



# SMART GRID INVESTMENT GRANT

## CONSUMER BEHAVIOR STUDY ANALYSIS

### **Experiences of Vulnerable Residential Customer Subpopulations with Critical Peak Pricing**

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# Overview of SGIG Consumer Behavior Studies

- **DOE Smart Grid Investment Grant (SGIG) Funding Opportunity Announcement (FOA) was released in June 2009**
  - Goal: Provide more definitive answers to policymakers responsible for modernizing the country's electricity infrastructure, in part by funding studies/pilots
- **FOA stated ideal approach for conducting funded consumer behavior studies:**
  - Focus on highly dynamic pricing tariffs (i.e., RTP, CPP)
  - Random assignment of start date for customers to be exposed mandatorily to dynamic pricing as default rate design
  - Customers remain on such rates for at least two (2) years
  - Requirement to deliver highly granular customer-level data for subsequent DOE cross-project analysis



# Overview of SGIG Consumer Behavior Studies (2)

	CEIC	DTE	GMP	LE	MMLD	MP	NVE	OG&E	SMUD	VEC
<b>Rate Treatments</b>										
CPP		•	•		•	•	•	•	•	
TOU		•		•		•	•	•	•	
VPP								•		•
CPR	•		•							
<b>Non-Rate Treatments</b>										
IHD	•	•	•					•	•	
PCT	•	•					•	•		
Education							•			
<b>Recruitment Approaches</b>										
Opt-In	•	•	•	•	•	•	•	•	•	•
Opt-Out				•					•	
Utility Abbreviations: Cleveland Electric Illuminating Company (CEIC), DTE Energy (DTE), Green Mountain Power (GMP), Lakeland Electric (LE), Marblehead Municipal Light Department (MMLD), Minnesota Power (MP), NV Energy (NVE), Oklahoma Gas and Electric (OG&E), Sacramento Municipal Utility District (SMUD), Vermont Electric Cooperative (VEC)										



# AMI, Time-Based Rates, and Vulnerable Customers

- **Some stakeholders have raised concerns about the assumptions underlying the benefits assessments in AMI business cases**
  - Especially benefits associated with broader adoption of time-based rates enabled by AMI, which the SGIG CBS program focused on
- **Concerns are especially acute for low income, elderly and those with chronic illness (i.e., vulnerable) who are believed to be:**
  - Less capable of responding to such rates;
  - More willing to reduce essential electricity use to avoid high bills resulting in potential physical harm; and
  - More adversely affected by higher and/or more volatile bills



# Outstanding Research Questions of Vulnerable Customers and Time-Based Rates

- **Do vulnerable subpopulations of customers:**
  1. Exhibit usage patterns (either in terms of their average usage or flexibility of usage) that differ from those of non-vulnerable subpopulations?
  2. Participate and stay enrolled in time-based rates at different levels than non-vulnerable subpopulations?
  3. Exhibit load response to time-based rates at different levels than non-vulnerable subpopulations?
  4. Benefit financially from time-based rates at different levels than non-vulnerable subpopulations?
  5. Curtail usage at the expense of comfort, well-being, or satisfaction to a greater extent than non-vulnerable subpopulations?



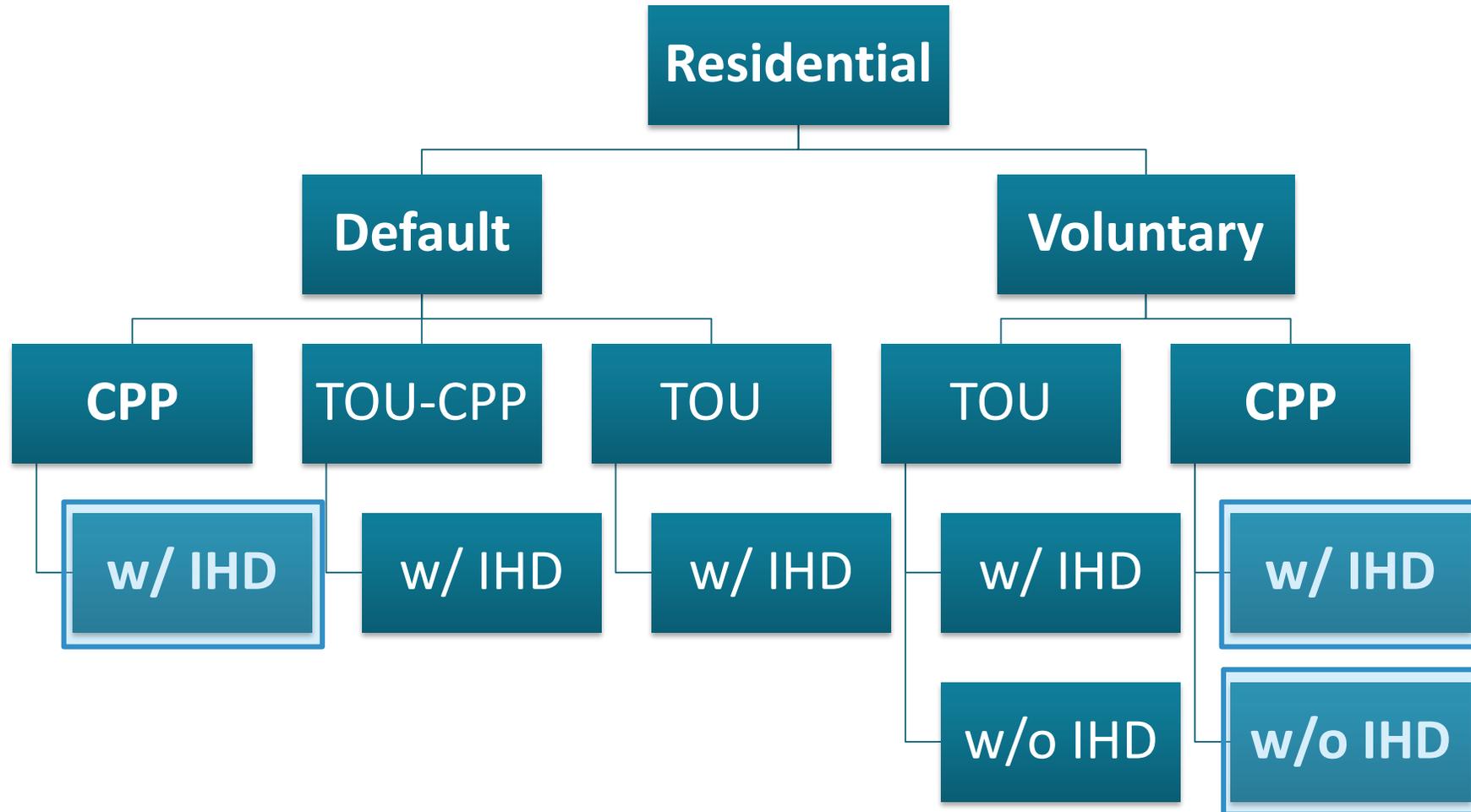
# SGIG Consumer Behavior Studies Able to Address These Outstanding Research Questions

- There has been a very modest amount of research concerning these research questions on the low-income community but little to no research on the elderly or those who are chronically ill
- An analysis of SMUD's and GMP's consumer behavior studies were able to contribute to this body of research because they fit the required criteria:
  - Implemented a time-base rate (Critical Peak Pricing in particular);
  - Had sufficient participation data;
  - Had sufficient interval meter data; and
  - Had sufficient survey and other sources of demographic data to identify customers as vulnerable or not



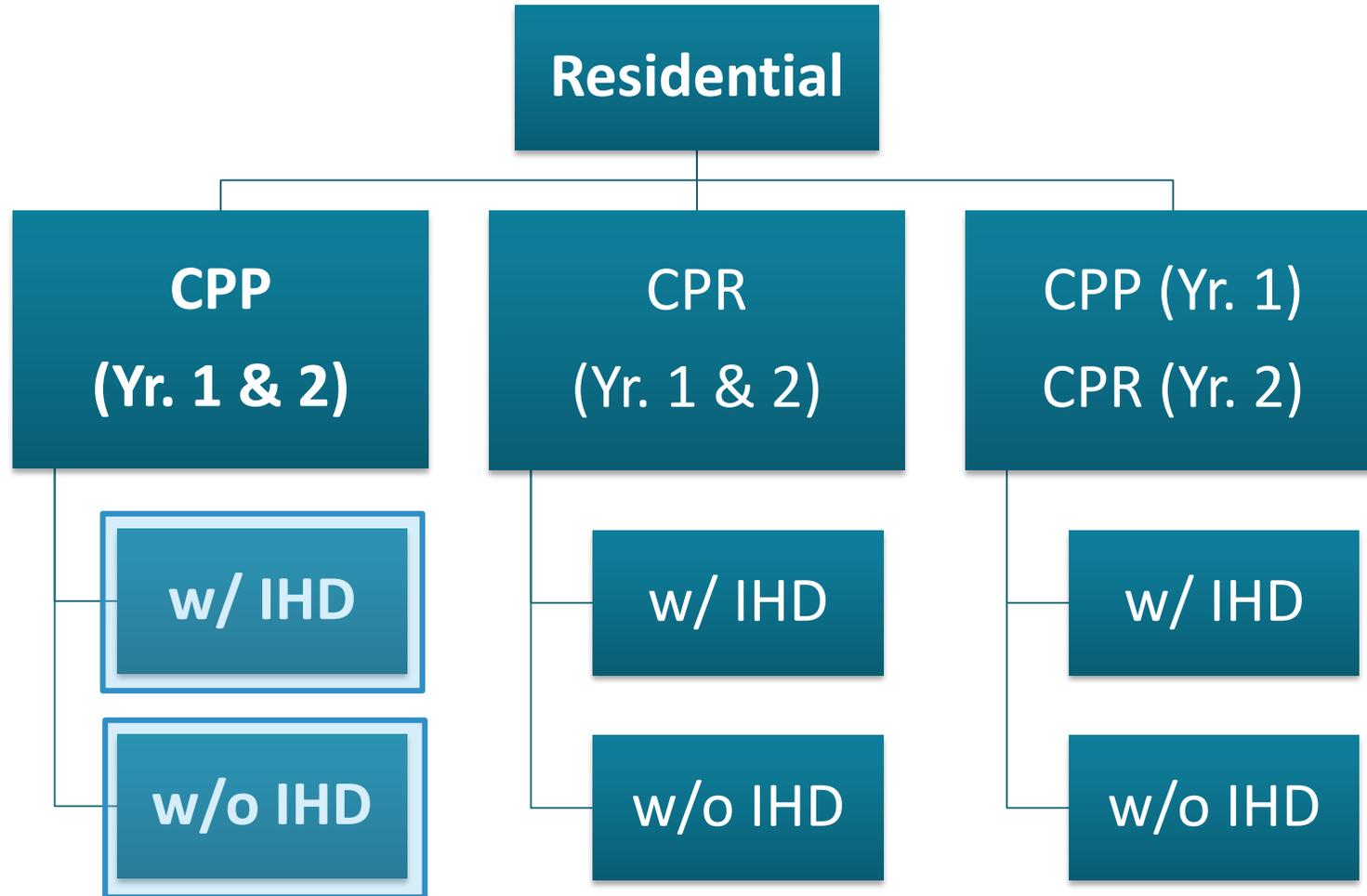
# SMUD Experimental Design

Included in analysis



# GMP Experimental Design

Included in analysis



# Analytical Approach to Address Outstanding Research Questions

- **Neither SMUD nor GMP's study was designed to have the power to identify load responses of disaggregated customer groups**
  - We chose to combine multiple similar treatment arms for both utilities in our analysis, in order to maximize the potential of identifying any differences in load response, enrollment rates, and bill impacts.
    - SMUD: Voluntary CPP with In Home Display (IHD) offer and without IHD offer (Analyzed in combination)
    - GMP: Voluntary CPP with IHD and without IHD offer (Analyzed in combination)
    - SMUD: Default CPP with IHD offer (Analyzed independently)



# Definitions of Vulnerable Customer Subpopulations

- **Low income**

- Determined by reported income levels and the number of people living in the residence via utility-administered survey instruments and a state-specific Low Income Home Energy Assistance Program (LIHEAP) cutoff definition;

- **Elderly**

- Determined by reported age of adults (those over 65 identified as elderly) living in the residence via utility-administered survey instruments; and

- **Chronically Ill**

- Determined by reported existence of a chronic illness of individuals living in the residence via utility-administered survey instruments.



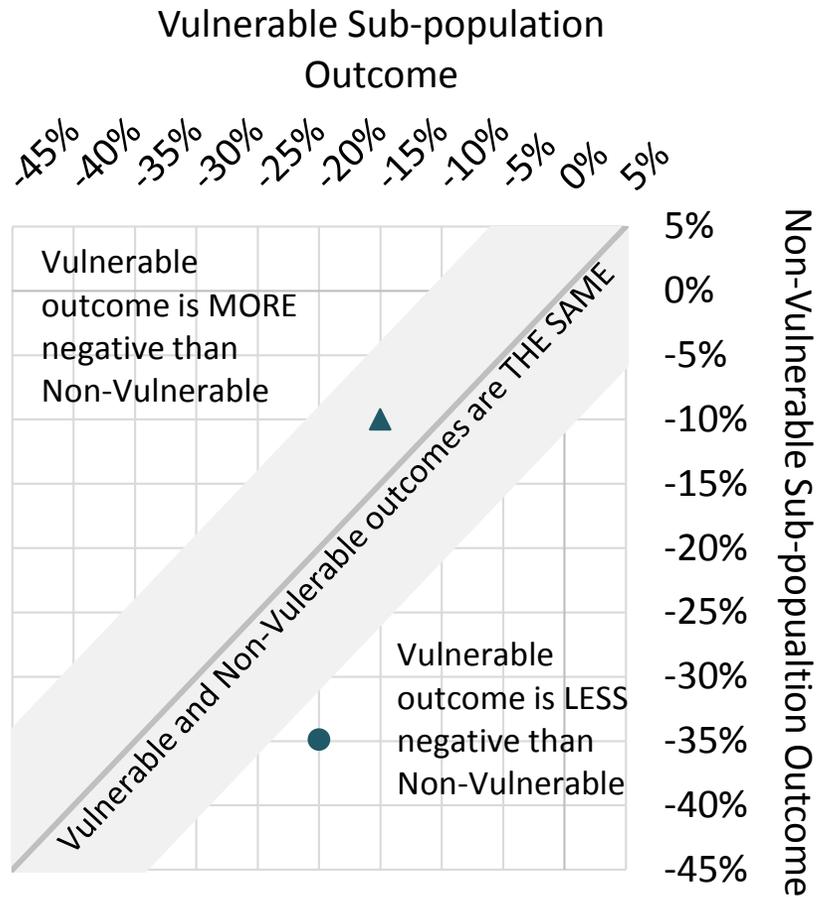
# Percent of Survey Respondents Affiliated with the Identified Vulnerable Customer Subpopulations

	Low Income	Elderly	Chronically Ill
<b>SMUD Voluntary Cells</b>	39% (435/1119)	35% (407/1176)	9% (110/1209)
<b>GMP Voluntary Cells</b>	15% (69/463)	41% (230/560)	20% (111/558)
<b>SMUD Default Cells</b>	32% (80/248)	31% (80/262)	12% (31/264)
<b>SMUD Control Cells</b>	41% (87/211)	34% (78/227)	13% (31/233)
<b>GMP Control Cells</b>	16% (48/302)	42% (155/373)	25% (92/372)

Note: numbers in parentheses report the following: (# of households identified as vulnerable / # of households in total that responded to the relevant survey question).

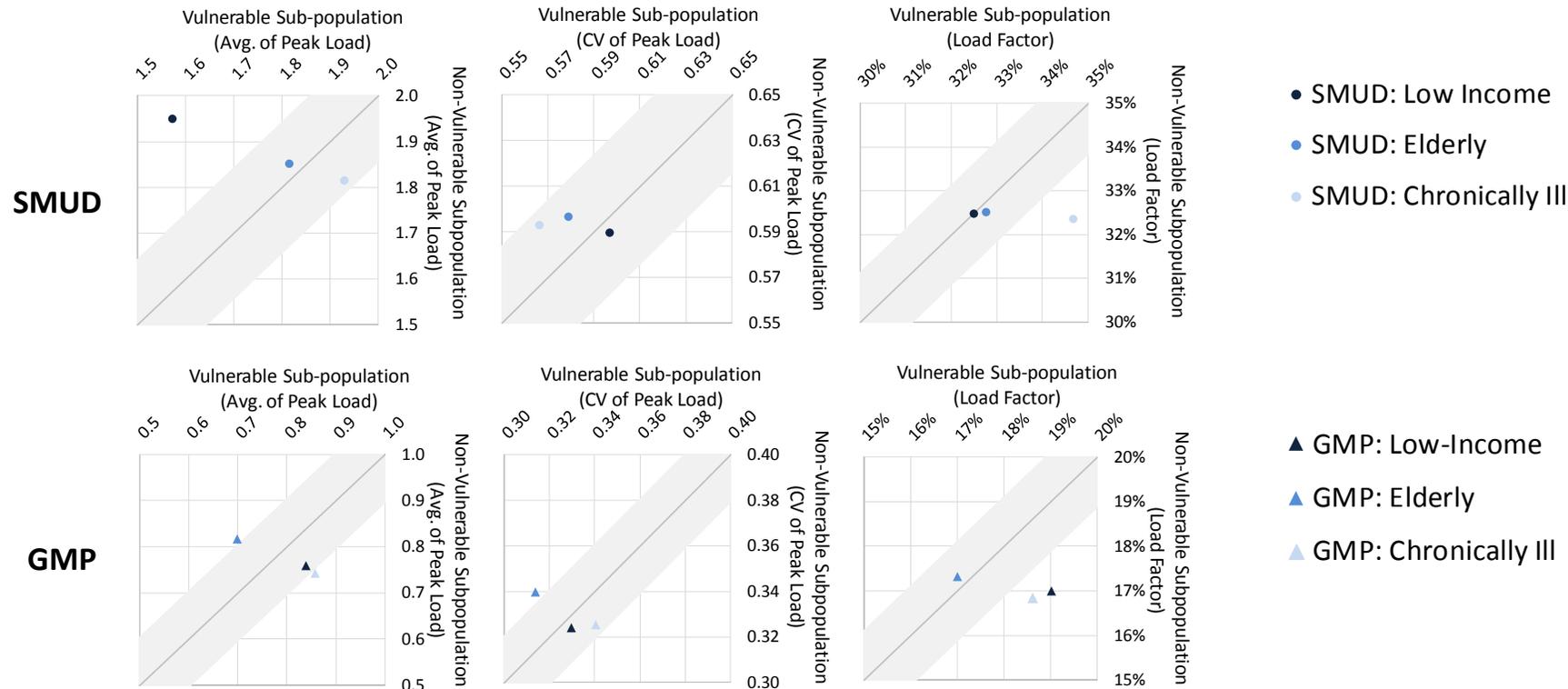


# Analysis Approach and Representation of Results



- Outcomes of interest for customers that fall into a given “vulnerable” category (e.g., elderly) are compared to that category’s “non-vulnerable” counterpart (e.g., non-elderly).
- If a point lies on the 45-degree line then the outcome is the same between the two subpopulations.
- The further from this line a point lies, the greater is the difference in the outcome between the vulnerable and non-vulnerable subpopulations.
- Any points located outside the gray shaded area indicate the difference is statistically significant at a 90% confidence level

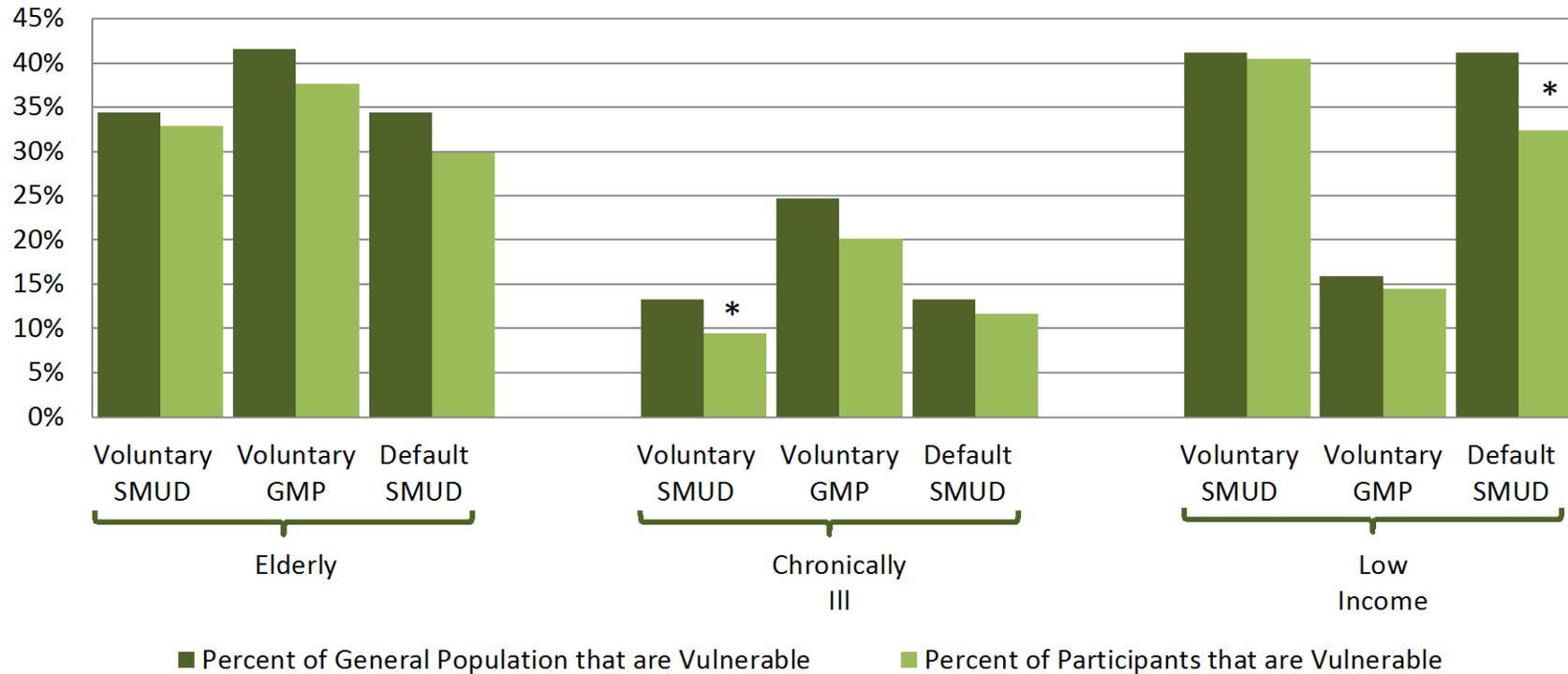
# Results: Average Load and Load Flexibility



Note: For any of the points that lie in the gray bar area, the difference of the relevant metric for the vulnerable population was not statistically significant (at a 90% confidence level) relative to the non-vulnerable counterpart population. The gray bar in and of itself is not the 90% confidence interval, but rather a graphical way of showing which estimates are statistically significant at the 90% confidence level and which are not.



# Results: Enrollment

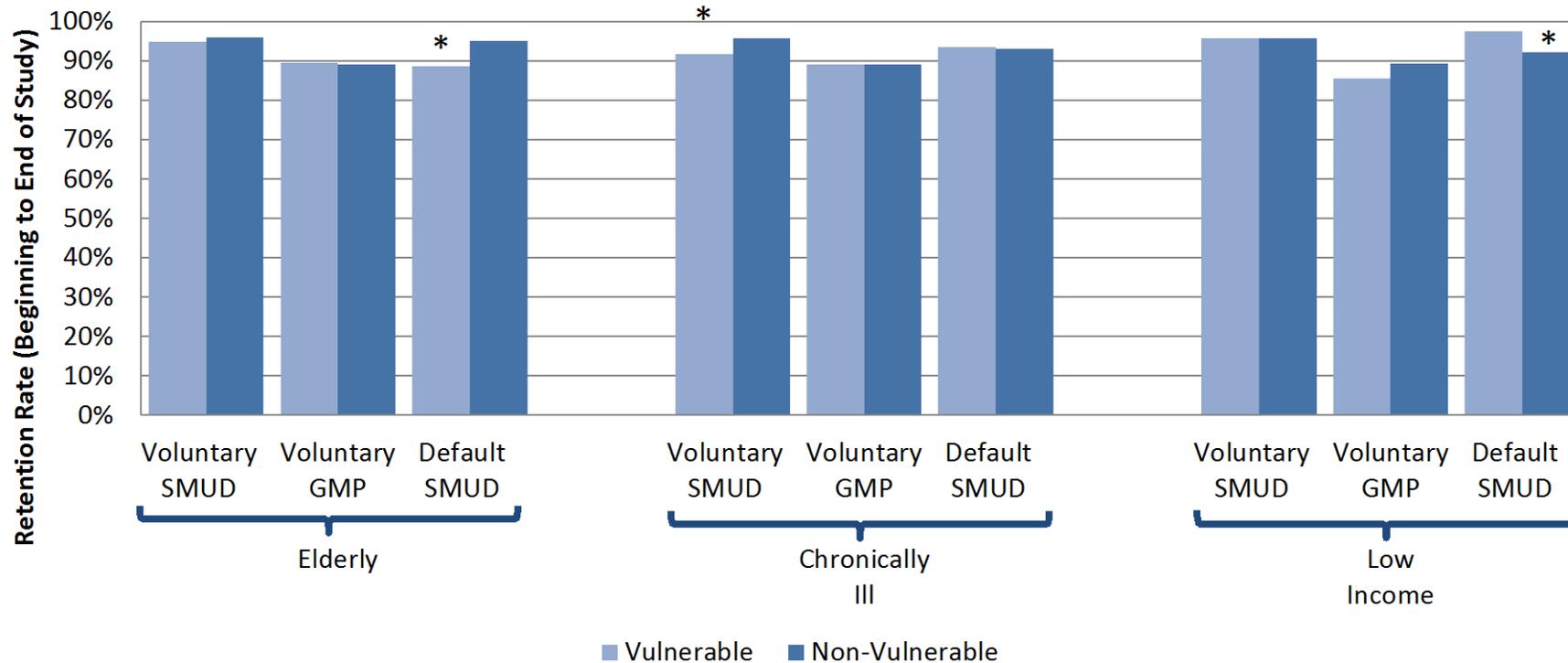


Note: These data are limited to those who responded to the survey. The percent of vulnerable households in the general population are based on those households from the control group that responded to the survey.

\* indicates that the difference between the percent of study participants that are vulnerable versus the percent that are vulnerable in the general population are statistically significant at least at the 90% confidence level, all other differences are not statistically significant.



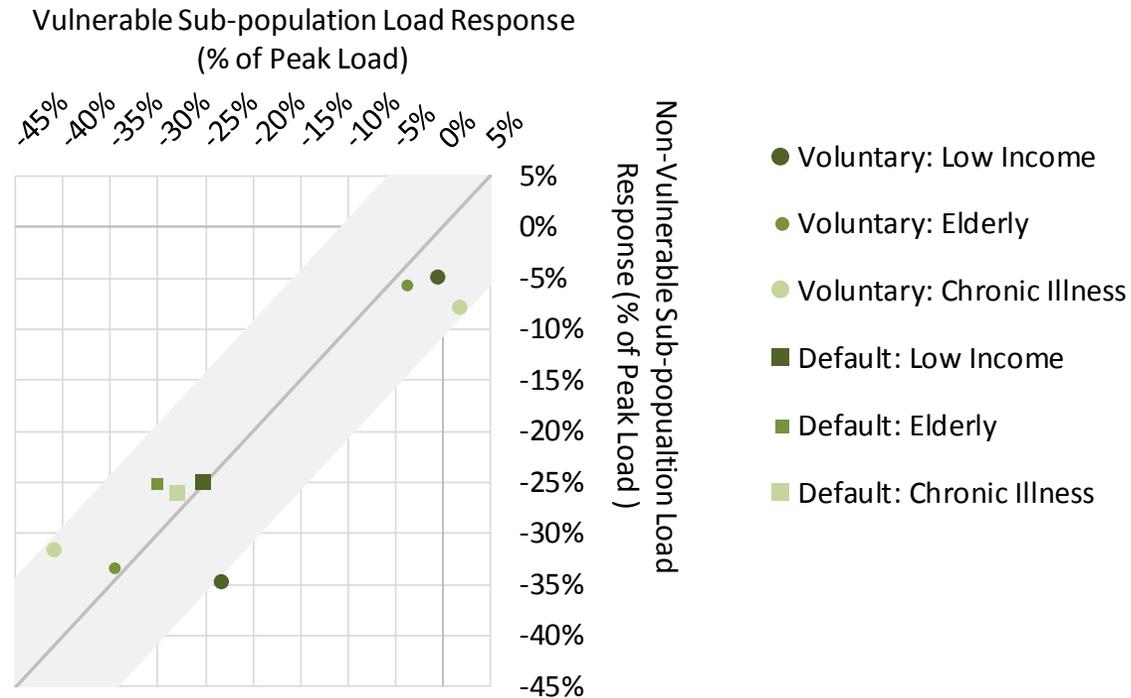
# Results: Retention



Note: \* indicates that the difference in retention rate between the vulnerable and non-vulnerable study participants are statistically significant at least at the 90% confidence level, all other differences are not statistically significant.

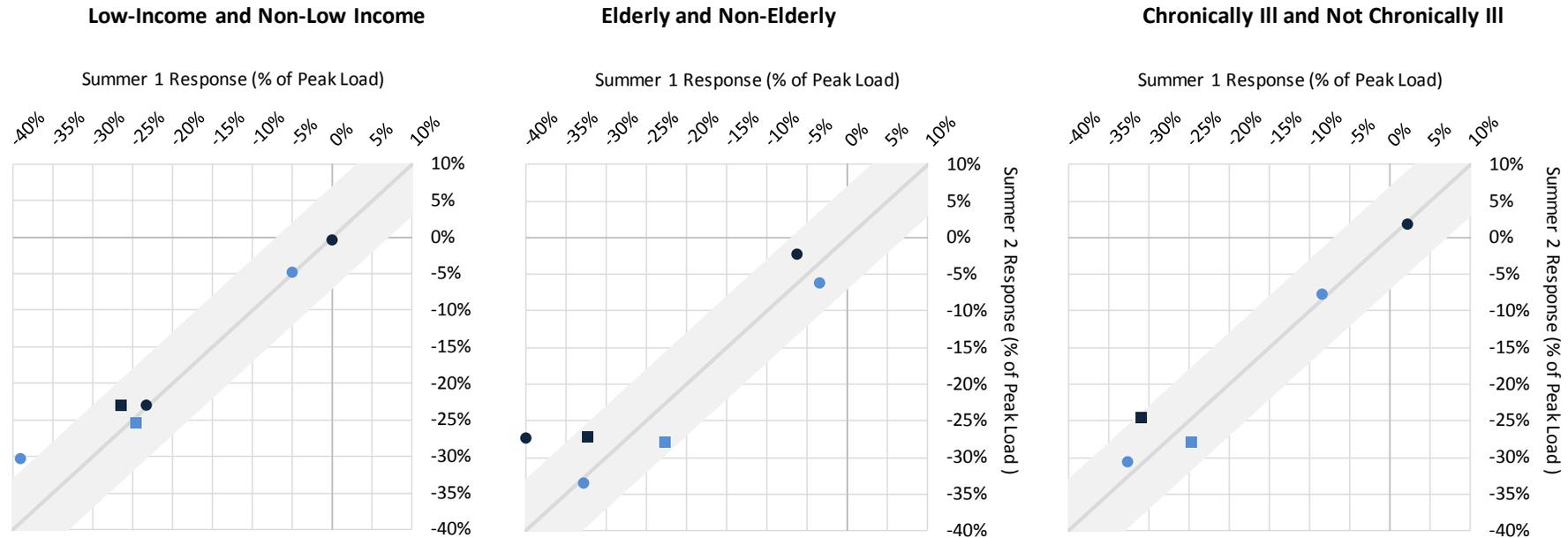


# Results: Load Response



Note: The markers in this graph indicate the estimated load response as a percent of average consumption. For any of the points that lie in the gray bar area, the difference between the estimated load response for the vulnerable population was not statistically significant (at a 90% confidence level) relative to the non-vulnerable counterpart population. The gray bar in and of itself is not the 90% confidence interval, but rather a graphical way of showing which estimated differences are statistically significant at the 90% confidence level and which are not.

# Results: Persistence of Load Response

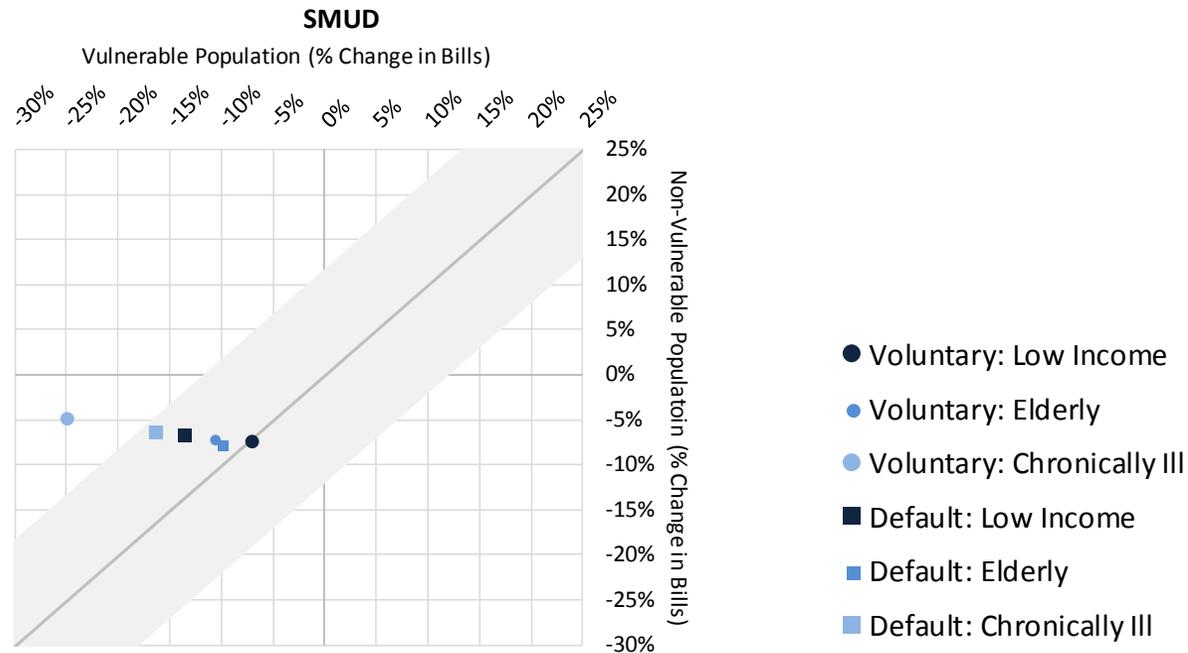


Note: The markers in these graphs indicate the estimated load response as a percent of average consumption. For any of the points that lie in the gray bar area, the difference between the estimated load response in the first summer of the pilot was not statistically significant (at a 90% confidence level) relative to the second summer. The gray bar in and of itself is not the 90% confidence interval, but rather a graphical way of showing which estimated differences are statistically significant at the 90% confidence level and which are not.

- Voluntary: Vulnerable
- Voluntary: Non-Vulnerable
- Default: Vulnerable
- Default: Non-Vulnerable

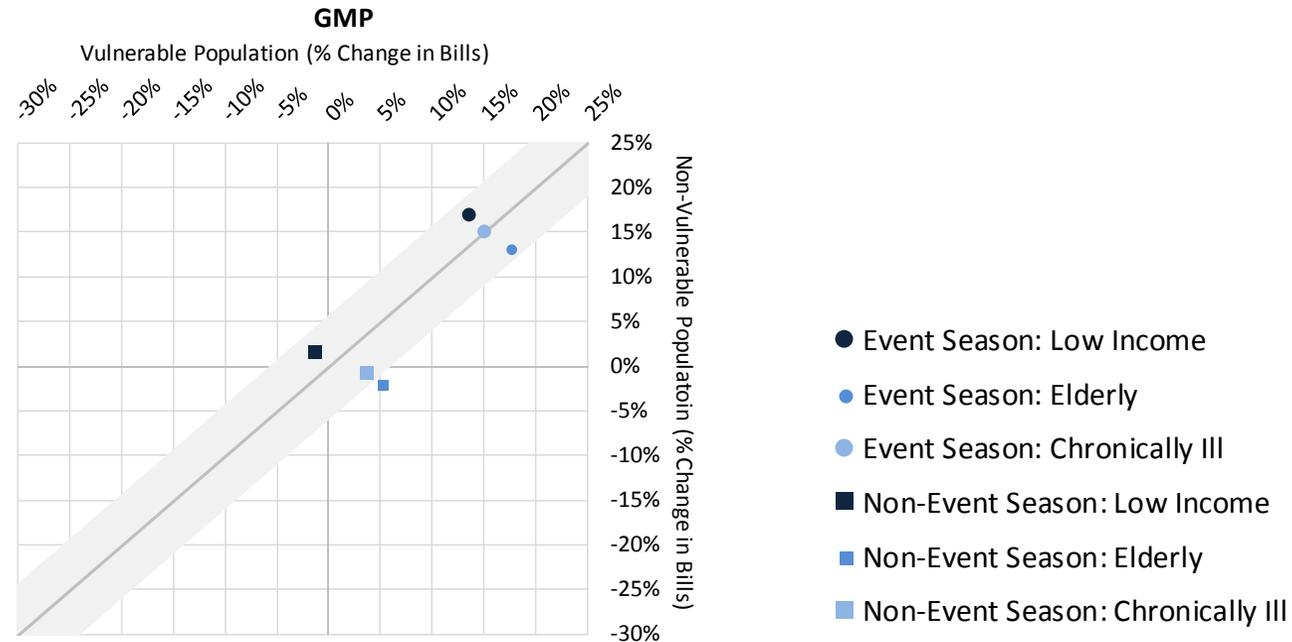


# Results: SMUD Bill Impacts



Note: The markers in this graph indicate the estimated bill impacts from the treatment rates as a percent of average expenditure. For any of the points that lie in the gray bar area, the difference between the estimated bill impact for the vulnerable population was not statistically significant (at a 90% confidence level) relative to the non-vulnerable counterpart population. The gray bar in and of itself is not the 90% confidence interval, but rather a graphical way of showing which estimated differences are statistically significant at the 90% confidence level and which are not. The estimates for SMUD were done during the event season only, as that was when the experimental rates were in effect.

# Results: GMP Bill Impacts

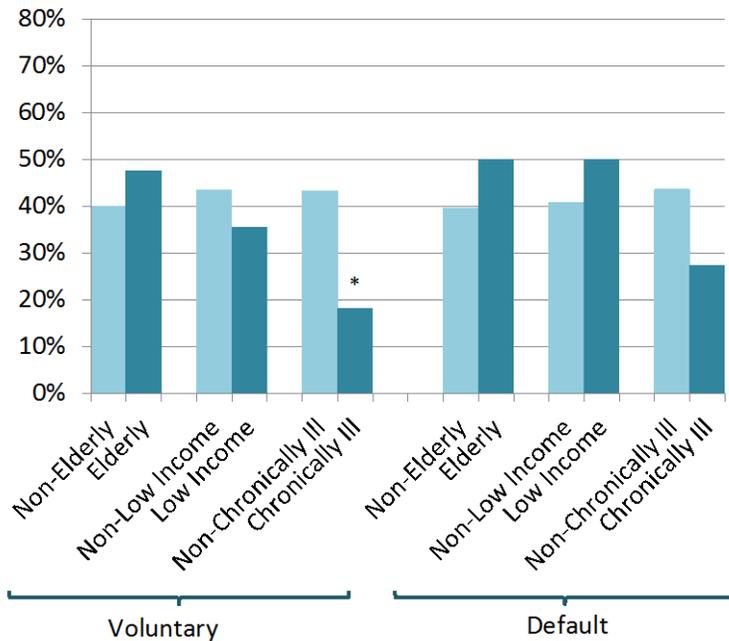


Note: The markers in this graph indicate the estimated bill impacts from the treatment rates as a percent of average expenditure. For any of the points that lie in the gray bar area, the difference between the estimated bill impact for the vulnerable population was not statistically significant (at a 90% confidence level) relative to the non-vulnerable counterpart population. The gray bar in and of itself is not the 90% confidence interval, but rather a graphical way of showing which estimated differences are statistically significant at the 90% confidence level and which are not. The estimates for GMP were done during both the event season and the non-event season separately, as GMP's rates were in effect throughout the year.

# Results: Customer Satisfaction (SMUD)

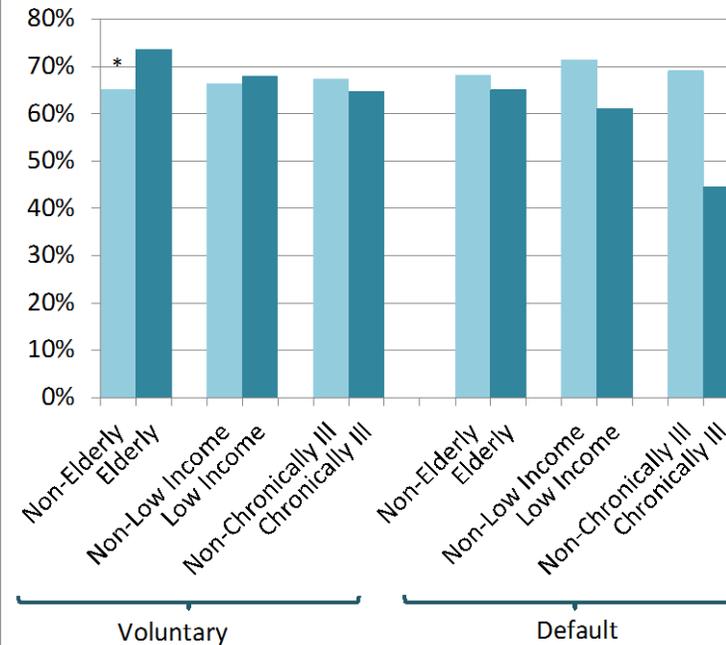
Percent who indicated that they were not uncomfortable, or indifferent, to the question:

"I sometimes feel uncomfortable inside my home on summer afternoons and evenings because it is too expensive to run my air conditioner."



Percent who indicated that it was not difficult in answering the question:

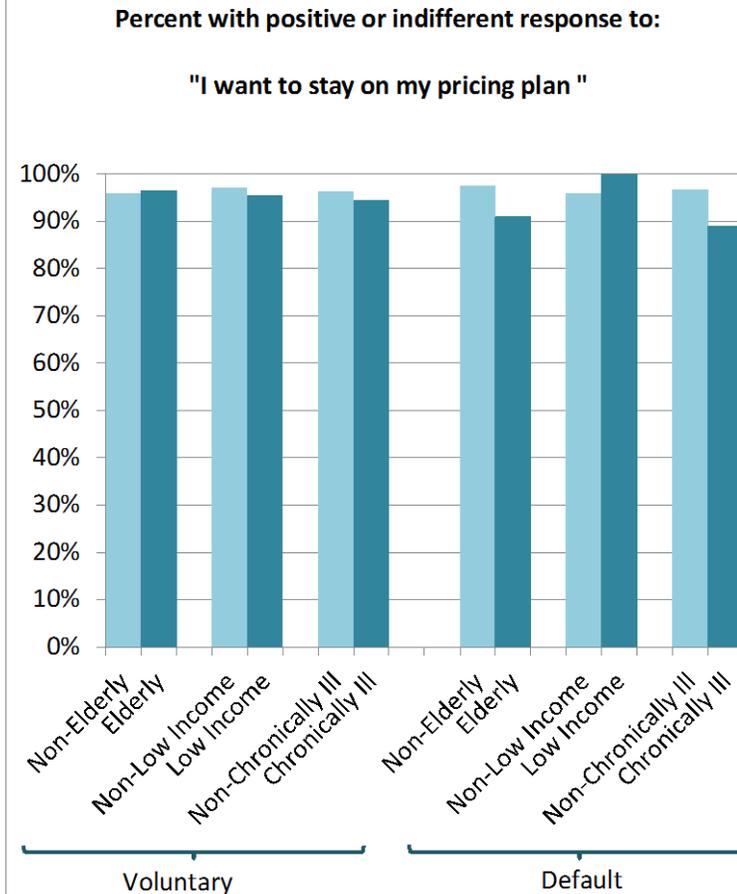
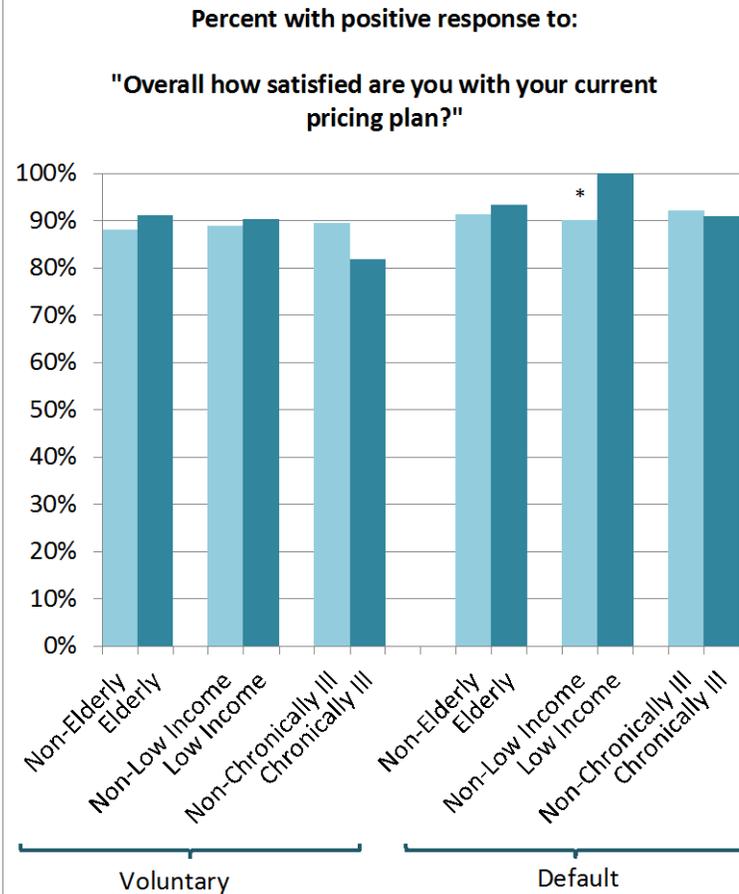
"How difficult were these changes to make?" in reference to the changes they reported making in their peak period energy use while on the pilot rate



Note: The bars show the percent of favorable survey responses. \* indicates the response rates between the vulnerable and non-vulnerable subpopulations is different with a confidence of 90% or higher. All other differences are not statistically significant.



# Results: Customer Satisfaction (SMUD)



Note: The bars show the percent of favorable survey responses. \* indicates the response rates between the vulnerable and non-vulnerable subpopulations is different with a confidence of 90% or higher. All other differences are not statistically significant.



# Conclusions & Take-Aways (1)

- Average Peak Period Usage and Load Flexibility
  - The average peak period usage
    - Evidence that it can be lower for
      - Elderly customers
      - low-income customers
    - Evidence that it can be higher for
      - Chronically ill customers
  - Load variability/flexibility
    - Evidence that it is slightly lower for
      - All vulnerable subpopulations



# Conclusions & Take-Aways (2)

- Enrollment
  - Vulnerable subpopulations participated in a CPP rate at similar levels in general as non-vulnerable subpopulations.
  - Exceptions:
    - chronically ill customers offered SMUD's voluntary rate participated at lower levels
    - low-income customers defaulted onto SMUD's CPP rate participated at slightly lower levels
- Retention
  - Comparable between vulnerable and non-vulnerable subpopulations
  - Exceptions (where statistically significant differences were identified):
    - low-income customers dropped out of SMUD's default rate at a slightly lower rate
    - chronically ill customers dropped out of SMUD's voluntary rate at a slightly higher rate
    - elderly customers dropped out of SMUD's default rate at a slightly higher rate



# Conclusions & Take-Aways (3)

- Load Response
  - Vulnerable subpopulations were usually just as responsive on a proportional basis as their non-vulnerable counterparts over the entire study period, though exhibiting varying degrees of persistence.
  - There were no differences in response level or persistence of response between vulnerable and non-vulnerable customers on the default rate.
  - In the voluntary rates, the only case in which there was a statistically significant difference was for low-income customers, who exhibited a slightly lower load response as compared to their higher income counterparts. However, these voluntary low-income customers had a persistent load response between the first and second summer of the pilot, while higher income customer load response attenuated over time.



# Conclusions & Take-Aways (4)

- Bill Impacts
  - Vulnerable subpopulations financially benefited at roughly similar proportional levels to their non-vulnerable counterparts.
  - SMUD:
    - Rate was designed to be revenue neutral during the event season summer months, but all customer groups actually experienced bill savings as a result of being on the rate.
    - Chronically ill customers experienced even lower bills relative to their non-vulnerable counterparts.
  - GMP:
    - Rate was designed to be revenue neutral over the entire year, but events were only called during the summer.
    - Bills were higher for all customer groups during the event season, and higher for elderly customers during the non-event season relative to non-elderly customers.



# Conclusions & Take-Aways (5)

- Customer Satisfaction
  - Using survey data available only from SMUD, we are able to analyze the responses of customers to questions regarding their comfort, the difficulty they faced in changing their usage, and their overall satisfaction with the rate.
  - With respect to reported comfort and difficulty of changing behavior there were no differences between vulnerable and non-vulnerable subpopulations in the default treatment.
  - In the voluntary treatment, chronically ill customers were more likely to report discomfort and elderly customers were less likely to indicate that behavior changes they undertook were difficult, relative to their respective non-vulnerable counterparts.
  - However, overall satisfaction levels were extremely high across all subpopulations (with between 91% and 100% indicating they would want to remain on the rate), and low-income customers in the default treatment indicating statistically significantly higher levels of satisfaction than their higher income counterparts.



## Conclusions & Take-Aways (6)

- The experience of vulnerable customer subpopulations in GMP's and SMUD's consumer behavior studies suggests there may be some differences from those who would not be considered vulnerable, but many such differences would be considered small in magnitude and are not statistically significant.
- However, these results often differ both across the three vulnerable subpopulations, and across the two utilities included in this analysis.
- This suggests a need to design and implement time-based rate studies utilizing experimental designs that are specifically targeted at these vulnerable subpopulations to gain more definitive and more broadly applicable results.

