Impacts of Solar Power on Electricity Rates and Bills

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Motivation

- The goal of this analysis is to understand the impact that solar mandates (RPS+NEM) may have on electricity rates and bills.
- Previous studies have noted that utility lost revenues are a potentially significant cost, particularly if there are no mechanisms in place to adjust for lost sales.
- Because some fixed costs are billed as throughput costs, NEM customers are able to avoid many of the fixed costs associated their service causing rates to rise…further incentivizing solar and EE investments…and the "death spiral".
- As a result, utilities are exploring different business models and rate options.

Background

- Because NEM customers may not be adequately paying for grid services -- transmission, distribution, and other ancillary services that they still consume -- non-participants in NEM subsidize participants.
- This result has equity consideration, especially since residential NEM participants have incomes well above average utility customers.
- On the other hand, solar NEM customers are providing valuable electricity to the grid since solar generators produce electricity when wholesale electricity prices are relatively high.

A prototypical utility modeled by GT-Solar

- NEM enables retail customers who generate electricity through their own renewable systems to receive full retail price for each solar kWh—not to exceed the customer's annual electric needs.
- Its power business is divided into an electricity supply system (that buys and sells power and manages high-voltage transmission lines along with associated transformers) and an electricity delivery system (that manages distribution substations, transformers, poles, and service lines that bring the electricity to meters).
- Three classes of customers: residential, small commercial, and large commercial and industrial.

Customer Load Shape Profiles

- Data for aggregate customer load profiles were obtained using 4 years of historical data from 2011 to 2014 from a northeastern utility.
  - A total of nine load profiles were developed from these data.
  - Each of these nine profiles contains 24 representative hours that we assume are identical for each day in a month.
  - A separate load profile was calculated for each of the three rate classes: residential, small business, and C&I.
  - Within each rate class a load profile was created for the average weekday (Monday through Friday), weekend, and system peak day.

Hourly Solar Generation of Participants

- The solar generation profiles were developed based on data from solar customers from 2010 to 2013 and
  - Includes both the system size and the kWh generated by hour.
  - The generation is divided by system size to calculate the capacity factor for each hour of each month for the entire year.
  - Independent solar profiles are created for each of the rate classes to account for different optimizations (i.e., to maximize peak simultaneity, or due to roof characteristics).
  - In addition to the average solar profile, a peak solar profile was created to represent an average of the solar generation for the peak day in each month for each of the four years.

Alternative Scenarios

- **"Base Case" = RPS requires 4.1% solar in 2028**
- **"High Cases" triple this requirement: 12.3% in 2028**

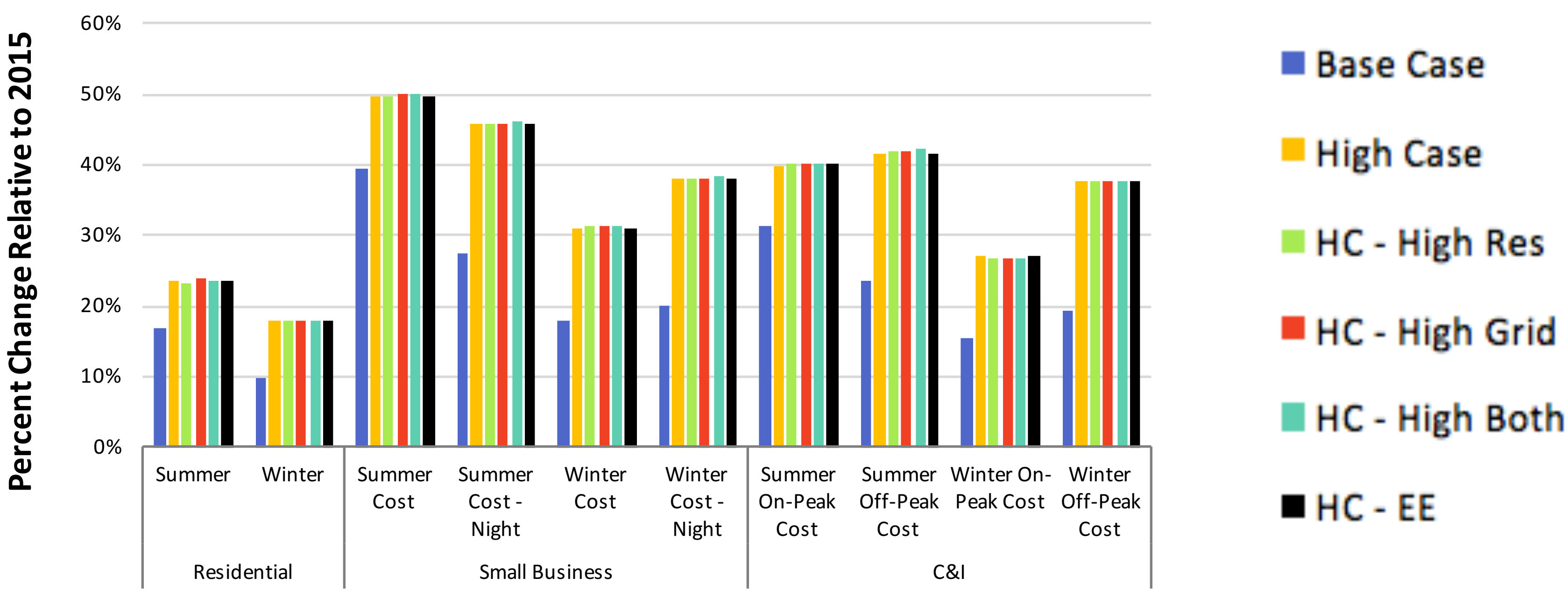
- **With High Residential Participation**
  - Grid-connected solar accounts for 33% of new additions annually
  - Residential solar accounts for 80% of new additions of net metered solar
  - Small business solar accounts for 20% of new additions of net metered solar in C&I
- **With a High Proportion of Grid-Connected Solar**
  - Grid-connected solar accounts for 50% of new additions annually
  - Residential solar accounts for 50% of new additions of net metered solar
  - Small business solar accounts for 20% of new additions of net metered solar in C&I
- **With Both of the Above**
  - Grid-connected solar accounts for 50% of new additions annually
  - Residential solar accounts for 80% of new additions of net metered solar
  - Small business solar accounts for 20% of new additions of net metered solar in C&I
- **With More Naturally Occurring Energy Efficiency**
  - The demand for electricity is assumed to stay flat rather than growing at an average annual growth rate of 0.25% used in the other scenarios

Estimating Supply Costs

- We estimate a market supply curve using historical market data.
- We focus primarily on changes to the electricity markets through both reduced demand (from NEM customers) and increased supply from grid connected solar installations.
- Due to the size of the wholesale market relative to the utility's electricity demand and our studied solar requirements, there are limited price changes in this market in response to increased solar penetration.

Supply Rates

Due to the size of the wholesale market relative to the RPS solar requirements, there are limited price increases in this market in response to increased solar penetration—prices do increase more in the winter.



Estimating Distribution Costs

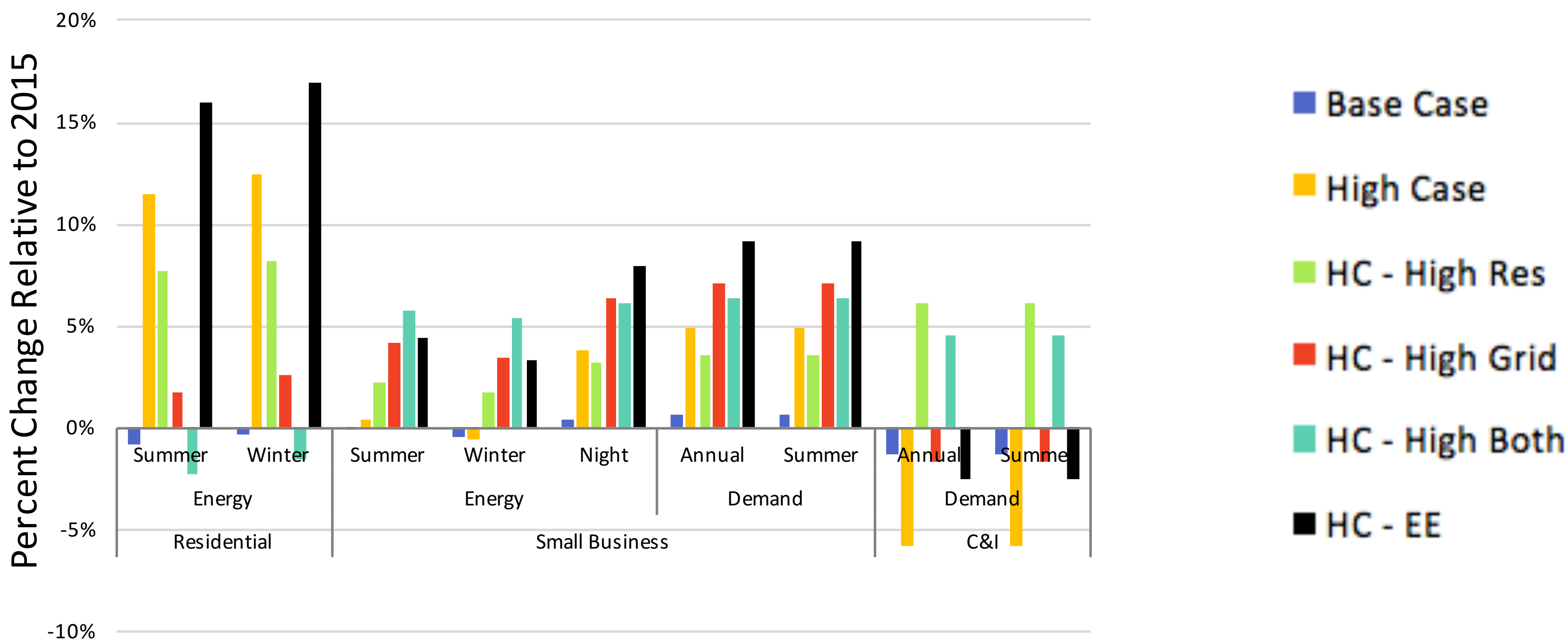
- We modeled a common distribution rate design
- Customers in each rate class are charged a fixed fee for service that recovers a portion of fixed costs
  - Residential customers are billed a fixed price per kWh to recover costs associated with distributing electricity to the customer's premises. The rate for the first 600 kWh is lower than for subsequent consumption. It is also seasonal.
  - Non-residential customers are subject to an annual demand charge that is assessed on a monthly basis and is determined by the highest kW demand registered in any 30-minute cycle during the billing period. A summer demand charge, determined by the highest on-peak kW demand helps the utility recover the higher costs of maintaining its electric distribution system during peak summer months.

Distribution Rates

Distribution rates are perturbed more when solar penetration is tripled. in the High Case (where C&I solar dominates, with only 20% in residences):

- rates decline for C&I customers
- rates are higher for residential and small business customers.

When 50% of new solar is residential, residential rates decline.



Distribution Rates

These changes are largely due to changes in the peaking hour of demand due to solar production and a subsequent change in how distribution costs are allocated.

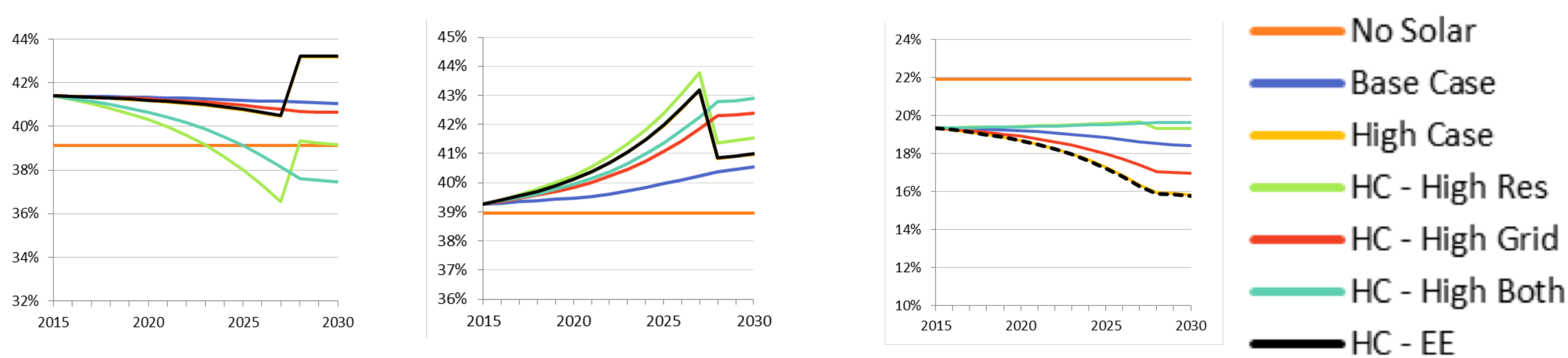
The percentage of coincident peak is affected by solar in two ways:
(1) by changing the peak hour, and
(2) by changing the demand of a particular rate class.

Change in Customer Class Allocation of System's Coincident Peak

- In 2015, the system coincident peak occurred in July at 4 pm.
- The significant increases in solar power represented by the High Case moves it to 5 pm between 2027 and 2028, and to 6 pm between 2028 and 2029.
- Residential customers were responsible for 41% of that peak in 2015. This % decreases until about 2028, when it increases in two cases (EE & High Res).
- The opposite occurs for small businesses, which accounted for 39% in 2015.
- C&I customer class mostly decreases in peak coincidence from 19% in 2015.

Percent of Utility System's Coincident Peak Attributable to Each Customer Class

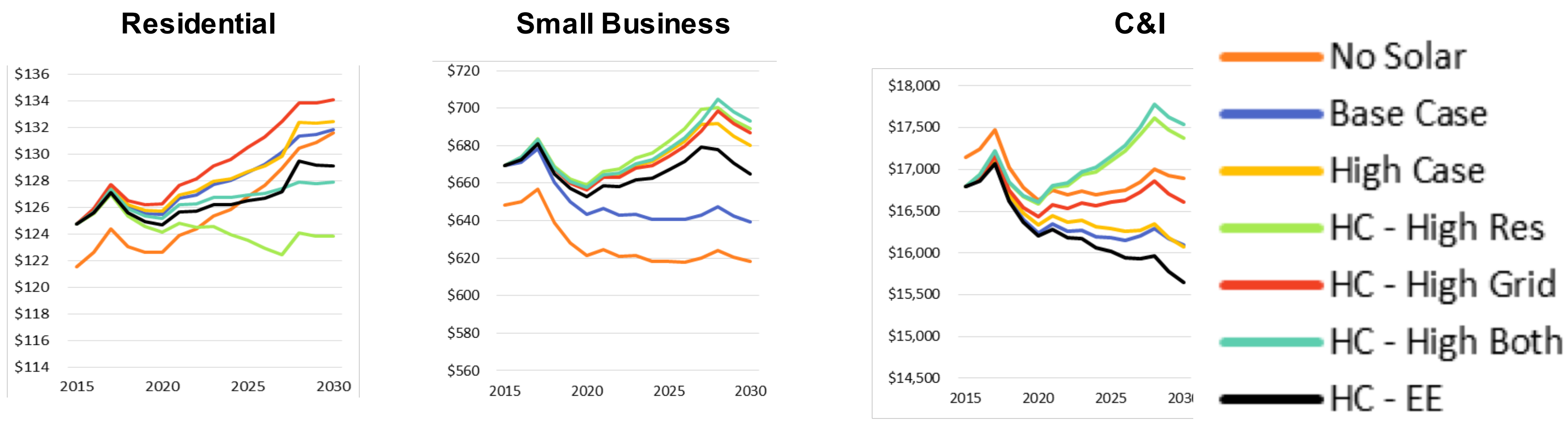
Residential **Small Business** **C&I**



Impact of Energy Efficiency on Bills

- Rates, consumption, and bills are all influenced by increased energy efficiency.
- When consumption decreases with EE and with distributed solar, the utility's fixed costs must be distributed over a smaller volume of sales and rates rise.
- Electricity bills are lowered when EE is introduced because consumption drops.
- This is illustrated when EE is added to the High Case.

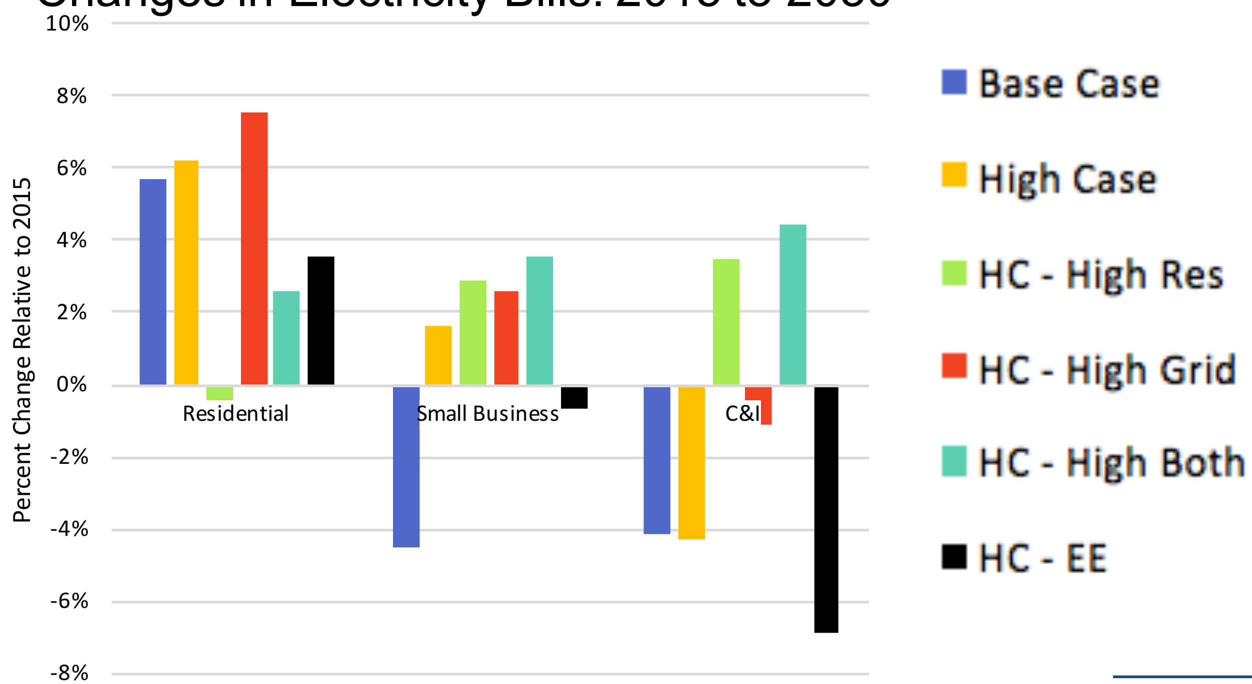
Average Monthly Bills Over Time (in $2015/Customer)



Electricity Bills

- Our modeling suggests that customer classes that install more solar fare better than customer classes that install less, because of the way that distribution costs are allocated.
- Thus, in the scenario with high solar penetration by C&I customers, the residential portion of distribution costs increases and experiences a further tick up when the system peak shifts to later in the afternoon.

Changes in Electricity Bills: 2015 to 2030

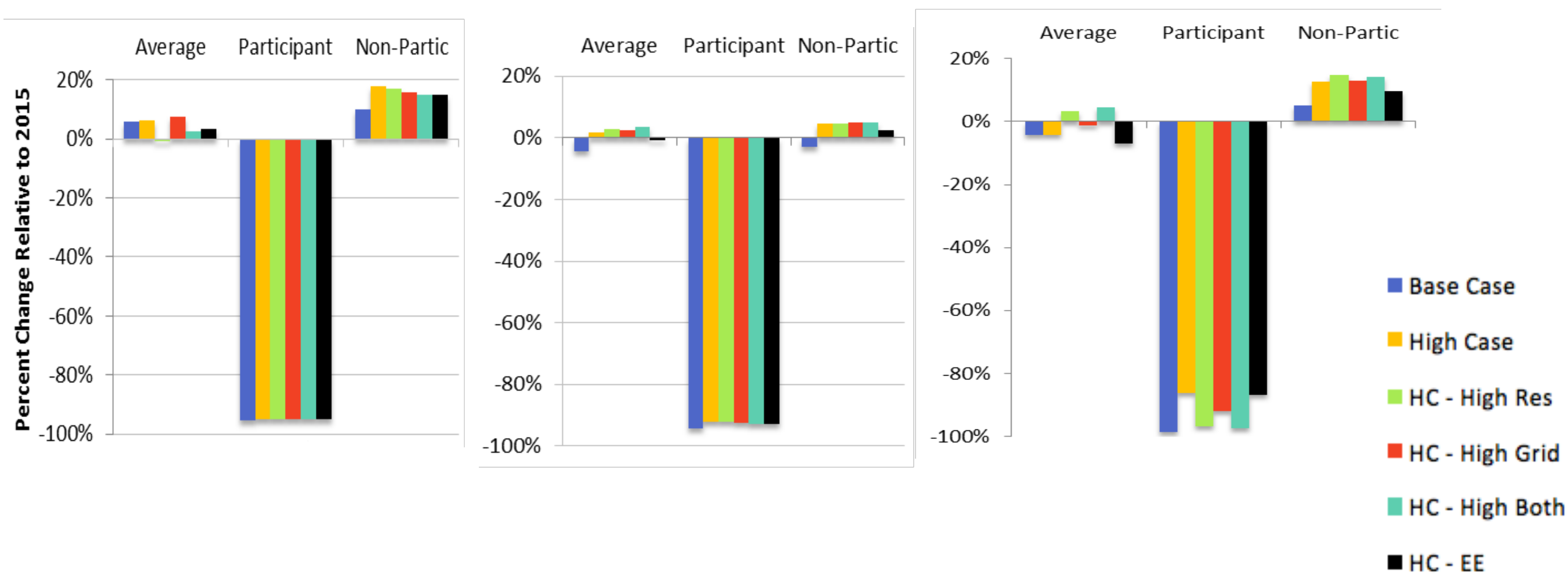


Electricity Bills for Participants/Non-Participants

Customers that install solar are able to reduce their bills substantially and transfer costs to non-participants.

% Change in Electricity Bills Across Participants & Non-Participants: 2015-2030

Residential **Small Business** **C&I**



Conclusions

- These findings suggest the need for increased attention and analysis to understand the potential impact of alternative rate structures and the apportionment of fixed and volumetric costs.
- It is becoming clear that current pricing policies are imperfect reflections of economic pricing principles, such as aligning charges with cost causation.
- Rate designs are clearly a product of a political process in which stakeholders vie for designs that best serve their interests.

Conclusions and Research Gaps

- Alternatives rate designs include the use of minimum bills, straight fixed variable rates with dynamic pricing, demand charges for residential customers, various net metering rate structures, and differential charges for DG participants and non-participants.
- Pricing options are hampered in the short run by the limited penetration of smart metering.
- As smart meters and DG become more prevalent, and as these are integrated into EE policy systems, the tradeoffs and consequences of alternative pricing strategies require further analysis.

For More Information

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