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ELECTRICAL ENGINEERING

Analysis of Dynamic Retail Electricity Rates and Domestic Demand Response Programs

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Overview

- Background
- Modified Real Time Price (mRTP)
- Rate Comparisons
  - Case Study 1: House Categorization
  - Case Study 2: Yearly Savings Analysis
- Findings
- Further Exploration

Background

State of Residential DR in the U.S.

- Advanced Metering Infrastructure (AMI) penetration increased from 4.8 % in 2008 to 23.9 % in 2012

- However only 2.1 million (~1.68 %) US residential customers reported TOU participation in 2012

- The proposed rate design, “Modified Real Time Price” (mRTP) attempts to solve the issue of participation

Source: FERC, *"Assessment of Demand Response & Advanced Metering"*, 2012.

Modified Real Time Price (mRTP)

California ISO (CAISO) Grid Condition RTP

- Customers receive a signal updating them on grid conditions

- Scale from 0-10, matching the grid condition to a certain multiple of the off or on peak average price

CAISO Grid Condition Index

Visual Cue	Grid State	Lower Limit	Upper Limit
Blue	0	n/a	<= $-30/MWh
	1	> $-30/MWh	<= $0
	2	> $0	< off-peak average
Green	3	>= off-peak average	< on-peak average
	4	>= on-peak average	< 1.1 * on-peak average
	5	>= 1.1 * on-peak average	< 1.33 * on-peak average
Yellow	6	>= 1.33 * on-peak average	< 1.67 * on-peak average
	7	>= 1.67 * on-peak average	< 2 * on-peak average
	8	>= 2 * on-peak average	< 3 * on-peak average
Red	9	>= 3 * on-peak average	< 10 * on-peak average
	10	>= 10 * on-peak average	n/a

Source: CAISO, *"White Paper Proposal – Wholesale Grid State Indicator to Enable Price Responsive Demand", 2012*

- Blue : Use Now
- Green: Use Freely
- Yellow: Use Cautiously, Defer Tasks if Possible
- Red: Use Sparingly, Shut Down Low Priority Devices

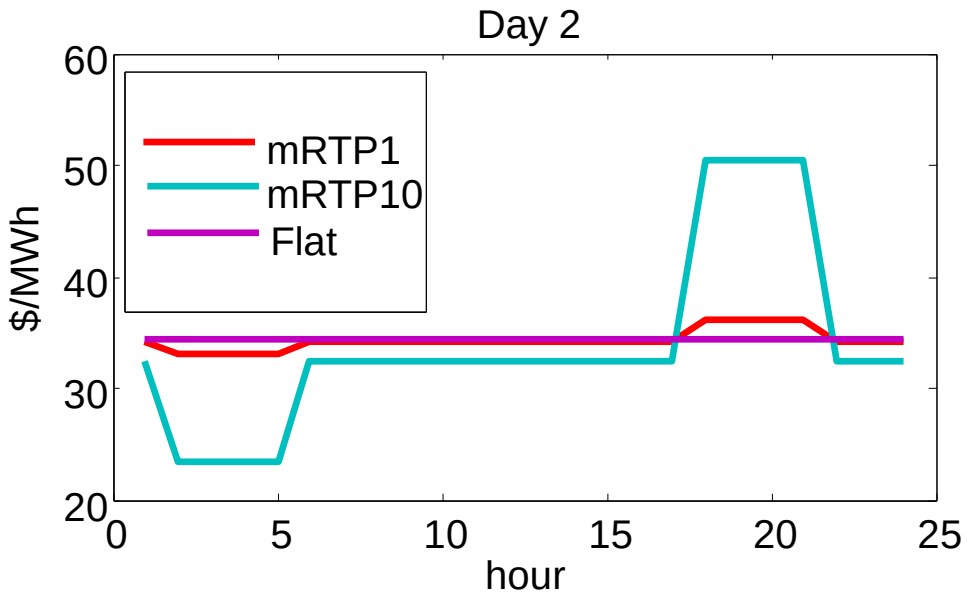
mRTP

- Uses the CAISO Grid Condition Index
- Gives customers several rate options rather than one flat rate
- Includes a real time component and a flat rate component

$$B * G + R_{min} = mRTP$$

R_{min} is the minimum rate, B is the customer chosen risk factor, G is the CAISO grid index.

Daily Example: Comparison of Rates

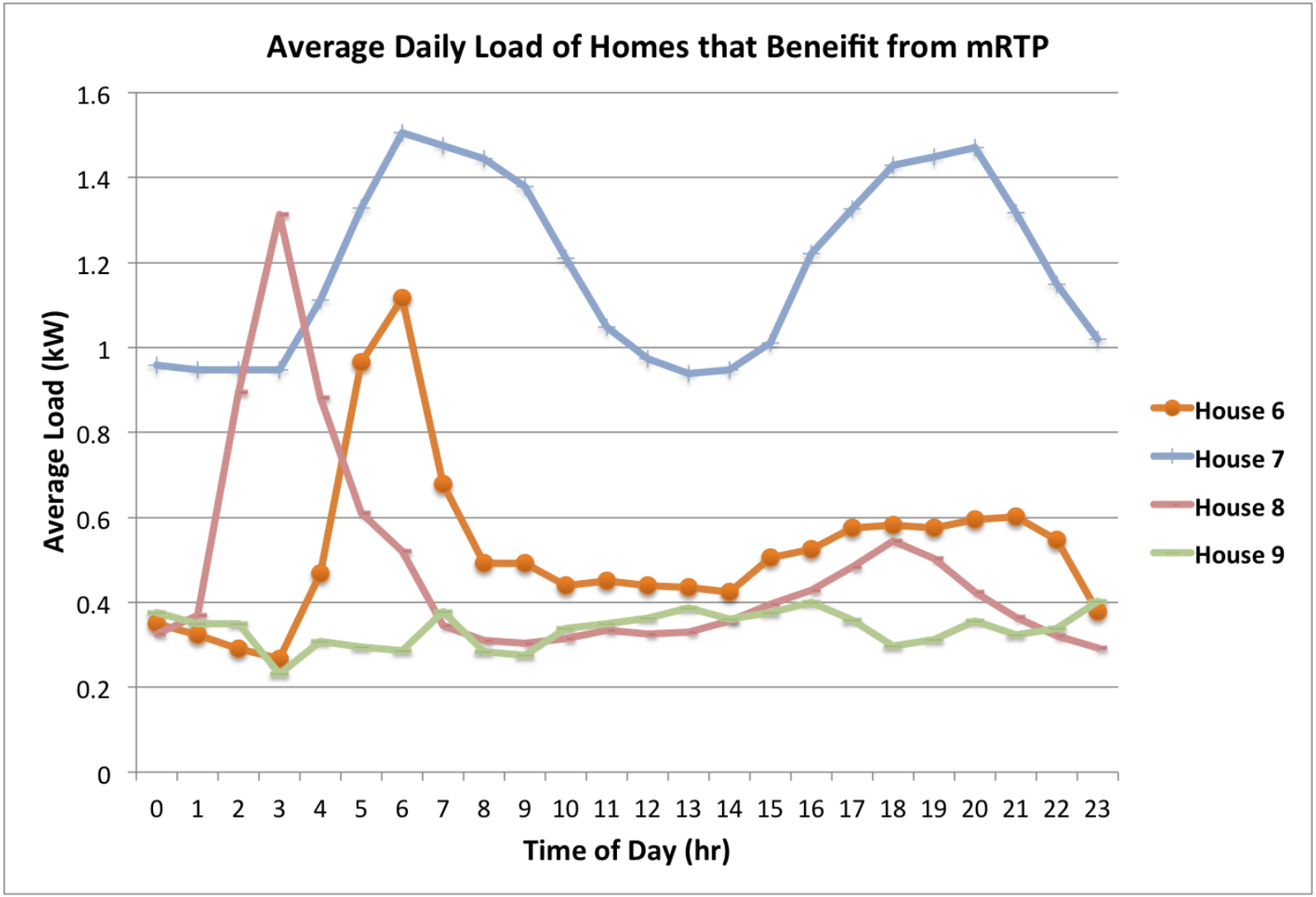


Rate Comparisons

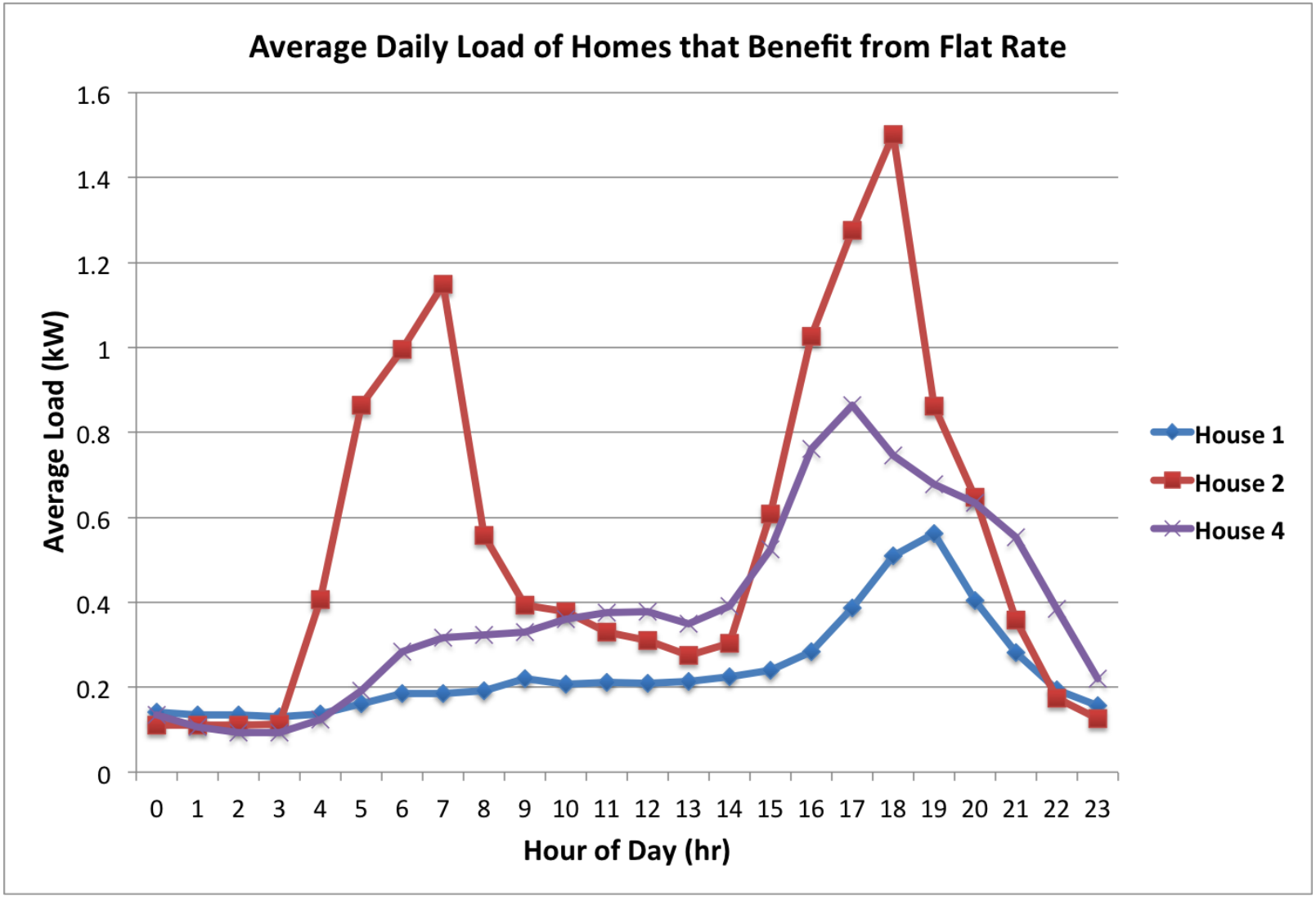
Case Study 1: House Categories

- Smart meter data from nine houses were analyzed.
- Houses fell into one of three categories
  - Houses that benefit from mRTP (Houses 6-9)
  - Houses that benefit from the flat rate (Houses 1, 2 & 4)
  - Houses that are indifferent to rate design (Houses 3 & 5)

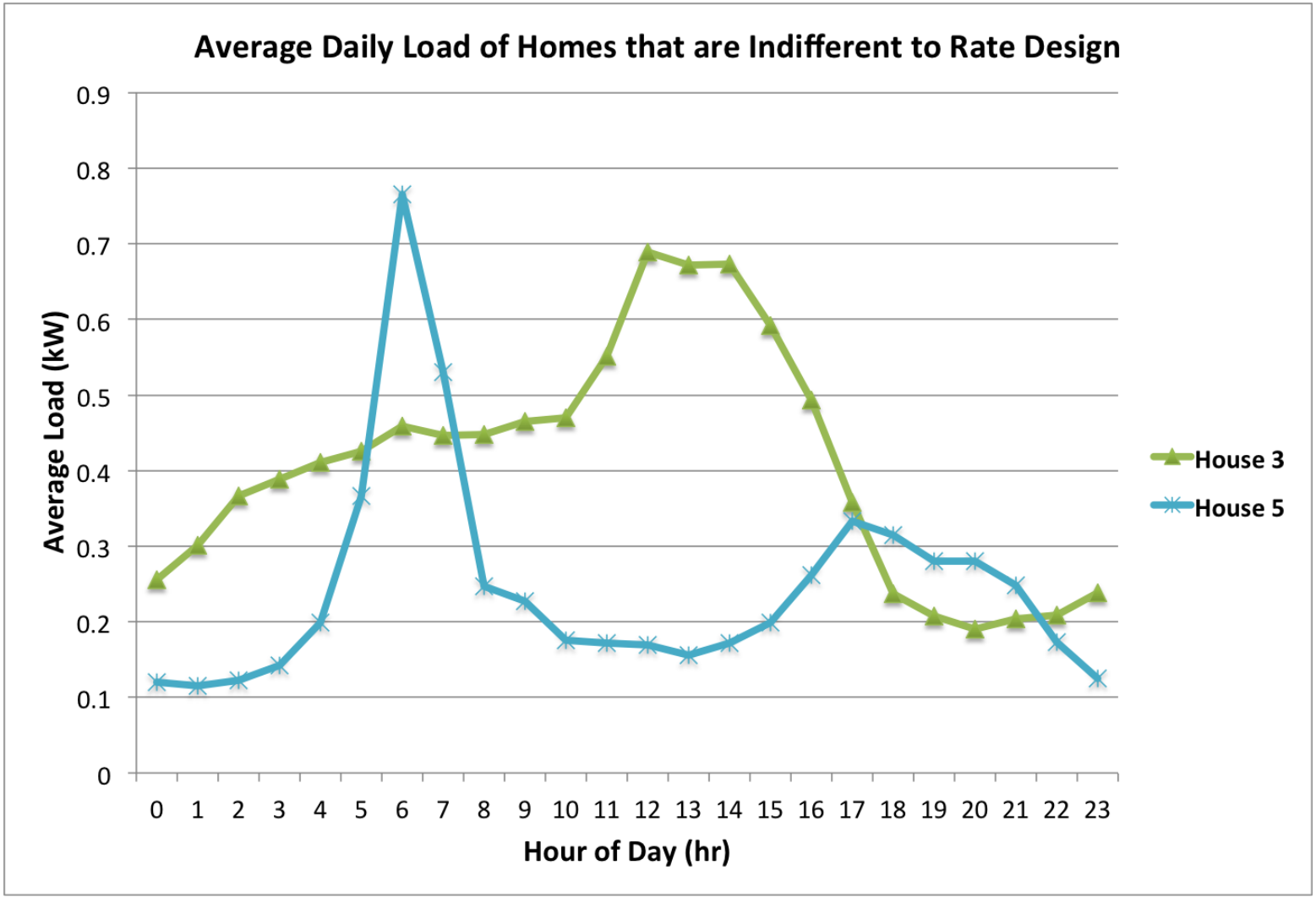
Average Daily Loads: Houses 6-9



Average Daily Loads: Houses 1, 2 & 4



Average Daily Loads: Houses 3 & 5



Case Study 2:Yearly Savings Analysis

- Goals:
  - Determine the amount of potential savings of each household (Δ), & pick a representative for each category
  - Differentiate between savings due to switching to mRTP and the savings due to shifting/ reducing load
  - Determine who service providers should focus their attention

Assumptions

- When households participate, they shift their load without reducing
- Household shift behavior is the same
  - Dependent on two factors:
    - *n*, the # of hours participated daily
    - *s*, the overall amount of shifted load in kW

Quantifying DR Participation

- Two metrics to quantify DR: Frequency (*F*) & Magnitude (*M)*
  - Frequency is measured in percent of hours where shifting occurs
  - Magnitude is measured in percent of load shifted at each instance of participation
  - *F* and *M* are both broken into 4 subsets

Quantifying DR Participation (cont.)

TABLE II. CUSTOMER DR FREQUENCY PARTICIPATION LEVELS

Frequency Participation	*F* (%)	Participation Threshold (*G*)	Actual # of Active Hours (for 2011 PJM Load)
Very Frequent	>10	>=4	1198
Frequent	~5-10	>=5	755
Occasional	~2-5	>=6	319
Rare	<2	>=7	118

Breakdown of the Four Different Frequency Participation Levels

TABLE III. CUSTOMER DR MAGNITUDE PARTICIPATION LEVELS

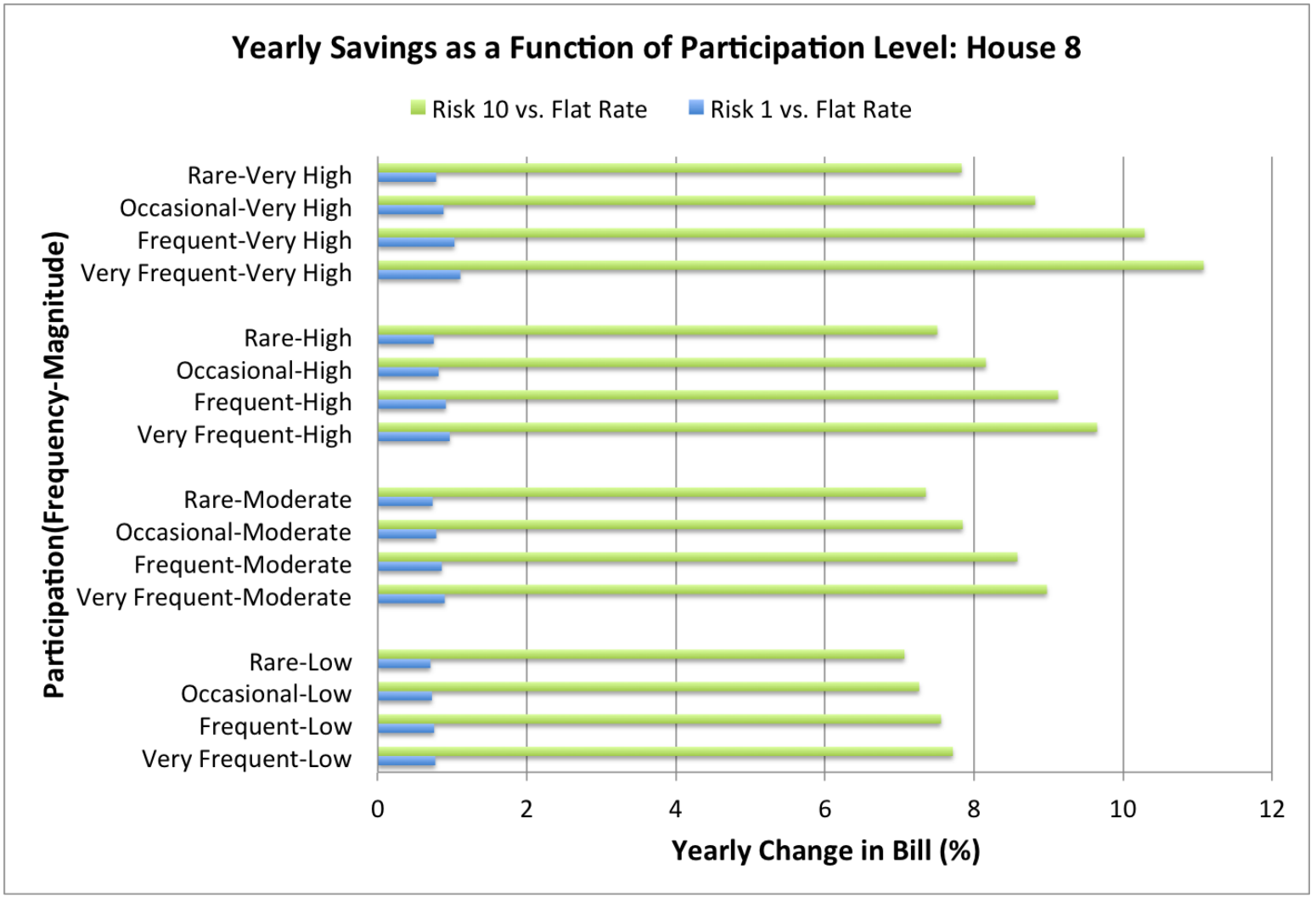
Magnitude Participation	*M* (%)
Low	~10
Moderate	~25
High	~33
Very High	~50

Breakdown of the Four Different Magnitude Participation Levels

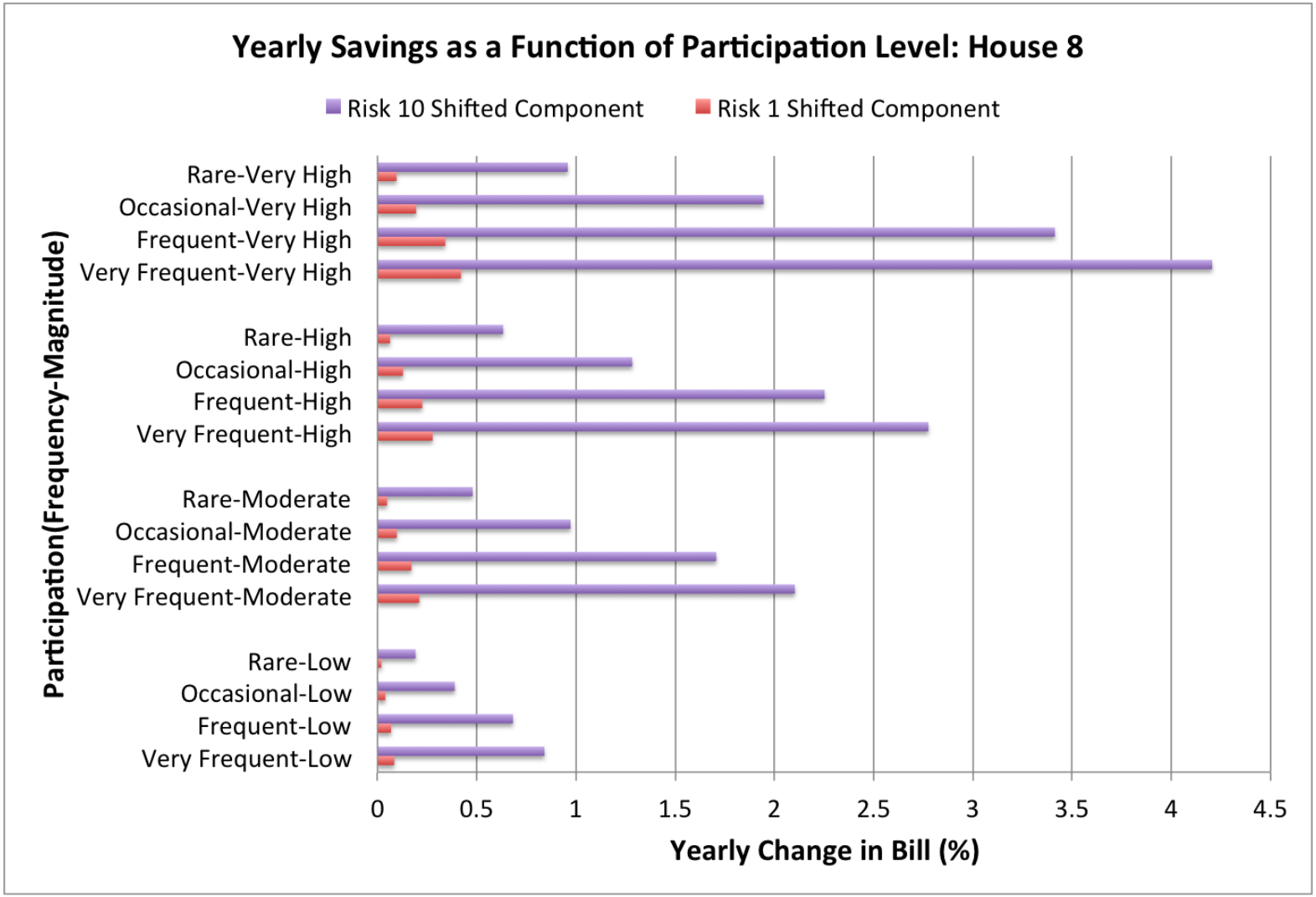
Yearly Savings Analysis (cont.)

- One household was selected for each category
  - House 8: Benefits from mRTP, Δ = + 6.87%/yr
  - House 4: Benefits from the flat rate, Δ = -3.52%/yr
  - House 3: Indifferent to rate design, Δ = 0.03 %/yr

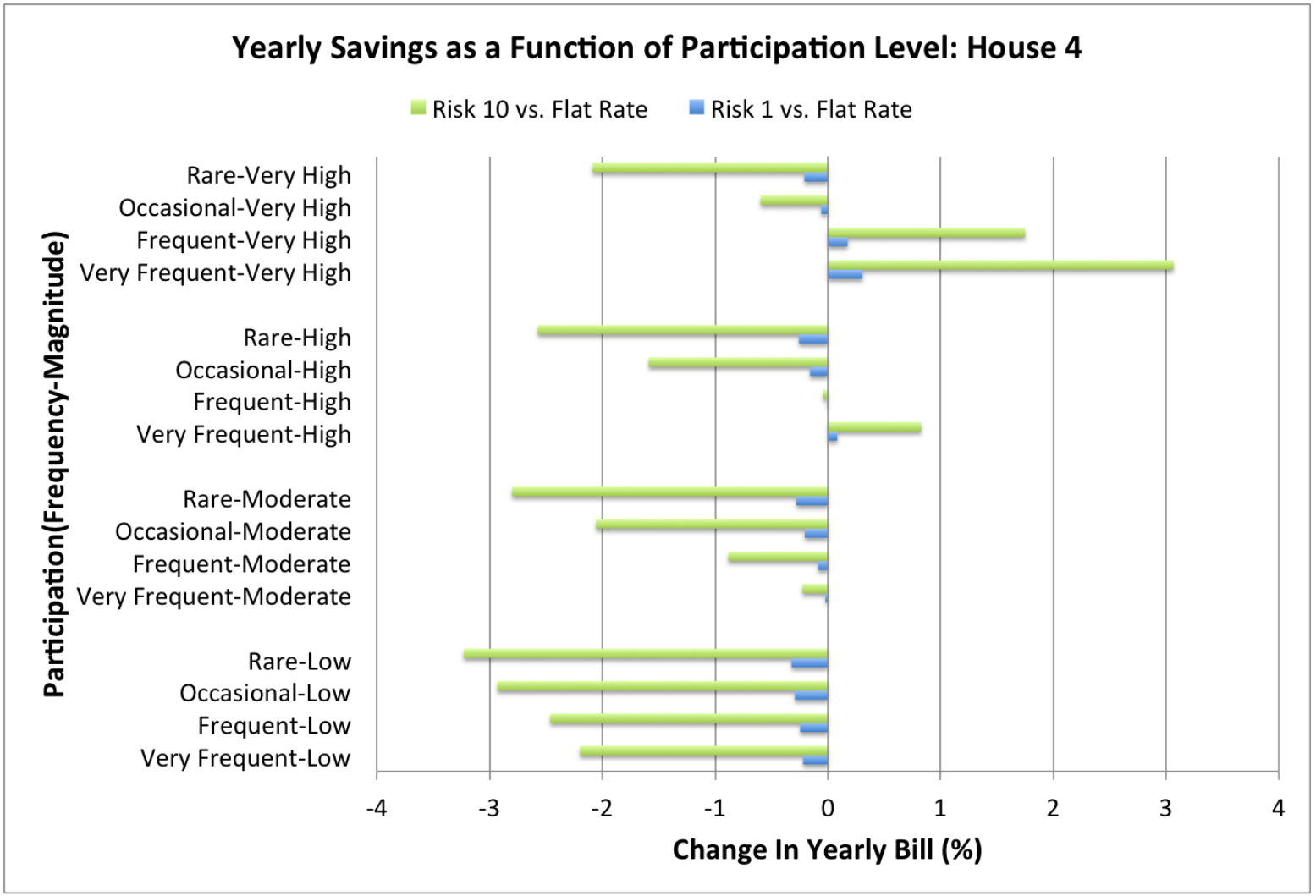
Yearly Savings: Benefits from mRTP



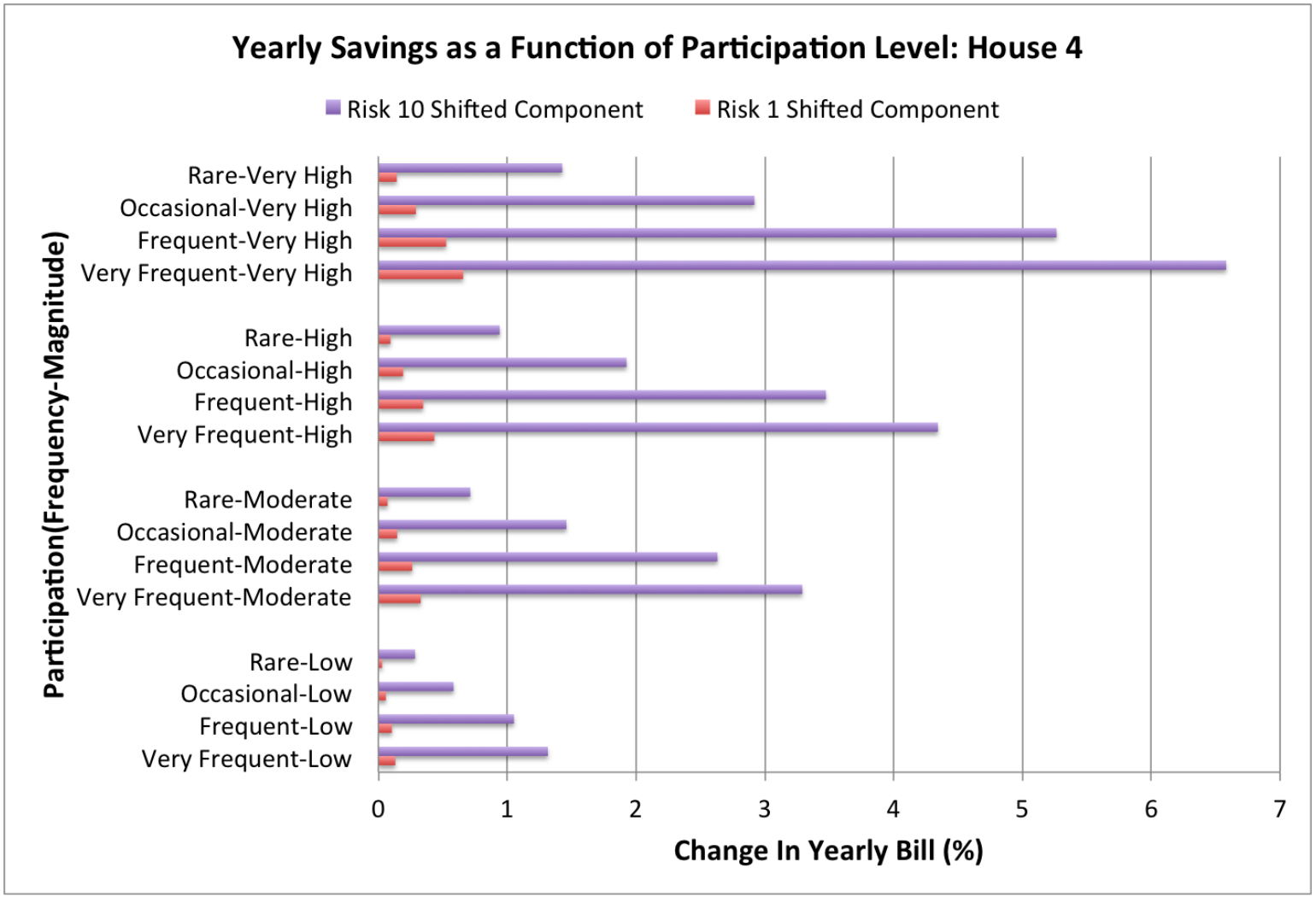
Component of Yearly Savings Due to Shifting Load: Benefits from mRTP



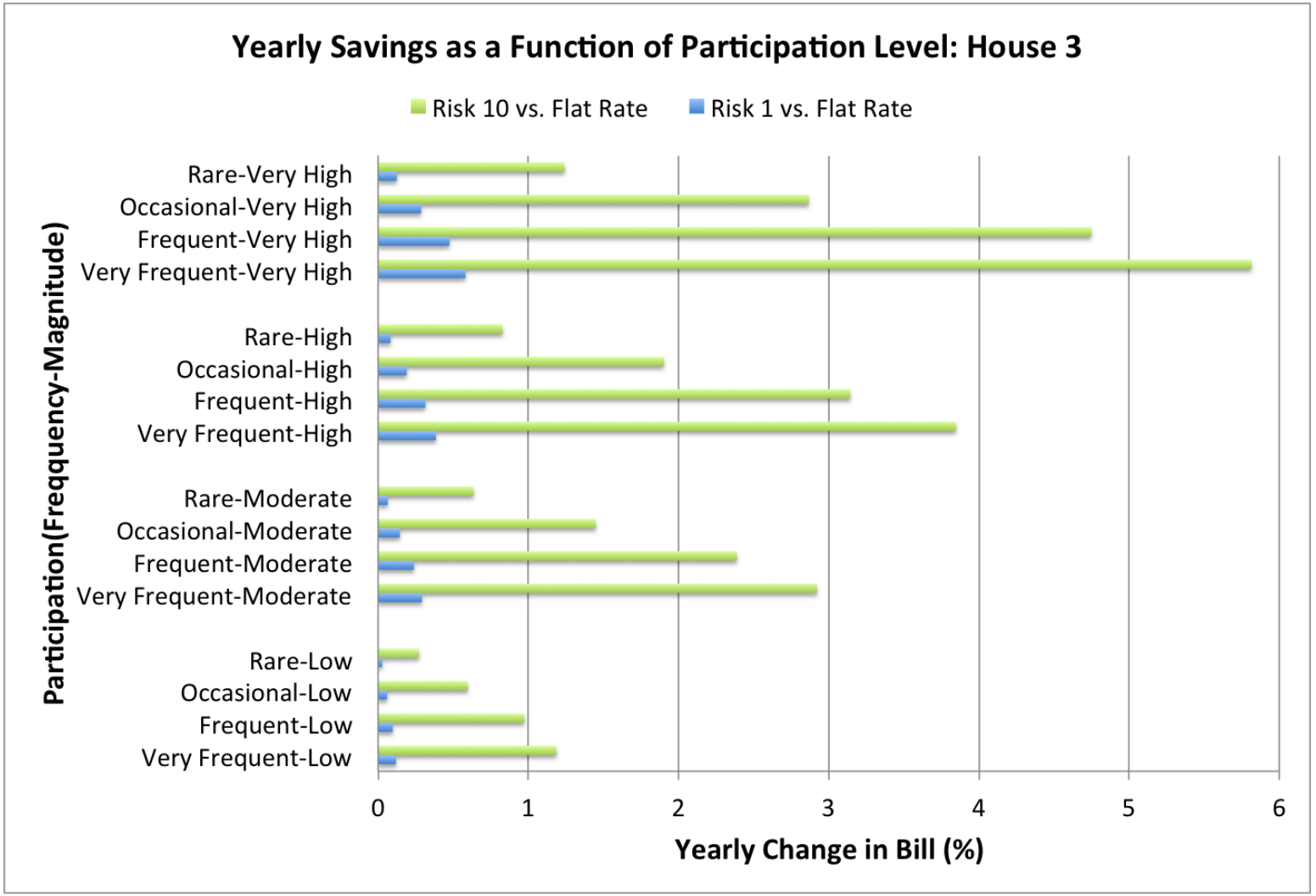
Yearly Savings: Benefits from Flat Rate



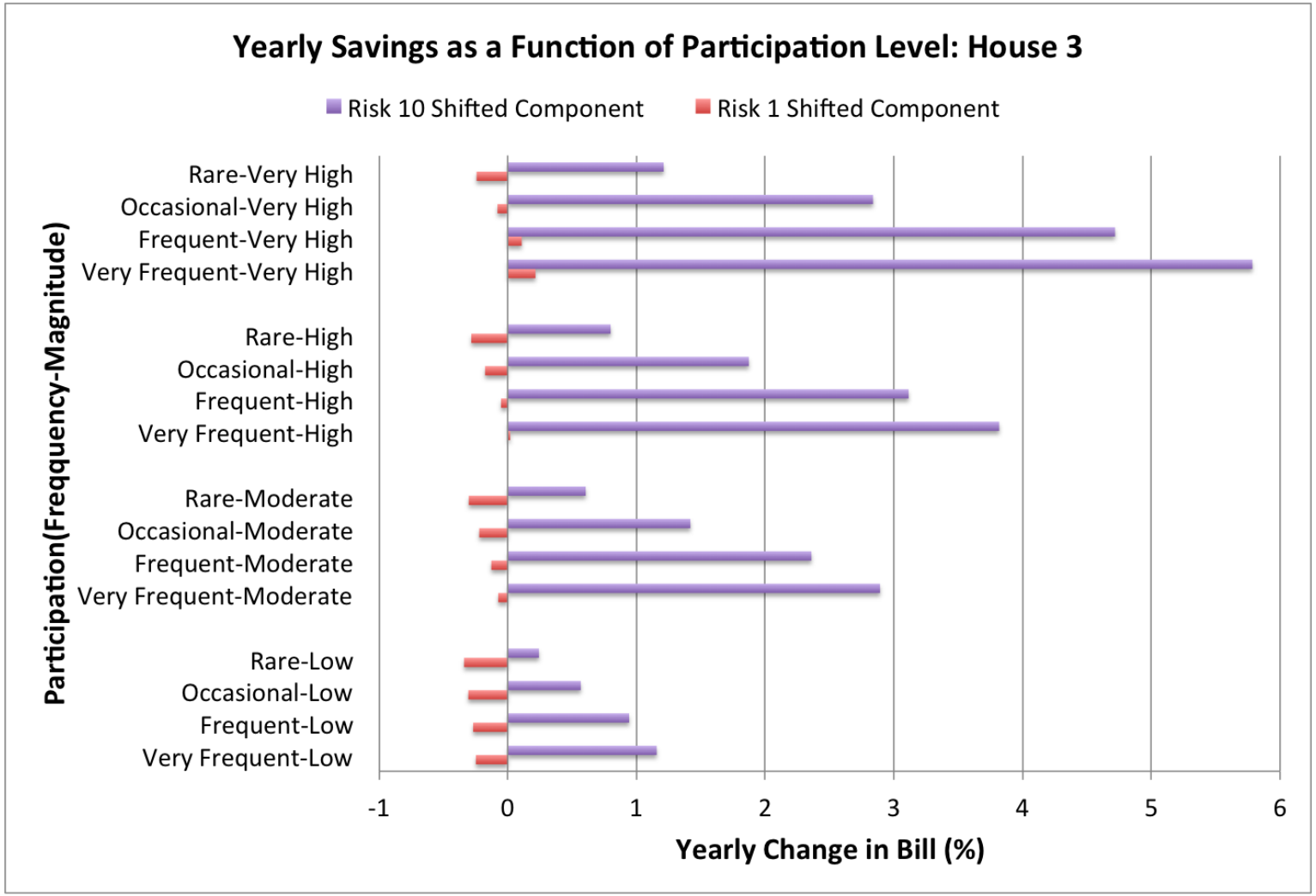
Component of Yearly Savings Due to Shifting Load: Benefits from Flat Rate



Yearly Savings: Indifferent from Rate Design



Component of Yearly Savings Due to Shifting Load: Indifferent to Rate Design



Main Conclusion

Households with average load profiles like the indifferent category, have the most incentive to participate in DR with mRTP.

Further Exploration

- Customer behavior is not ideal: Developing a model with random customer behavior
- Exploration of mRTP in different regions of the United States
- Quantifying the effect of grid condition indexing (incentivizing participation on the front end)

Questions?