

Estimating the Potential Impact of Advanced Rate Designs in Hawaii: MAIN BODY OF REPORT

PRESENTED TO
Ingrid Rohmund (AEG)

PRESENTED BY
Ahmad Faruqui
Maria Castaner

April 13, 2020



THE **Brattle** GROUP

Agenda

Preliminary Results
CONFIDENTIAL

Background

- Existing Rate Designs in Hawaii

Proposed Rate Designs

- Summary of Proposed Rate Designs
- Rate Calculation Methodology
- Residential and Commercial Class Attributes
- Sample Charges for the Proposed Rate Designs

Simulated Rate Design Impacts

Utilities in Hawaii are Offering the Following Residential Rate Designs Today

Preliminary Results
CONFIDENTIAL

Residential rates offered by **Hawaiian Electric Co (HECO)**, **Hawaii Electric Light Co (HELCO)**, and **Maui Electric Co (MECO)**:

| Schedule | Rate Design | Description |
|--------------------|-------------------------------|---|
| R | Tiered fixed volumetric | Standard residential rate |
| TOU-R | TOU + Tiered fixed volumetric | Pilot TOU rate; closed to new participants since 2016 |
| Residential TOU EV | TOU + Tiered fixed volumetric | Pilot TOU EV rate; closed to new participants since 2016 |
| TOU-RI | TOU | Interim TOU rate; also applies to customers with EVs (required to have separate meter); capped at 5,000 customers |

Residential rates offered by **Kauai Island Utility Cooperative (KIUC)**:

| Schedule | Rate Design | Description |
|----------|------------------|---------------------------|
| D | Fixed volumetric | Standard residential rate |
| TOU-S | TOU | Capped at 300 customers |

Utilities in Hawaii are Offering the Following Commercial Rate Designs Today

Preliminary Results
CONFIDENTIAL

Commercial rates offered by **Hawaiian Electric Co (HECO)**, **Hawaii Electric Light Co (HELCO)**, and **Maui Electric Co (MECO)**:

| Schedule | Rate Design | Description |
|--------------------------|--------------------------|---|
| G | Flat volumetric | General Service Non-Demand |
| J | Demand + flat volumetric | General Service Demand |
| TOU-G | TOU | Small Commercial Time-of-Use |
| TOU-J | Demand + TOU | Commercial Time-of-Use Service |
| TOU-P | Demand + TOU | Large Commercial Time-of-Use Service |
| EV-F / EV-U | TOU | Commercial Public Electric Vehicle Charging Pilots |
| E-Bus-J / E-Bus-P | Demand + TOU | Commercial Electric Bus Charging Facility Service Pilot |

Commercial rates offered by **Kauai Island Utility Cooperative (KIUC)**:

| Schedule | Rate Design | Description |
|--------------|----------------------------------|---|
| G | Fixed volumetric | General Light and Power Service |
| J | Demand + flat volumetric | General Light and Power Service |
| L / P | Demand + tiered fixed volumetric | Large Power Primary (L) / Secondary (P) Service |

Our Proposed Rate Designs

Preliminary Results
CONFIDENTIAL

We propose the following **three rate designs** for the residential and commercial classes:

- **3-period TOU rate**
- **3-period TOU rate with demand charge**
- **3-period TOU rate with CPP charge**

The next part of this presentation focuses on (1) providing sample charges that follow the rate structures proposed above and (2) describing the methodology used to calculate those charges.

We designed the sample rates to be **revenue-neutral**, meaning that each rate is designed to collect the same total revenue as the existing residential rate, in absence of any customer price response.

Rate Determination Methodology

Preliminary Results
CONFIDENTIAL

Step 1: We gathered some data on the billing determinants (e.g. monthly electricity consumption*, monthly electricity sales*, monthly peak demand) for a typical residential/commercial customer in Hawaii. This data is summarized in the next two slides.

Step 2: We calculated the current average residential/commercial monthly bills in Hawaii (based on 2018 *sales* data**).

Step 3: We calculated revenue-neutral rates that would collect the same total revenue as the existing residential/commercial rates.

For a more detailed description of the methodology, please refer to Appendix (“Detailed Rate Calculation Methodology”).

Notes:

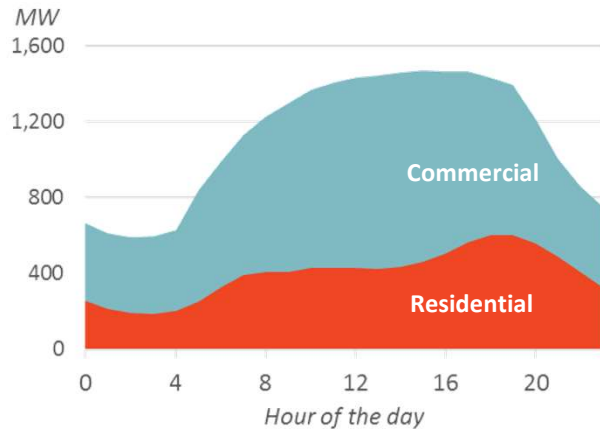
**Sales* describe the kWh of electricity sold to the customer by the utility. *Consumption* describes a customer’s total electricity needs, which might include self-consumption of electricity generated through the customer’s solar PV systems. This distinction is particularly important to highlight for Hawaii given the high levels of distributed solar PV penetration in the residential sector.

**Average monthly bills and the revenue-neutral rates were calculated based on *sales*, not consumption, as electric rates are set by the utility and determined based on their electricity sales. Consumption data was not used in the rate determination analysis, but was used later on in the price response analysis to estimate customers’ response to the new rate structures.

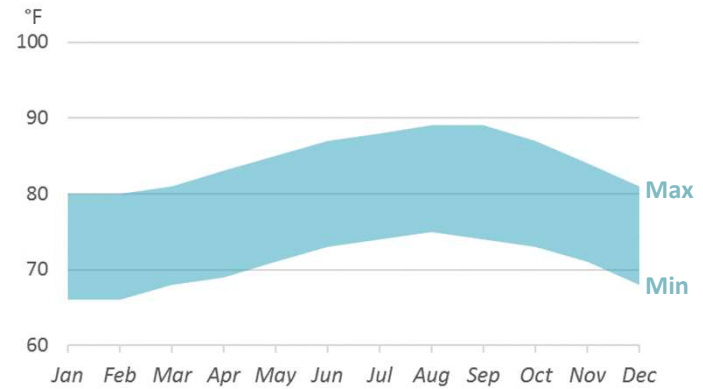
Residential and Commercial Class Consumption Summary

Preliminary Results
CONFIDENTIAL

Residential and Commercial Average Annual Consumption Profiles (Stacked)

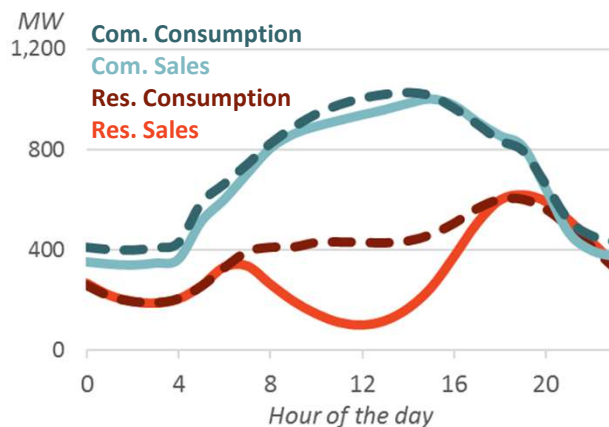


Avg. Temperature Range in Honolulu, HI



Source: <https://www.rssweather.com/climate/Hawaii/Honolulu/>

Average Annual Customer Consumption vs Sales Shapes

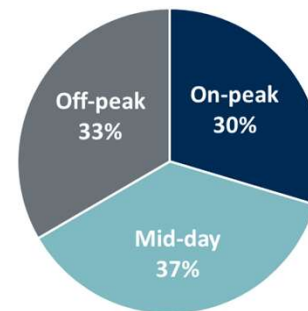


Source: Residential and commercial class consumption and sales shapes for 2018 provided by AEG.

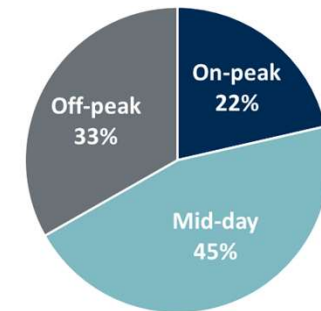
Average consumption by TOU period

Off-peak: 10pm-9am, mid-day: 9am-5pm, on-peak: 5pm-10pm

Residential



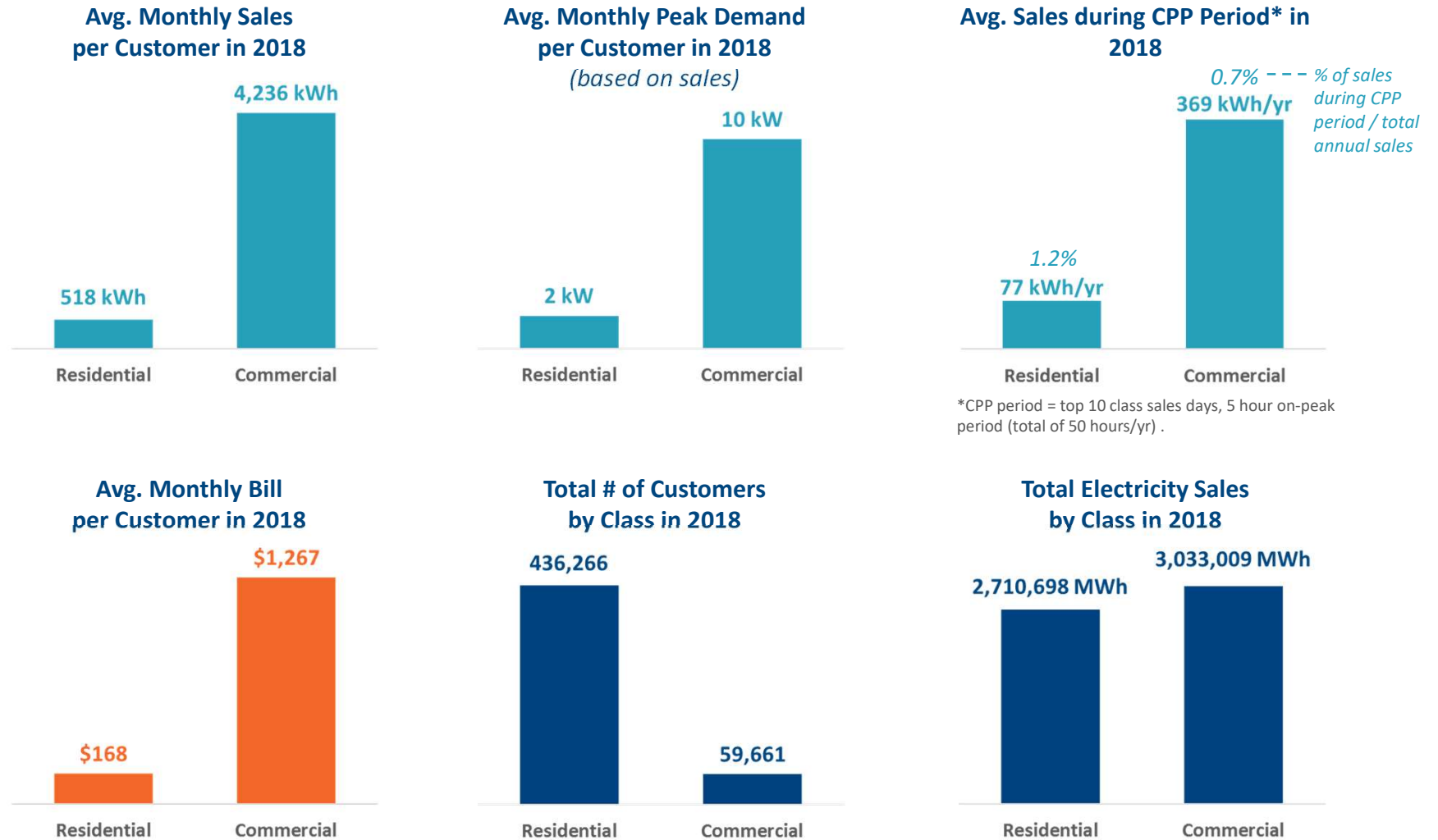
Commercial



Source: Residential and commercial class consumption profiles for 2018 provided by AEG. Note: Period definition based on HECO's TOU period definition for residential and commercial customers (same period definition for both classes).

Residential and Commercial Class Electricity Sales, Customers and Monthly Bills

Preliminary Results
CONFIDENTIAL



Source: EIA 2018 and sales profiles by class provided by AEG.

Rate Proposals for the Residential Class

Preliminary Results
CONFIDENTIAL

The table below summarizes the proposed charges for three **revenue-neutral** rate designs for the residential class:

| Rate Design | Non-Fuel Energy Charges | | | | | Other Charges | |
|--------------------|-------------------------|------------------|-------------------|-------------------|--------------------|---------------|---------------------|
| | TOU | | | Demand | CPP | Fixed Charge | Fuel + Other Charge |
| | On-peak | Mid-day | Off-peak | On-peak | On-peak | | |
| | 5pm-10pm ¢/kWh | 9am-5pm ¢/kWh | 10pm-9am ¢/kWh | 5pm-10pm \$/kW | 5pm-10pm* ¢/kWh | n.a. \$/mo | All hours ¢/kWh |
| Existing Flat Vol. | 11.83 | 11.83 | 11.83 | n.a. | n.a. | 11.50 | 18.42 |
| Existing TOU | 24.68 | -4.48 | 15.85 | n.a. | n.a. | 11.50 | 18.42 |
| TOU | 25.00 | 1.00 | 5.00 | n.a. | n.a. | 11.50 | 18.42 |
| TOU + Demand | 19.85 | 1.00 | 5.00 | 6.33 | n.a. | 11.50 | 18.42 |
| TOU + CPP | 19.85 | 1.00 | 5.00 | n.a. | 174.28 | 11.50 | 18.42 |

Notes:

- *Only applies during the top 10 highest sales days of the year. During the on-peak period of those critical 10 days, the TOU on-peak charge gets replaced by the CPP on-peak charge.
- “Existing TOU” rate based on HECO Schedule TOU-RI and “Existing Flat Vol.” rate based on HECO Schedule R. The non-fuel energy charges of the “Existing Flat Vol.” rate are tiered: 10.6812¢/kWh for the first 350 kWh, 11.8347¢/kWh for the next 850 kWh, and 13.7121¢/kWh for all kWh over 1,200 kWh.
- Monthly fixed charge of \$11.50 based on HECO’s Schedule TOU-RI and Schedule R fixed charge for single-phase service.
- Fuel charge of \$0.18/kWh estimated based on the difference between the avg. residential all-in electricity price and the fixed and non-fuel energy charges.
- The demand and CPP charges collect 20% of the total revenue collected from on-peak hours in the “TOU” rate.

Rate Proposals for the Commercial Class

Preliminary Results
CONFIDENTIAL

The table below summarizes the proposed charges for three **revenue-neutral** rate designs for the commercial class:

| Rate Design | Non-Fuel Energy Charges | | | | | Other Charges | |
|--------------------|-------------------------|---------|----------|----------|----------|---------------|---------------------|
| | TOU | | | Demand | CPP | Fixed Charge | Fuel + Other Charge |
| | On-peak | Mid-day | Off-peak | On-peak | On-peak | | |
| | 5pm-10pm | 9am-5pm | 10pm-9am | 5pm-10pm | 5pm-10pm | n.a. | All hours |
| ¢/kWh | ¢/kWh | ¢/kWh | \$/kW | ¢/kWh | \$/mo | ¢/kWh | |
| Existing Flat Vol. | 9.60 | 9.60 | 9.60 | n.a. | n.a. | 35.00 | 18.42 |
| Existing Demand | 5.32 | 5.32 | 5.32 | 13.00 | n.a. | 66.00 | 18.42 |
| Existing TOU | 14.60 | 6.60 | 11.60 | n.a. | n.a. | 35.00 | 18.42 |
| TOU | 30.00 | 1.00 | 8.50 | n.a. | n.a. | 35.00 | 18.42 |
| TOU + Demand | 18.00 | 1.00 | 8.50 | 11.42 | n.a. | 35.00 | 18.42 |
| TOU + CPP | 24.00 | 1.00 | 8.50 | n.a. | 210.45 | 35.00 | 18.42 |

Notes:

- "Existing Flat Vol." based on HECO Schedule G, "Existing Demand" based on HECO Schedule J, and "Existing TOU" rate based on Schedule TOU-G for HECO.
- CPP on-peak charge is in addition to the TOU charge during that period.
- Monthly fixed charges based on HECO's Schedule J charge for single-phase service.
- Assumed same fuel charge as for the residential class.
- The demand and CPP charges collect 40% and 20%, respectively, of the total revenue collected from on-peak hours in the "TOU" rate. brattle.com | 10

Estimating Consumption Impacts from Change in Rate Design

Preliminary Results
CONFIDENTIAL

Once we calculated the sample charges for the proposed rate designs, we estimated customers' response to the change in rate structure.

In particular, we estimated customers' average change in:

- Overall consumption
- On-peak consumption
- Off-peak consumption
- Super-off-peak consumption

Finally, we estimated the % impact that the new rate designs would have on total residential consumption under three adoption scenarios: opt-in, opt-out and mandatory.

Estimating the Impact of New Rate Designs

Preliminary Results
CONFIDENTIAL

To estimate the average customer's change in overall consumption in response to the new rate structures, we reviewed a wide range of TOU, demand, and CPP pilot studies, which are summarized in the next slide. No Hawaii-specific studies are available on the topic.

Then, we fed that parameters into the Price Response Impact Simulation Model (PRISM) to model the shift in energy consumption across periods.

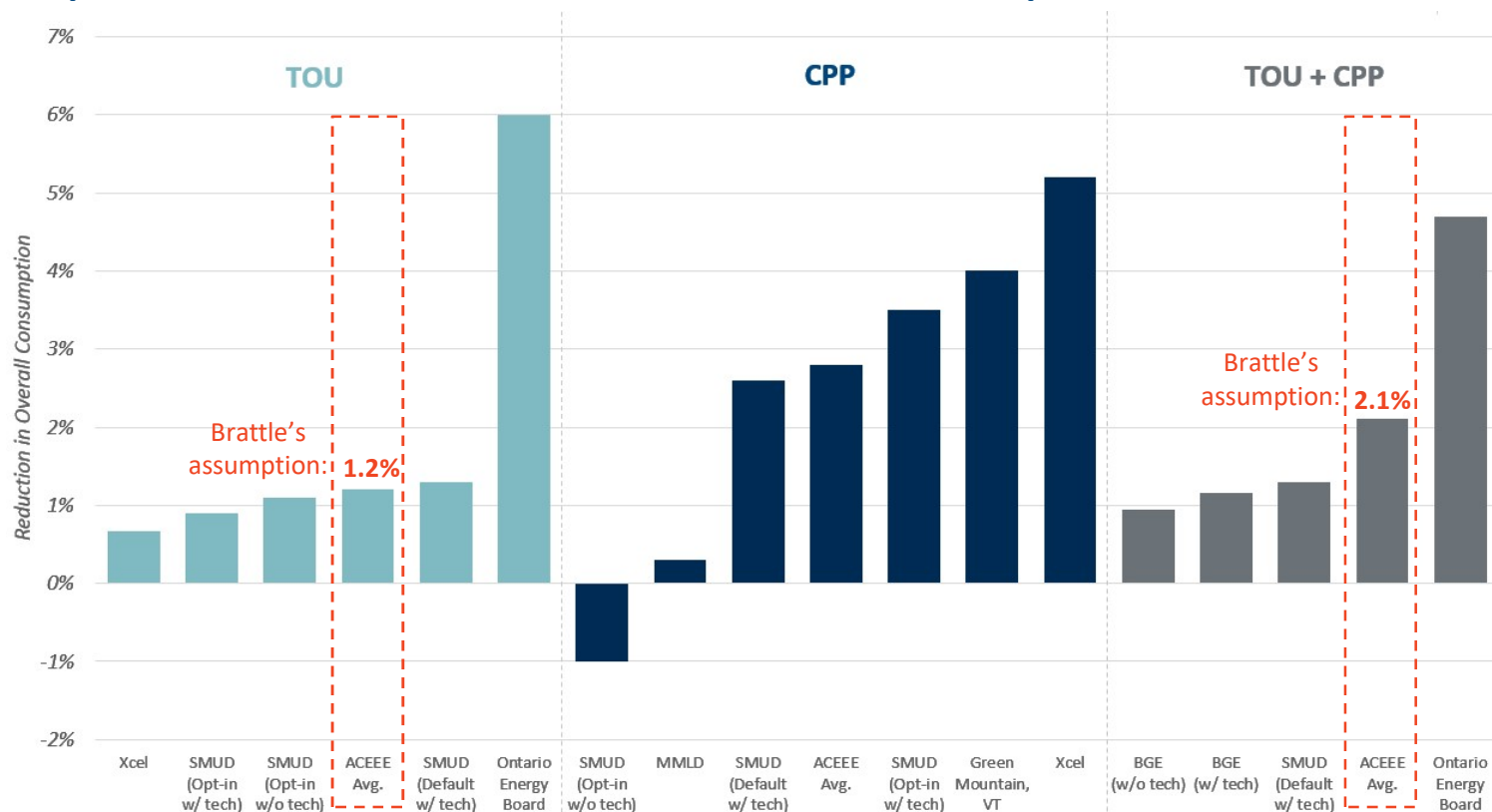
- The inputs to PRISM were:
 - Change in total energy consumption (based on literature review)
 - Average customer 8760 consumption profile (provided by AEG)
 - Proposed new rates (derived by Brattle)
 - Elasticities of substitution (based on literature review)
- Based on those inputs, PRISM outputs the change in energy consumption for each TOU period.

Change in Total Energy Consumption (Based on Literature Review)

Preliminary Results
CONFIDENTIAL

The figure below summarizes a sample of studies reviewed that evaluate the change in overall consumption from TOU, CPP and demand rates.

Comparison across Studies of Reduction in Overall Consumption for Residential Customers



Sources: listed in Appendix. Note: We assumed the same reduction in overall consumption for the TOU and the TOU+Demand rates.

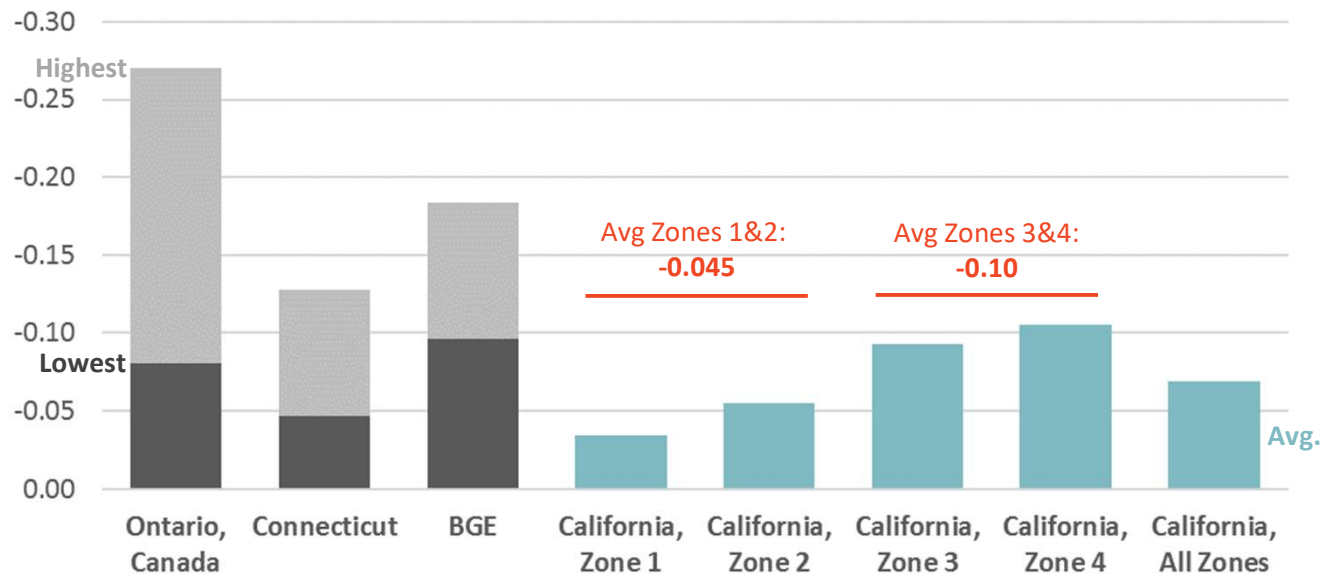
PRISM Inputs

Preliminary Results
CONFIDENTIAL

The inputs to PRISM were:

- Change in total energy consumption (based on literature review)
- Average customer 8760 consumption shapes (provided by AEG)
- Proposed new rates (derived by Brattle)
- Elasticities of substitution (based on literature review, **summarized below**)
 - The elasticity of substitution measures a customer's willingness to shift consumption across periods in response to the price differences across those periods.

Comparison of Elasticities of Substitution Across Residential Rate Design Pilots



We based our elasticity parameters on the results from a study in California, given the similarity in climate to Hawaii compared to other regions in the US. We tested two elasticities values: the averages from the two mild climate zones in California (Zone 1 and Zone 2) and from the two hot climates zones (Zone 3 and Zone 4).

Residential Results

Summary of Average % Consumption Impact per Customer

Preliminary Results
CONFIDENTIAL

| Period | Consumption kWh/yr | Three-Period TOU | | Three-Period TOU + Demand Charge | | Three-Period TOU + CPP Charge | |
|---|-----------------------|------------------|-----------------|----------------------------------|-----------------|-------------------------------|-----------------|
| | | Estimated Impact | Estimated Usage | Estimated Impact | Estimated Usage | Estimated Impact | Estimated Usage |
| | | % | kWh/yr | % | kWh/yr | % | kWh/yr |
| | [A] | [B] | [C] | [D] | [E] | [F] | [G] |
| <i>Elasticity of Substitution = -0.045</i> | | | | | | | |
| On-Peak | 2,390 | -3.3% | 2,310 | -3.3% | 2,310 | -4.0% | 2,290 |
| Off-Peak | 2,690 | -0.7% | 2,670 | -0.7% | 2,670 | -1.8% | 2,640 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,990 | 0.1% | 2,990 | 0.1% | 2,990 | -1.1% | 2,960 |
| CPP On-Peak | 72 | n.a. | n.a. | n.a. | n.a. | -10.4% | 64 |
| Peak Demand | n.a. | n.a. | n.a. | -3.3% | n.a. | n.a. | n.a. |
| All periods | 8,070 | -1.2% | 7,970 | -1.2% | 7,970 | -2.1% | 7,900 |
| <i>Elasticity of Substitution = -0.10</i> | | | | | | | |
| On-Peak | 2,390 | -5.8% | 2,250 | -5.8% | 2,250 | -6.3% | 2,240 |
| Off-Peak | 2,690 | -0.2% | 2,690 | -0.2% | 2,690 | -1.4% | 2,650 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,990 | 1.6% | 3,040 | 1.6% | 3,040 | 0.3% | 3,000 |
| CPP On-Peak | 72 | n.a. | n.a. | n.a. | n.a. | -19.7% | 58 |
| Peak Demand | n.a. | n.a. | n.a. | -5.8% | n.a. | n.a. | n.a. |
| All periods | 8,070 | -1.2% | 7,970 | -1.2% | 7,970 | -2.1% | 7,900 |

Note: All consumption results (in kWh) are rounded to the nearest ten except for CPP On-Peak.

Residential Results

Summary of Average % Consumption Impact per Customer: Key Takeaways

Preliminary Results
CONFIDENTIAL

- Using Hawaii-specific residential consumption shapes and customer elasticities of substitution between -0.045 and -0.010, we estimated that residential customers would on average reduce **consumption** during the **on-peak period** by **3.3%-5.8%**, from **2,390 kWh/yr** to **2,250-2,310 kWh/yr** under a **TOU rate** design, assuming an on-peak/off-peak ratio of 2. **Overall energy consumption** would be reduced by an average of **1.2%**, from **8,070 kWh/yr** to **7,970 kWh/yr**.
- The change in overall and on-peak consumption by switching to a **TOU rate with a demand charge** (assuming revenue neutrality) would be expected to be similar to that of the simple TOU rate on average. In addition, we would also expect customers to reduce their **peak demand** by **3.3%-5.8%**, from **1.8 kW** to **1.70-1.75 kW**.
- Under a revenue neutral **TOU+CPP rate**, we estimate that **on-peak consumption** would decrease by **4.0%-6.3%** on average, from **2,390 kWh/yr** to **2,240-2,290 kWh/yr**. In addition, consumption during the **on-peak hours** of the **critical peak days** would be reduced by **10%-20%**, from **72 kWh/yr** to **58-64 kWh/yr**.

Modeling Residential Class Consumption Impact under Three Adoption Scenarios

Preliminary Results
CONFIDENTIAL

Once we modeled the average % consumption impact per customer, we estimated the aggregate impact of the proposed rate designs on consumption under three adoption scenarios: opt-in, opt-out, and mandatory.

Rate of adoption (%) under opt-in, opt-out and mandatory scenarios

| | |
|------------------|------|
| Opt-in | 20% |
| Opt-out | 80% |
| Mandatory | 100% |

Residential Results

Estimated Residential Class Consumption Impact for Opt-in Scenario

Preliminary Results
CONFIDENTIAL

| Period | Consumption GWh/yr | Opt-in | | | | | |
|--|-----------------------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|
| | | TOU | | TOU + Demand | | TOU + CPP | |
| | | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load |
| | | % | GWh/yr | % | GWh/yr | % | GWh/yr |
| | | [A] | [B] | [C] | [D] | [E] | [F] |
| Elasticity of Substitution = -0.045 | | | | | | | |
| On-Peak | 1,030 | -0.7% | 1,025 | -0.7% | 1,025 | -0.8% | 1,020 |
| Off-Peak | 1,160 | -0.1% | 1,160 | -0.1% | 1,160 | -0.4% | 1,155 |
| Mid-Day (<i>Super-Off-Peak</i>) | 1,290 | 0.0% | 1,290 | 0.0% | 1,290 | -0.2% | 1,285 |
| CPP On-Peak | 31 | n.a. | n.a. | n.a. | n.a. | -2.1% | 30 |
| Peak Demand | n.a. | n.a. | n.a. | -0.7% | n.a. | n.a. | n.a. |
| All periods | 3,480 | -0.2% | 3,470 | -0.2% | 3,470 | -0.4% | 3,465 |
| Elasticity of Substitution = -0.10 | | | | | | | |
| On-Peak | 1,030 | -1.2% | 1,020 | -1.2% | 1,020 | -1.3% | 1,015 |
| Off-Peak | 1,160 | 0.0% | 1,160 | 0.0% | 1,160 | -0.3% | 1,155 |
| Mid-Day (<i>Super-Off-Peak</i>) | 1,290 | 0.3% | 1,295 | 0.3% | 1,295 | 0.1% | 1,290 |
| CPP On-Peak | 31 | n.a. | n.a. | n.a. | n.a. | -3.9% | 30 |
| Peak Demand | n.a. | n.a. | n.a. | -1.2% | n.a. | n.a. | n.a. |
| All periods | 3,480 | -0.2% | 3,470 | -0.2% | 3,470 | -0.4% | 3,465 |

Note: All consumption results (in kWh) are rounded to the nearest five except for CPP On-Peak.

Residential Results

Estimated Residential Class Consumption Impact for Opt-out Scenario

Preliminary Results
CONFIDENTIAL

| Period | Consumption GWh/yr | Opt-out | | | | | |
|--|-----------------------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|
| | | TOU | | TOU + Demand | | TOU + CPP | |
| | | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load |
| | | % | GWh/yr | % | GWh/yr | % | GWh/yr |
| | | [A] | [B] | [C] | [D] | [E] | [F] |
| Elasticity of Substitution = -0.045 | | | | | | | |
| On-Peak | 1,030 | -2.6% | 1,005 | -2.6% | 1,005 | -3.2% | 995 |
| Off-Peak | 1,160 | -0.6% | 1,155 | -0.6% | 1,155 | -1.4% | 1,145 |
| Mid-Day (<i>Super-Off-Peak</i>) | 1,290 | 0.0% | 1,290 | 0.0% | 1,290 | -0.9% | 1,280 |
| CPP On-Peak | 31 | n.a. | n.a. | n.a. | n.a. | -8.4% | 28 |
| Peak Demand | n.a. | n.a. | n.a. | -2.6% | n.a. | n.a. | n.a. |
| All periods | 3,480 | -1.0% | 3,445 | -1.0% | 3,445 | -1.7% | 3,420 |
| Elasticity of Substitution = -0.10 | | | | | | | |
| On-Peak | 1,030 | -4.7% | 980 | -4.7% | 980 | -5.0% | 980 |
| Off-Peak | 1,160 | -0.1% | 1,160 | -0.1% | 1,160 | -1.1% | 1,145 |
| Mid-Day (<i>Super-Off-Peak</i>) | 1,290 | 1.3% | 1,305 | 1.3% | 1,305 | 0.2% | 1,295 |
| CPP On-Peak | 31 | n.a. | n.a. | n.a. | n.a. | -15.8% | 26 |
| Peak Demand | n.a. | n.a. | n.a. | -4.7% | n.a. | n.a. | n.a. |
| All periods | 3,480 | -1.0% | 3,445 | -1.0% | 3,445 | -1.7% | 3,420 |

Note: All consumption results (in kWh) are rounded to the nearest five except for CPP On-Peak.

Residential Results

Estimated Residential Class Consumption Impact for Mandatory Scenario

Preliminary Results
CONFIDENTIAL

| Period | Consumption GWh/yr | Mandatory | | | | | |
|--|-----------------------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|
| | | TOU | | TOU + Demand | | TOU + CPP | |
| | | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load |
| | | % | GWh/yr | % | GWh/yr | % | GWh/yr |
| | | [A] | [B] | [C] | [D] | [E] | [F] |
| Elasticity of Substitution = -0.045 | | | | | | | |
| On-Peak | 1,030 | -3.3% | 995 | -3.3% | 995 | -4.0% | 990 |
| Off-Peak | 1,160 | -0.7% | 1,150 | -0.7% | 1,150 | -1.8% | 1,140 |
| Mid-Day (<i>Super-Off-Peak</i>) | 1,290 | 0.1% | 1,290 | 0.1% | 1,290 | -1.1% | 1,275 |
| CPP On-Peak | 31 | n.a. | n.a. | n.a. | n.a. | -10.4% | 28 |
| Peak Demand | n.a. | n.a. | n.a. | -3.3% | n.a. | n.a. | n.a. |
| All periods | 3,480 | -1.2% | 3,440 | -1.2% | 3,440 | -2.1% | 3,405 |
| Elasticity of Substitution = -0.10 | | | | | | | |
| On-Peak | 1,030 | -5.8% | 970 | -5.8% | 970 | -6.3% | 965 |
| Off-Peak | 1,160 | -0.2% | 1,160 | -0.2% | 1,160 | -1.4% | 1,145 |
| Mid-Day (<i>Super-Off-Peak</i>) | 1,290 | 1.6% | 1,310 | 1.6% | 1,310 | 0.3% | 1,295 |
| CPP On-Peak | 31 | n.a. | n.a. | n.a. | n.a. | -19.7% | 25 |
| Peak Demand | n.a. | n.a. | n.a. | -5.8% | n.a. | n.a. | n.a. |
| All periods | 3,480 | -1.2% | 3,440 | -1.2% | 3,440 | -2.1% | 3,405 |

Note: All consumption results (in kWh) are rounded to the nearest five except for CPP On-Peak.

Residential Results

Estimated Residential Class Consumption Impact: **Key Takeaways**

Preliminary Results
CONFIDENTIAL

- Under the assumptions laid out in this presentation, we estimate that **residential consumption** during **on-peak hours** could be reduced on average by
 - **0.7%-1.3%** under **opt-in** rates, from **1,030** to **1,015-1,025** GWh/yr
 - **2.6%-5.0%** under **opt-out** rates, from **1,030** to **980-1,005** GWh/yr
 - **3.3%-6.3%** under mandatory rates, from **1,030** to **965-995** GWh/yr
- We estimate that **total residential consumption** could be reduced on average by
 - **0.2%-0.4%** under **opt-in** rates, from **3,480** to **3,465-3,470** GWh/yr
 - **1.0%-1.7%** under **opt-out** rates, from **3,480** to **3,420-3,445** GWh/yr
 - **1.2%-2.1%** under **mandatory** rates, from **3,480** to **3,405-3,440** GWh/yr.

Commercial Class Analysis

Preliminary Results
CONFIDENTIAL

We used the same methodology for estimating the consumption impacts for the commercial class as for the residential class.

We used commercial consumption data (provided by AEG) and the proposed commercial rates presented earlier to estimate the commercial class consumption impacts.

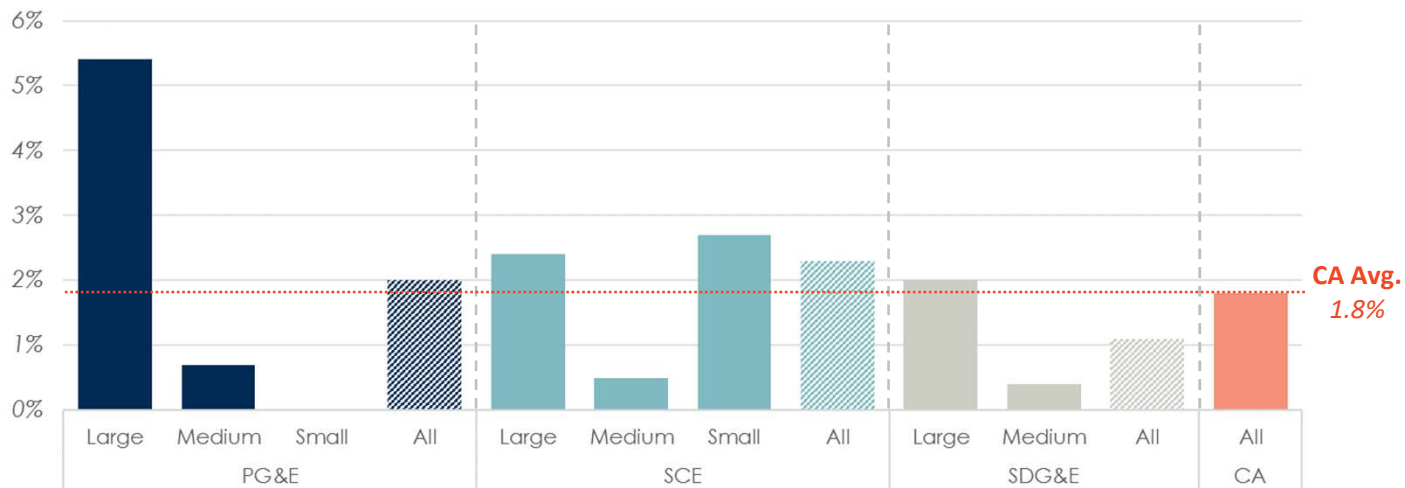
Given the lack of information available about the possible range of customer elasticities for the commercial class, we have used the same change in total energy consumption and the same elasticities of substitution as for the residential analysis.

Commercial Class Consumption Impact Studies

Preliminary Results
CONFIDENTIAL

- We reviewed a range of consumption impact studies for the commercial sector, including the CPP load impact study for non-residential customers in California (results summarized below).
- Overall, the consumption impact studies available for the commercial class are limited. As a result, we used PRISM to model the shift in consumption across periods based on the HI-specific commercial class consumption shapes and commercial rates, and assumed the same change in total energy consumption and the same elasticities of substitution for the commercial analysis as for the residential analysis.

% Consumption Impact Results for CPP Programs in 2018 in California



Source: Applied Energy Group, "2018 Statewide Load Impact Evaluation of California Non-Residential CPP Programs", April 2019.

Commercial Results

Summary of Average % Consumption Impact per Customer

Preliminary Results
CONFIDENTIAL

| Period | Consumption kWh/yr [A] | Three-Period TOU | | Three-Period TOU + Demand Charge | | Three-Period TOU + CPP Charge | |
|---|------------------------------|--------------------|------------------------|----------------------------------|------------------------|-------------------------------|------------------------|
| | | Estimated Impact % | Estimated Usage kWh/yr | Estimated Impact % | Estimated Usage kWh/yr | Estimated Impact % | Estimated Usage kWh/yr |
| | | [B] | [C] | [D] | [E] | [F] | [G] |
| <i>Elasticity of Substitution = -0.045</i> | | | | | | | |
| On-Peak | 11,500 | -4.0% | 11,030 | -4.0% | 11,030 | -4.5% | 10,990 |
| Off-Peak | 17,800 | -1.2% | 17,580 | -1.2% | 17,580 | -2.3% | 17,400 |
| Mid-Day (<i>Super-Off-Peak</i>) | 24,320 | 0.2% | 24,360 | 0.2% | 24,360 | -0.9% | 24,110 |
| CPP On-Peak | 377 | n.a. | n.a. | n.a. | n.a. | -11.6% | 334 |
| Peak Demand | n.a. | n.a. | n.a. | -4.0% | n.a. | n.a. | n.a. |
| All periods | 53,620 | -1.2% | 52,980 | -1.2% | 52,980 | -2.1% | 52,490 |
| <i>Elasticity of Substitution = -0.10</i> | | | | | | | |
| On-Peak | 11,500 | -7.4% | 10,640 | -7.4% | 10,640 | -7.6% | 10,630 |
| Off-Peak | 17,800 | -1.3% | 17,560 | -1.3% | 17,560 | -2.5% | 17,360 |
| Mid-Day (<i>Super-Off-Peak</i>) | 24,320 | 1.8% | 24,770 | 1.8% | 24,770 | 0.6% | 24,480 |
| CPP On-Peak | 377 | n.a. | n.a. | n.a. | n.a. | -21.9% | 294 |
| Peak Demand | n.a. | n.a. | n.a. | -7.4% | n.a. | n.a. | n.a. |
| All periods | 53,620 | -1.2% | 52,980 | -1.2% | 52,980 | -2.1% | 52,490 |

Note: All consumption results (in kWh) are rounded to the nearest ten except for CPP On-Peak.

Commercial Results

Summary of Average % Consumption Impact per Customer: Key Takeaways

Preliminary Results
CONFIDENTIAL

- Using Hawaii-specific commercial consumption profiles and customer elasticities of substitution between -0.045 and -0.010, we estimated that commercial customers would **reduce consumption during the on-peak period by 4.0%-7.3%** under a **TOU rate structure**, from **11,500 kWh/yr** to **10,640-11,030 kWh/yr**, assuming an on-peak/off-peak ratio of 2. **Overall energy consumption would be reduced** by an average of **1.2%**, from **53,620 kWh/yr** to **52,980 kWh/yr**.
- The change in overall and on-peak consumption by switching to a **TOU rate with a demand charge** (assuming revenue neutrality) would be expected to be similar to that of the simple TOU rate. However, we would also expect **peak demand to reduce by 4.0%-7.4%**, from **11.2 kW** to **10.2-10.7 kW**.
- Under a revenue neutral **TOU+CPP rate**, we estimate that **on-peak consumption would decrease by 4.5%-7.6%**, from **11,500 kWh/yr** to **10,630-10,990 kWh/yr**. In addition, consumption during the on-peak hours of the **critical peak days would reduce by 11%-22%**, from **377 kWh/yr** to **294-334 kWh/yr**.

Modeling Commercial Class Consumption Impact under Three Adoption Scenarios

Preliminary Results
CONFIDENTIAL

Similarly to the residential class analysis, we estimated the aggregate impact of the proposed rate designs on consumption under three adoption scenarios: opt-in, opt-out, and mandatory.

Rate of adoption (%) under opt-in, opt-out and mandatory scenarios

| | |
|-----------|------|
| Opt-in | 20% |
| Opt-out | 80% |
| Mandatory | 100% |

Commercial Results

Estimated Commercial Class Consumption Impact for Opt-in Scenario

Preliminary Results
CONFIDENTIAL

| Period | Consumption GWh/yr | Opt-in | | | | | |
|--|-----------------------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|
| | | TOU | | TOU + Demand | | TOU + CPP | |
| | | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load |
| | | % | GWh/yr | % | GWh/yr | % | GWh/yr |
| | | [A] | [B] | [C] | [D] | [E] | [F] |
| Elasticity of Substitution = -0.045 | | | | | | | |
| On-Peak | 1,350 | -0.8% | 1,340 | -0.8% | 1,340 | -0.9% | 1,340 |
| Off-Peak | 2,090 | -0.2% | 2,085 | -0.2% | 2,085 | -0.5% | 2,080 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,855 | 0.0% | 2,855 | 0.0% | 2,855 | -0.2% | 2,850 |
| CPP On-Peak | 44 | n.a. | n.a. | n.a. | n.a. | -2.3% | 43 |
| Peak Demand | n.a. | n.a. | n.a. | -0.8% | n.a. | n.a. | n.a. |
| All periods | 6,295 | -0.2% | 6,280 | -0.2% | 6,280 | -0.4% | 6,270 |
| Elasticity of Substitution = -0.10 | | | | | | | |
| On-Peak | 1,350 | -1.5% | 1,330 | -1.5% | 1,330 | -1.5% | 1,330 |
| Off-Peak | 2,090 | -0.3% | 2,085 | -0.3% | 2,085 | -0.5% | 2,080 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,855 | 0.4% | 2,865 | 0.4% | 2,865 | 0.1% | 2,860 |
| CPP On-Peak | 44 | n.a. | n.a. | n.a. | n.a. | -4.4% | 42 |
| Peak Demand | n.a. | n.a. | n.a. | -1.5% | n.a. | n.a. | n.a. |
| All periods | 6,295 | -0.2% | 6,280 | -0.2% | 6,280 | -0.4% | 6,270 |

Note: All consumption results (in kWh) are rounded to the nearest five except for CPP On-Peak.

Commercial Results

Estimated Commercial Class Consumption Impact for Opt-out Scenario

Preliminary Results
CONFIDENTIAL

| Period | Consumption GWh/yr | Opt-out | | | | | |
|--|-----------------------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|
| | | TOU | | TOU + Demand | | TOU + CPP | |
| | | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load |
| | | % | GWh/yr | % | GWh/yr | % | GWh/yr |
| | | [A] | [B] | [C] | [D] | [E] | [F] |
| Elasticity of Substitution = -0.045 | | | | | | | |
| On-Peak | 1,350 | -3.2% | 1,305 | -3.2% | 1,305 | -3.6% | 1,300 |
| Off-Peak | 2,090 | -1.0% | 2,070 | -1.0% | 2,070 | -1.8% | 2,050 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,855 | 0.1% | 2,860 | 0.1% | 2,860 | -0.7% | 2,835 |
| CPP On-Peak | 44 | n.a. | n.a. | n.a. | n.a. | -9.2% | 40 |
| Peak Demand | n.a. | n.a. | n.a. | -3.2% | n.a. | n.a. | n.a. |
| All periods | 6,295 | -1.0% | 6,235 | -1.0% | 6,235 | -1.7% | 6,190 |
| Elasticity of Substitution = -0.10 | | | | | | | |
| On-Peak | 1,350 | -6.0% | 1,270 | -6.0% | 1,270 | -6.1% | 1,270 |
| Off-Peak | 2,090 | -1.1% | 2,070 | -1.1% | 2,070 | -2.0% | 2,050 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,855 | 1.5% | 2,895 | 1.5% | 2,895 | 0.5% | 2,870 |
| CPP On-Peak | 44 | n.a. | n.a. | n.a. | n.a. | -17.5% | 37 |
| Peak Demand | n.a. | n.a. | n.a. | -6.0% | n.a. | n.a. | n.a. |
| All periods | 6,295 | -1.0% | 6,235 | -1.0% | 6,235 | -1.7% | 6,190 |

Note: All consumption results (in kWh) are rounded to the nearest five except for CPP On-Peak.

Commercial Results

Estimated Commercial Class Consumption Impact for **Mandatory** Scenario

Preliminary Results
CONFIDENTIAL

| Period | Consumption GWh/yr | Mandatory | | | | | |
|--|-----------------------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|
| | | TOU | | TOU + Demand | | TOU + CPP | |
| | | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load | Estimated Impact | Estimated Load |
| | | % | GWh/yr | % | GWh/yr | % | GWh/yr |
| | | [A] | [B] | [C] | [D] | [E] | [F] |
| Elasticity of Substitution = -0.045 | | | | | | | |
| On-Peak | 1,350 | -4.0% | 1,295 | -4.0% | 1,295 | -4.5% | 1,290 |
| Off-Peak | 2,090 | -1.2% | 2,065 | -1.2% | 2,065 | -2.3% | 2,045 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,855 | 0.2% | 2,860 | 0.2% | 2,860 | -0.9% | 2,830 |
| CPP On-Peak | 44 | n.a. | n.a. | n.a. | n.a. | -11.6% | 39 |
| Peak Demand | n.a. | n.a. | n.a. | -4.0% | n.a. | n.a. | n.a. |
| All periods | 6,295 | -1.2% | 6,220 | -1.2% | 6,220 | -2.1% | 6,165 |
| Elasticity of Substitution = -0.10 | | | | | | | |
| On-Peak | 1,350 | -7.4% | 1,250 | -7.4% | 1,250 | -7.6% | 1,245 |
| Off-Peak | 2,090 | -1.3% | 2,060 | -1.3% | 2,060 | -2.5% | 2,040 |
| Mid-Day (<i>Super-Off-Peak</i>) | 2,855 | 1.8% | 2,910 | 1.8% | 2,910 | 0.6% | 2,875 |
| CPP On-Peak | 44 | n.a. | n.a. | n.a. | n.a. | -21.9% | 35 |
| Peak Demand | n.a. | n.a. | n.a. | -7.4% | n.a. | n.a. | n.a. |
| All periods | 6,295 | -1.2% | 6,220 | -1.2% | 6,220 | -2.1% | 6,165 |

Note: All consumption results (in kWh) are rounded to the nearest five except for CPP On-Peak.

Commercial Results

Estimated Commercial Class Consumption

Impact: **Key Takeaways**

Preliminary Results
CONFIDENTIAL

- Under the modeled assumptions, we estimate that **commercial consumption during on-peak hours** could be reduced on average by
 - **0.8%-1.5%** under **opt-in** rates, from **1,350** to **1,330-1,340** GWh/yr
 - **3.2%-6.1%** under **opt-out** rates, from **1,350** to **1,270-1,305** GWh/yr
 - **4.0%-7.6%** under **mandatory** rates, from **1,350** to **1,245-1,295** GWh/yr
- We estimate that **total commercial consumption** could be reduced on average by
 - **0.2%-0.4%** under **opt-in** rates, from **6,295** to **6,270-6,280** GWh/yr
 - **1.0%-1.7%** under **opt-out** rates, from **6,295** to **6,190-6,235** GWh/yr
 - **1.2%-2.1%** under **mandatory** rates, from **6,295** to **6,165-6,220** GWh/yr

Summary and Conclusions

Preliminary Results
CONFIDENTIAL

- We developed several time-varying rates for the residential and commercial classes in Hawaii
- These rates reflected the sales profiles of these two classes in Hawaii and were designed to recover the same revenue as the rates that are in place today
- We estimated the impact of time-varying rates on energy consumption by pricing period for the two customer classes using:
 - Elasticities of substitution and daily conservation impacts for time-varying rates derived from the mainland
 - Customer participation rates across alternative deployment scenarios derived from the mainland
 - The Price Response Impact Simulation Model (PRISM)

Conclusions: Residential Class

Preliminary Results
CONFIDENTIAL

- We estimate that **residential consumption** during **on-peak hours** could be reduced on average by
 - **0.7%-1.3%** under **opt-in** rates, from **1,030** to **1,015-1,025** GWh/yr
 - **2.6%-5.0%** under **opt-out** rates, from **1,030** to **980-1,005** GWh/yr
 - **3.3%-6.3%** under **mandatory** rates, from **1,030** to **965-995** GWh/yr

- We estimate that **total residential consumption** could be reduced on average by
 - **0.2%-0.4%** under **opt-in** rates, from **3,480** to **3,465-3,470** GWh/yr
 - **1.0%-1.7%** under **opt-out** rates, from **3,480** to **3,420-3,445** GWh/yr
 - **1.2%-2.1%** under **mandatory** rates, from **3,480** to **3,405-3,440** GWh/yr

Conclusions: Commercial Class

Preliminary Results
CONFIDENTIAL

- We estimate that **commercial consumption** during **on-peak hours** could be reduced on average by
 - **0.8%-1.5%** under **opt-in** rates, from **1,350** to **1,330-1,340** GWh/yr
 - **3.2%-6.1%** under **opt-out** rates, from **1,350** to **1,270-1,305** GWh/yr
 - **4.0%-7.6%** under **mandatory** rates, from **1,350** to **1,245-1,295** GWh/yr.
- We estimate that **total commercial consumption** could be reduced on average by
 - **0.2%-0.4%** under **opt-in** rates, from **6,295** to **6,270-6,280** GWh/yr
 - **1.0%-1.7%** under **opt-out** rates, from **6,295** to **6,190-6,235** GWh/yr
 - **1.2%-2.1%** under **mandatory** rates, from **6,295** to **6,165-6,220** GWh/yr

Recommendations

Preliminary Results
CONFIDENTIAL

- The results of our analysis are a function of the elasticities assumed in our analysis.
 - These parameters can vary widely across regions and customer types.
- To validate our analysis, we recommend that scientific experiments (pilots) be carried out in Hawaii to generate state-specific elasticities for various time-varying rates.
 - These experiments should test alternative rate designs and alternative enabling technologies and behavioral treatments.
- We also recommend that market research (focus groups and conjoint analysis) be carried out to determine likely customer participation rates under alternative scenarios of deployment.

Appendix

- I. Detailed Rate Determination Methodology
- II. Detailed Rate Impact Simulation Methodology

Appendix: Detailed Rate Determination Methodology

Steps and Calculations

Preliminary Results
CONFIDENTIAL

- Calculated existing revenue from residential class
 - Based on EIA, the average all-in residential rate in Hawaii in 2018 was \$0.32/kWh, and average sales were 6,216 kWh/yr/customer
 - Estimated total residential revenue per customer = $\$0.32/\text{kWh} \times 6,216 \text{ kWh/yr/customer} = \mathbf{\$2,000/\text{yr/customer}}$

- We estimated the share of total revenue by component
 - Rev. from fixed charge: $\$11.50/\text{month/cust} \times 12 \text{ months/yr} = \mathbf{\$138/\text{yr}}$
 - Rev. from non-fuel energy charge: $\$0.12/\text{kWh} \times 6,216 \text{ kWh/yr/cust} = \mathbf{\$736/\text{yr}}$
 - Rev. from all other charges: $\$0.18/\text{kWh} \times 6,216 \text{ kWh/yr/cust} = \mathbf{\$1,145/\text{yr}}$
 - Levelized fixed charge = $\$11.50/\text{mo} \times 12 \text{ mo/yr} / 6,216 \text{ kWh/yr} = \$0.02/\text{kWh}$
 - Other charges = $(\$0.32/\text{kWh} - \$0.12/\text{kWh} - \$0.02/\text{kWh}) = \$0.18/\text{kWh}$

- The new rates have the same fixed charge and “other” charges as the existing rates, thus only the non-fuel energy charges will have a different rate design, even though they will collect the same amount of revenue as the existing rate, i.e. they’re revenue neutral

Appendix: Detailed Rate Determination Methodology

Steps and Calculations

Preliminary Results
CONFIDENTIAL

- The new non-fuel energy charges should collect the same amount of revenue as the existing residential rate, that is, \$736/yr
- We defined non-fuel energy TOU price ratios of 5 for on-peak/off-peak and 25 of on-peak/super-off-peak to create a price differential large enough for customers to react to
- Using the total non-fuel energy revenue requirement, the TOU price ratios, and the customer sales patterns, we were able to calculate the values of the TOU prices (without demand or CPP charges)
 - We used the same TOU period definitions as currently used (peak: 5pm-10pm, off-peak: 10pm-9am, super-off-peak: 9am-5pm)
 - We estimated the following charges: on-peak = \$0.25/kWh, off-peak = \$0.05/kWh, super-off-peak = \$0.01/kWh

Appendix: Detailed Rate Determination Methodology

Steps and Calculations

Preliminary Results
CONFIDENTIAL

- To estimate the values of the demand and CPP charges, we assumed that 20% of the TOU on-peak revenue (TOU on-peak charge x TOU on-peak consumption) would be collected by demand or CPP charges.
 - The % of on-peak revenue collected through demand and CPP charges was established to be 20% so that the resulting demand and CPP charges would be within the range of similar charges offered by other utilities
 - 20% of TOU on-peak revenue = $20\% \times \$0.25/\text{kWh} \times 2,400 \text{ kWh}/\text{yr}/\text{cust} = \$120/\text{yr}/\text{cust}$
 - **Demand charge** = $\$120/\text{yr}/\text{cust} / 18.8 \text{ kW} = \$6.33/\text{kW}/\text{mo}$
 - Demand billing determinant: sum of monthly maximum coincident demand during on-peak period = $1.57 \text{ kW}/\text{mo} \times 12 \text{ mo} = 18.8 \text{ kW}$
 - **CPP charge** = $\$120/\text{yr}/\text{cust} / \text{XX kWh CPP} = \$1.54/\text{kW}/\text{mo}$
 - CPP billing determinant: sum of consumption during peak hours of top 10 highest sales days
 - This charge is in addition to the TOU on-peak charge applicable during that period
 - **On-peak charge** = $\$0.25/\text{kWh} \times 20\% = \$0.20/\text{kWh}$

Appendix: Detailed Rate Impact Simulation Methodology

Estimating Consumption Impacts

Preliminary Results
CONFIDENTIAL

This section summarizes the assumptions and methodology used to estimate the impact on customer electricity consumption in response to the introduction of the proposed rate designs.

First, we estimated the change in overall energy consumption based on a literature review of TOU, CPP and demand-based rate studies. The results from those studies are summarized in the main section of the slides, and the source is provided below:

- Brendon Baatz, “Rate Design Matters: The Intersection of Residential Rate Design and Energy Efficiency”, American Council for an Energy-Efficient Economy (ACEEE), March 2017.

Appendix: Detailed Rate Impact Simulation Methodology

Modeling Shifts in Consumption Across Periods

Preliminary Results
CONFIDENTIAL

Next, we used PRISM to model the shift in energy consumption across periods.

- The inputs to PRISM were:
 - Change in total energy consumption (based on literature review)
 - Average customer 8760 consumption shape (provided by AEG)
 - Proposed new rates (derived by Brattle)
 - Elasticities of substitution (based on literature review)
- Based on those inputs, PRISM outputs the change in energy consumption for each TOU period

The equations used in the PRISM model are shown in the next few slides.

Appendix: Detailed Rate Impact Simulation Methodology

PRISM Equations for Three-Period TOU

Preliminary Results
CONFIDENTIAL

Old and new average consumption:

$$\bar{K} = \frac{h_1 K_1 + h_2 K_2 + h_3 K_3}{24}$$

$$\bar{K}' = \bar{K} \times (1 + d)$$

Where:

\bar{K} = old daily kWh/hr usage

\bar{K}' = new daily kWh/hr usage

K_i = old kWh/hr usage in period i

h_i = hours in period i

d = % change in daily usage

Appendix: Detailed Rate Impact Simulation Methodology

PRISM Equations for Three-Period TOU (cont'd)

Preliminary Results
CONFIDENTIAL

Consumption during each TOU period:

$$K_1' = e^{A_{12}} K_2'$$

$$K_2' = \frac{24\bar{K}'}{e^{A_{12}}h_1 + h_2 + e^{-A_{23}}h_3}$$

$$K_3' = e^{-A_{23}} K_2'$$

Where:

K_i = old kWh/hr usage in period i

K_i' = new kWh/hr usage in period i

\bar{K}' = new daily kWh/hr usage

h_i = hours in period i

A_{12} See next slide for formula

A_{23} See next slide for formula

Appendix: Detailed Rate Impact Simulation Methodology

PRISM Equations for Three-Period TOU (cont'd)

Preliminary Results
CONFIDENTIAL

Constants:

$$A_{12} = \ln\left(\frac{K_1}{K_2}\right) + b_{12}\left(\ln\left(\frac{P'_1}{P'_2}\right) - \ln\left(\frac{P_1}{P_2}\right)\right)$$

$$A_{23} = \ln\left(\frac{K_2}{K_3}\right) + b_{23}\left(\ln\left(\frac{P'_2}{P'_3}\right) - \ln\left(\frac{P_2}{P_3}\right)\right)$$

Where:

K_i = old kWh/hr usage in period i

P_i = old daily price per kWh

\bar{P}' = new daily price per kWh

b_{12} = constant elasticity of substitution between periods 1 and 2

b_{23} = constant elasticity of substitution between periods 2 and 3

THE POWER OF **ECONOMICS**

brattle.com

THE **Brattle** GROUP

