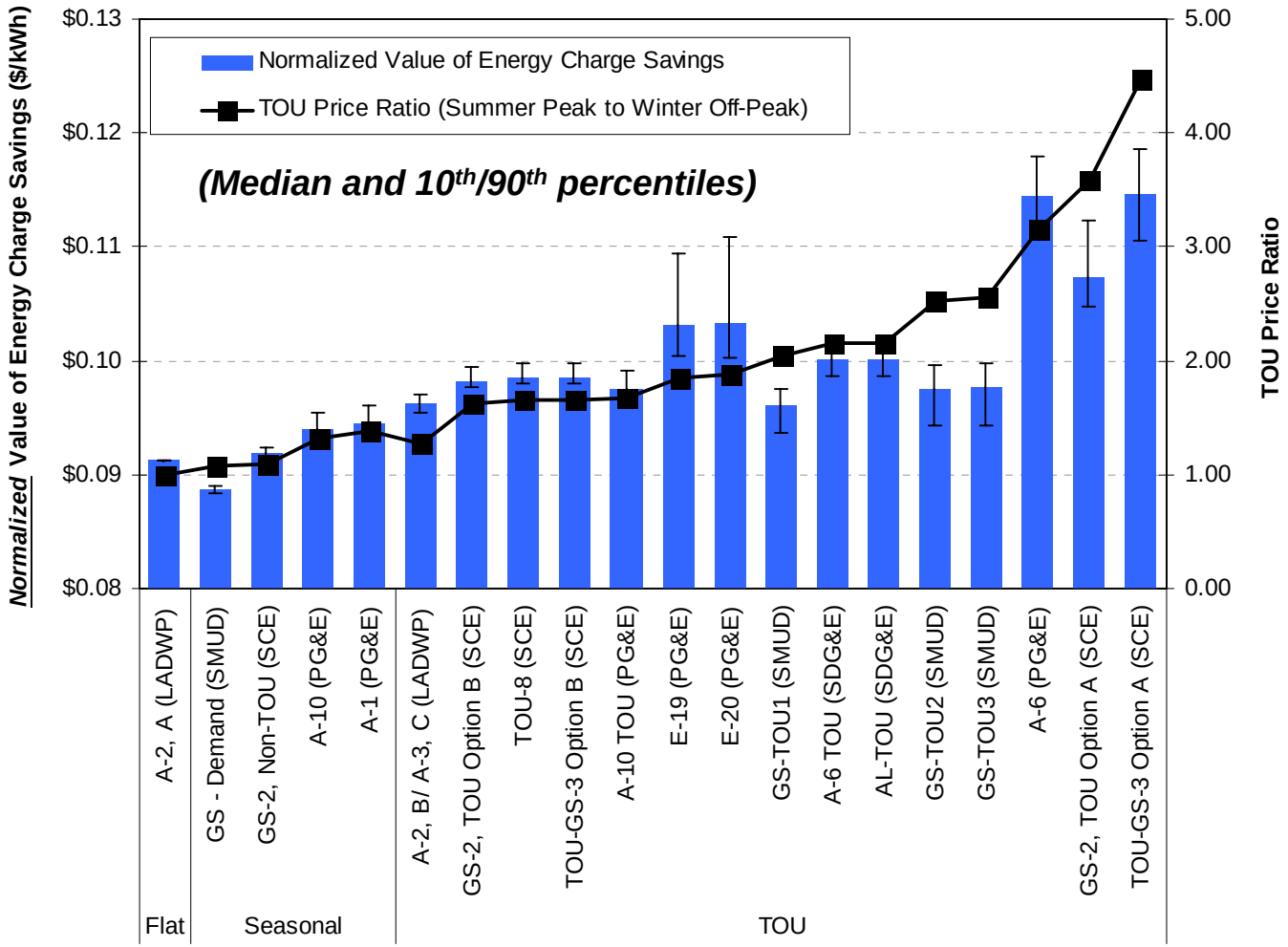
(Median and 10th/90th percentiles)





- Customers with afternoon peaks can generate significant demand charge savings across all types of demand charges
- Customers with inverted or flat load profiles can earn modest demand charge savings if TOD-based demand charges are used

TOU Energy Rates with a Large Peak to Off-Peak Price Spread Offer More Value

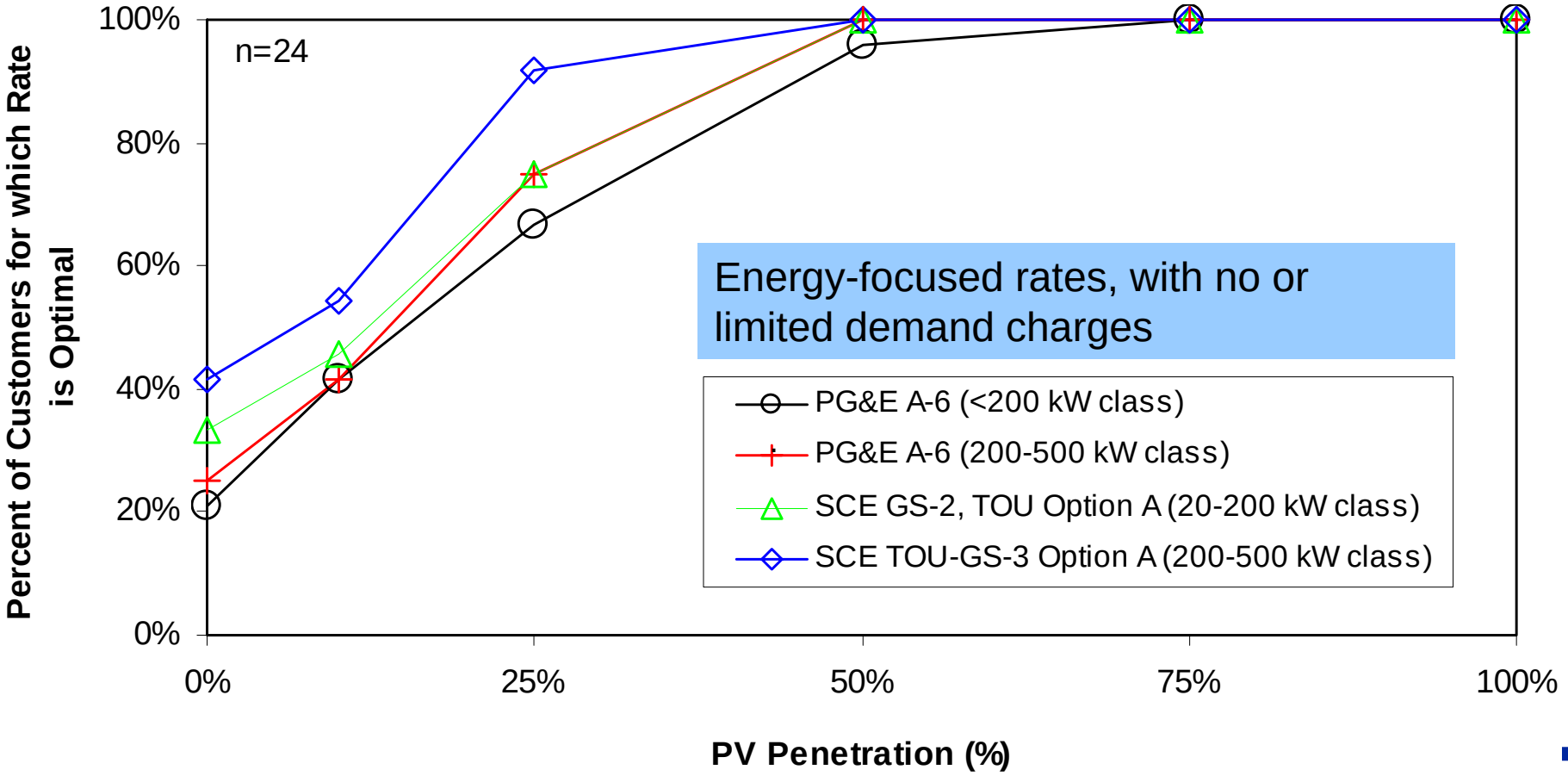


TOU rates heavily weighted toward the summer peak period provide the greatest savings on energy charges:

- ~20% greater than flat/seasonal rates
- ~10% greater than TOU rates with a low price ratio

Energy-Focused Rates Are Advantageous at Higher PV Penetration Levels

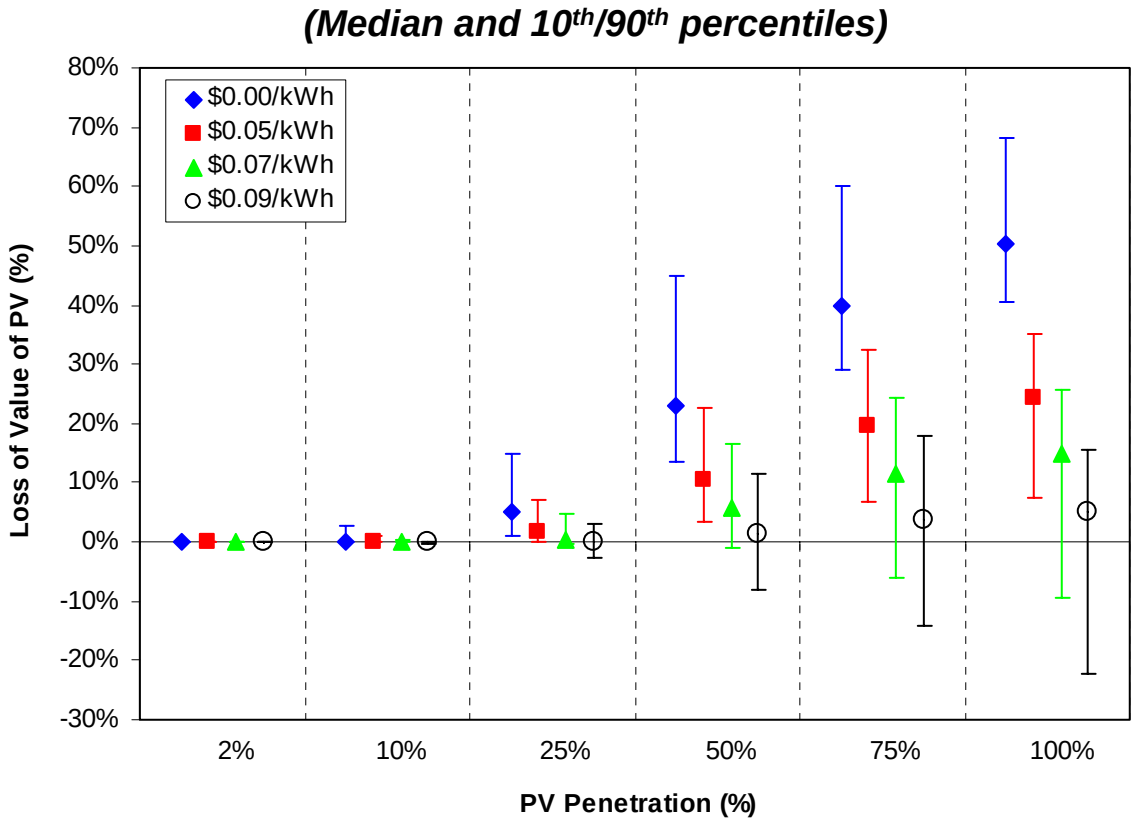
At low levels of PV penetration, customer load characteristics determine the optimal rate; at high levels of PV penetration, nearly all customers would switch to a rate with minimal demand charges



The Loss of Net Metering Could Greatly Reduce the Value of PV for Large PV Systems

The figure shows the percentage reduction in bill savings that would occur if, instead of net metering, customers were compensated for excess generation at a specified "sell back" rate

- At PV penetration of 25% or less, net metering provides little value compared to the alternative considered
- At higher PV penetration, net metering is much more valuable, but is highly sensitive to the sell-back price



Thanks for your attention...

Download the report:

http://eetd.lbl.gov/ea/ems/re-pubs.html

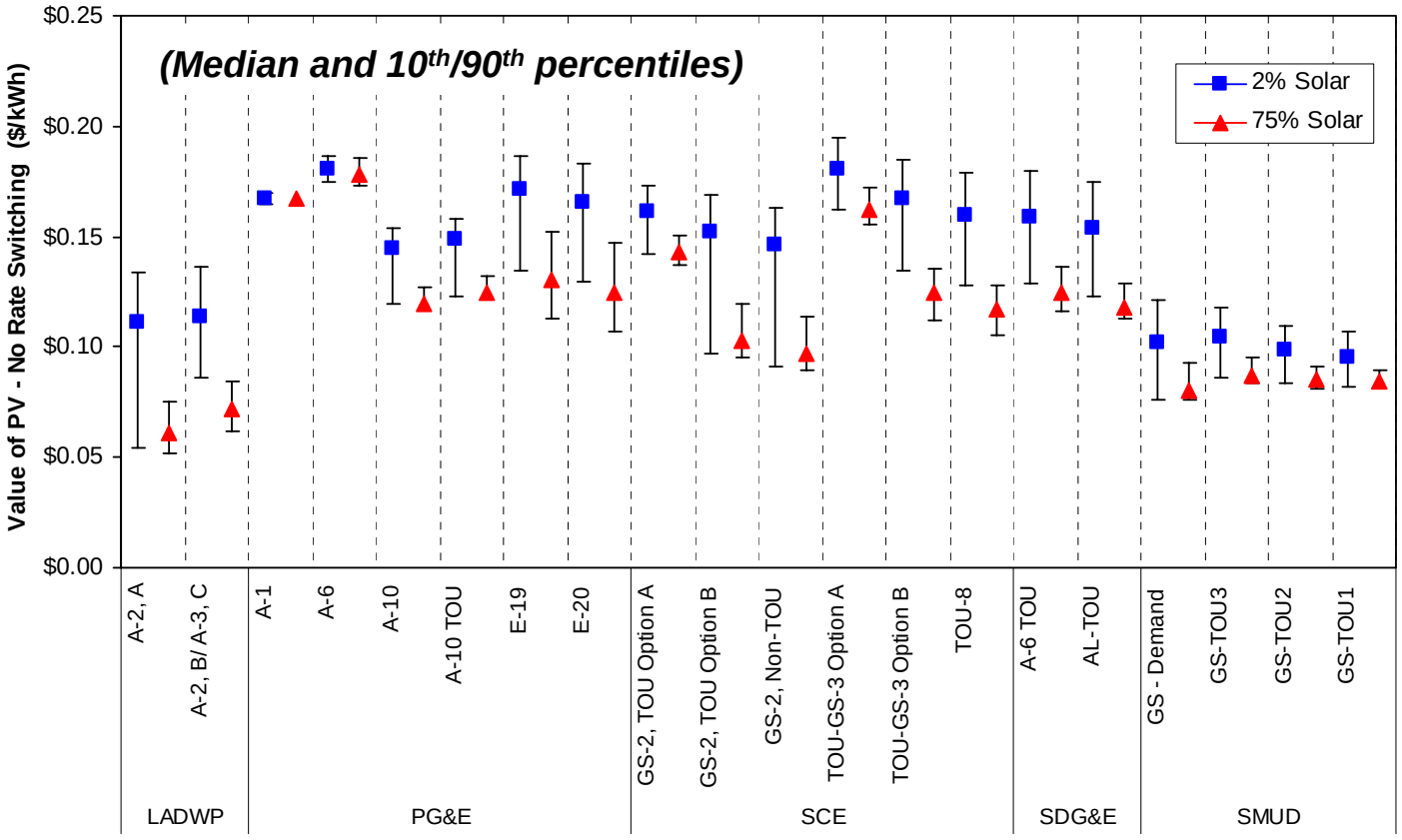
Contact the authors:

Ryan Wiser, 510-486-5474, RHWiser@lbl.gov
Andrew Mills, 510-486-4059, ADMills@lbl.gov
Galen Barbose, 510-495-2593, GLBarbose@lbl.gov

Appendix: Additional Results

The Value of Bill Savings Varies Widely Across Rates

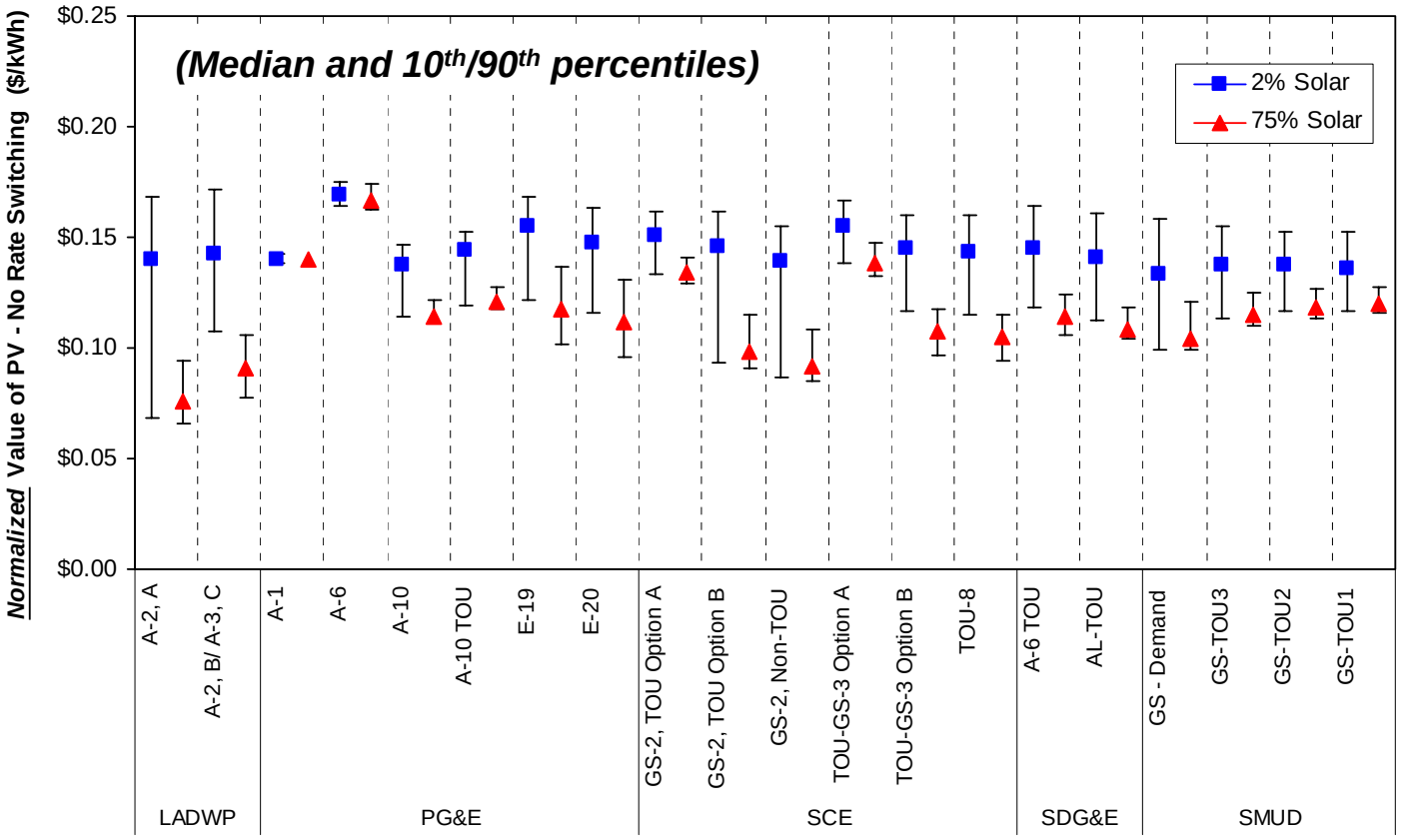
The figure shows the distribution in the value of PV across customers, for each rate, at 2% and 75% penetration levels



- Variation across rates reflects differences in rate *structure* and rate *level*
- Drop off from 2% to 75% is quite pronounced for some rates, less so for others
- Variation across customers is much larger for some rates than others

Normalizing for Differences in Revenue Requirements Isolates Impact of Rate Structure

The figure shows the value of PV for each rate, when *normalized* based on the average cost of electricity prior to PV installation

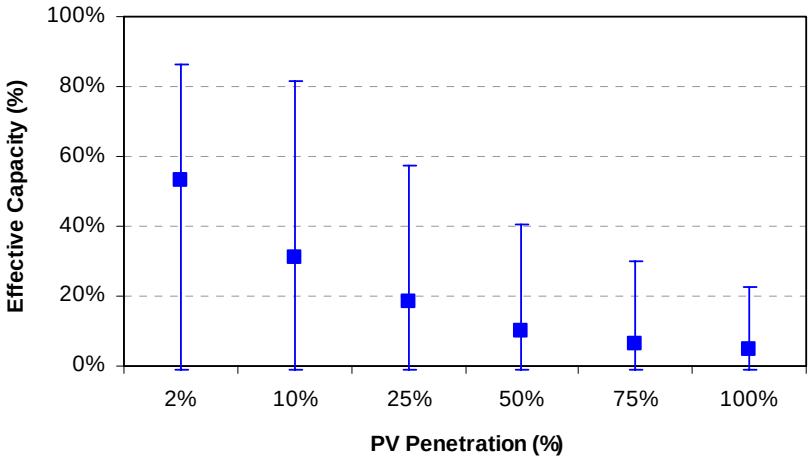


- Differences in rate structure are more important at high PV penetration levels, for the "average" customer
- Rate design is important at low PV penetration levels, insofar as it affects the importance of customer-specific factors

Demand Charge Definitions Matter

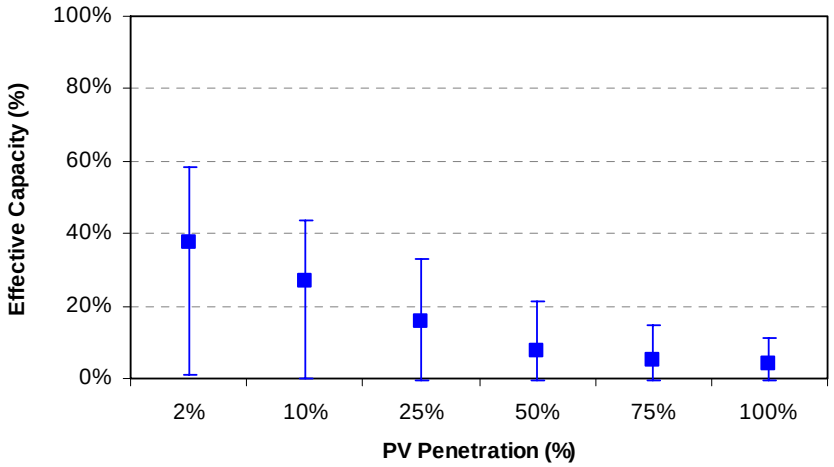
Effective Capacity: **Demand reduction as a percentage of maximum PV output**

Reduction in Maximum Annual Demand

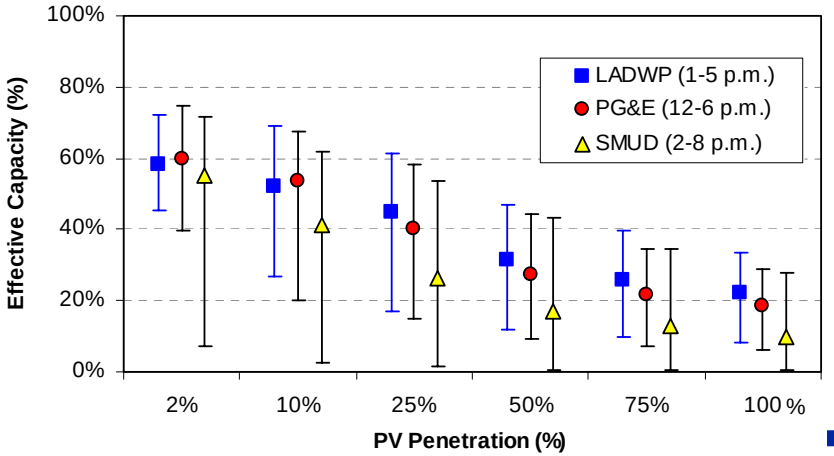


- Demand reductions are largest when focused on Summer Peak TOD
- Wide percentile bands indicate that differences in load shape and/or PV profile across the 24 customers have large effect

Reduction in Maximum Monthly Demand

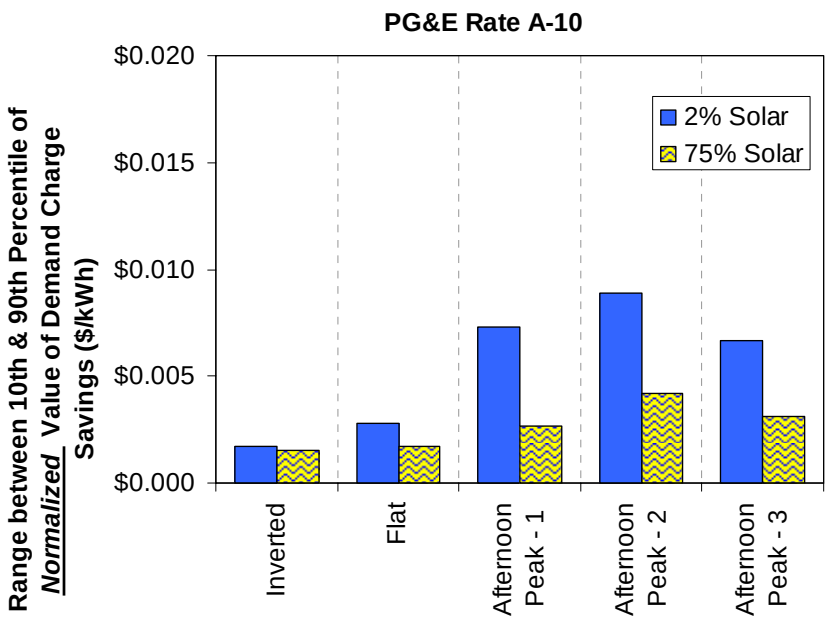


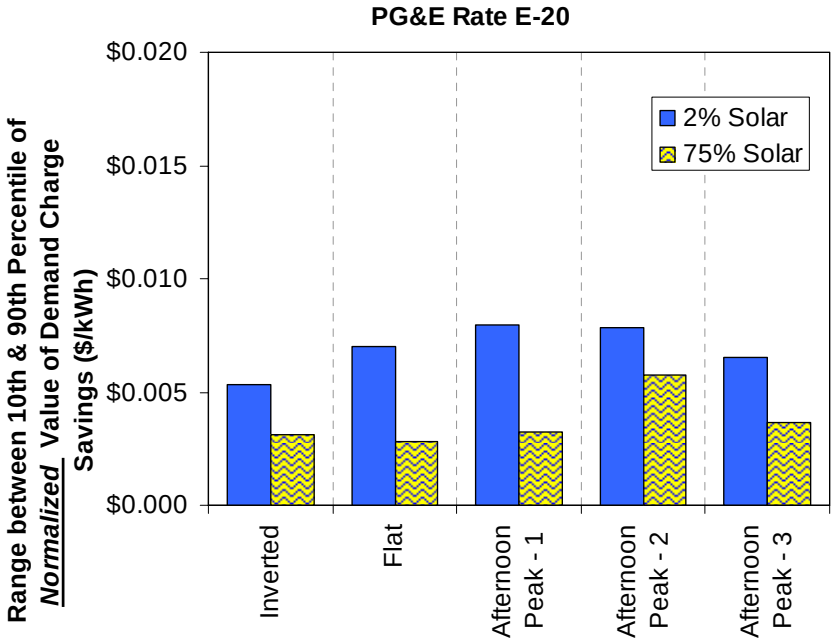
Reduction in Maximum Monthly Demand in Summer Peak TOD Period



Differences in Temporal PV Production Profiles Have Modest Impact on PV Value

To isolate the impact of differences in PV production profiles, we match each of the 24 PV datasets with five representative load profiles





- The figures show the range between the 10th and 90th percentile values for each load profile
- We compare two rates with different types of demand charges
- The effect of differences in PV production profile is < $0.01/kWh
- The implication is that variation in the value of PV across customers is due primarily to differences in load profiles