# Appendices for “Limitations of econometric evaluation of non-randomized residential energy efficiency programs: Case study of Northern California rebate programs”

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##### Extended data description

Graphical user interface, application

Description automatically generated

**Region**

**Coastal**

**Inland Hills**

**Central Valley**

**Figure A1.** Regions in the Pacific Gas and Electric Company (PG&E) service territory. PG&E randomly selected approximately 10,000 households from each of the region to construct the sample. Reproduced with permission from the Wharton Customer Analytics Initiative. Republished with permission under a Creative Commons Attribution License 4.0 in (Sherwin and Azevedo, 2020).



**Figure A2.** Penetration of advanced metering infrastructure within our sample, March 1, 2008 to December 31, 2011 by region. © 2017, Sherwin, E.D., Azevedo, I.M.L., Meyer, R.M. Reproduced from Figure 2 in (Sherwin et al., 2017). Republished with permission under a Creative Commons Attribution License 4.0 in (Sherwin and Azevedo, 2020).

###### Wharton Customer Analytics Initiative data

The main dataset from PG&E consists of fourteen distinct tables. The **Customer** table links household account numbers, which are unique for each customer, with service agreements, which may change as households move or change billing schemes, and premises in which a household lives within the study period. The **Premise** table provides location information for each household, including Census block and climatic region. The **Accounts** table, which we do not use, links accounts to psychographic information, such as environmental views. 30,000 accounts were randomly selected in this dataset, corresponding to slightly more than 30,000 service points due to household moves or multiple residences. 10,000 accounts each were randomly sampled from the Coast, Inland Hills, and Central Valley regions. The **Billing** table, which we do not use, includes monthly electricity and natural gas consumption, as well as monthly bill amounts for each. The **Payments** table, which we do not use, gives bill payment information for each account. The **Programs** table includes start and end dates for household enrollment in each of the programs examined in this study. The **Rebates** table provides the category, application date, acceptance date, and check issue date for each rebate in the sample. This table maps rebates to service points, which generally map one-to-one to premises, but differentiate individual customers in the case of multifamily dwellings. The **Tickets** table, which we do not use, records help tickets submitted by PG&E technicians. The **IVR** table, which we do not use, records customer calls to PG&E’s interactive voice response system. The **Communications** table records communications from PG&E to customers in our sample about program opportunities, and changes in service, such as the introduction of smart-meters. The **Emails** table, includes outbound emails from PG&E, which we do not use because they only began to be recorded in September 2011, shortly before the end of data collection in December 2011. The **Census** table provides the Census block identifier for each service point, as well as its longitude and latitude. The **Weather** table, which we do not use in favor of data from the National Oceanic and Atmospheric Administration (NOAA), provides hourly temperature data for 591 weather stations in the PG&E service territory. **Daily electricity and natural gas** consumption data are available, and correspond to service points, which generally correspond to individual dwellings. **15-minute electricity** consumption data are available, however in the majority of cases 15-minute readings are identical over the same hour. For this reason, we aggregate 15-minute interval data to hourly data for our analysis.

###### Data from NOAA

We draw hourly temperature data for all weather stations in California. We match Census block location to the nearest three weather stations, and compute hourly weather based on the average temperature observed at these three stations.

###### Census-level demographics

We draw demographic information for each Census block using the 2010 Census and map this information to each household in the sample, described below in **Table 1** (Census, 2012).

**Table A1.** Summary statistics for 2010 census block neighborhoods of households in the sample\*. The Central Valley has the lowest incomes and home values. % CARE is the percentage of households enrolled in the California Alternate Rates for Energy program, which was available to and widely adopted by households below 200% of the Federal Poverty Level (Evergreen Economics, 2013). © 2014, Meyer, R.M. Adapted from Table 8 in (Meyer, 2014). Republished under a Creative Commons Attribution License 4.0 in (Sherwin and Azevedo, 2020).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Central Valley | Inland Hills | Coast | Full sample |
| Median Home Value\* | 282,000 | 586,000 | 597,000 | 479,000 |
| Median Income\* | 51,800 | 78,500 | 63,400 | 65,600 |
| Median % Renters | 34 | 32 | 51 | 38 |
| Median % w/ Bachelors (or higher) | 17 | 38 | 40 | 32 |
| % CARE | 44% | 23% | 28% | 30% |
| Number of dwellings | 8,597 | 11,391 | 10,217 | 30,205 |

\* These values are medians from the sample of Census block neighborhood medians, except % CARE, which is derived directly from the dataset at the end of the sample, December 31, 2011. The values are top-coded by the US Census at $1M and $250k, respectively. We report the values rounded to the nearest $1000 for median home value, and to the nearest $100 for median income values.

###### Fine-grained energy efficiency information

To further understand the types of rebates used by households in the original dataset provided by PG&E, we use a secondary dataset, also provided by PG&E. This secondary dataset describes in more detail the efficiency measures received by households in the primary dataset. The supplementary fine-grained dataset documents 65,535 energy efficiency measures for the households in our sample over a longer period of time than the study period. These efficiency measures include 15,801 from the Energy Savings Assistance Program, which are not included in the main dataset.

The secondary dataset provides detailed efficiency measure descriptions. This allows us, for instance, to distinguish a rebate for a clothes washer from one for a clothes dryer, both of which are labeled simply as “appliance” rebates in the primary dataset.

In addition to efficiency measure descriptions, the secondary dataset contains the following fields: the customer’s account, service agreement, and premise pseudo-identifier (the same ones used in the primary dataset); customer zip code or climate zone; whether the customer receives electricity, natural gas, or both services from Pacific Gas and Electric (PG&E); the date at which the household became and, if applicable, stopped being a PG&E customer; an indicator of whether the household was enrolled in the California Alternate Rates for Energy (CARE) program at the time the efficiency measure was installed; indicators for whether the household had participated in ESAP, and whether the measure was provided through ESAP; the abbreviated code and longer description for the type of efficiency measure installed; and ex-ante estimates of gross annual savings of electric power, electric energy, and natural gas.

Unfortunately, the secondary dataset does not provide information on the timing of these efficiency measures. As a result, it is only possible to map these efficiency measures back to rebates from the primary dataset in cases in which a household has only one rebate in the primary dataset and only one efficiency measure in the secondary dataset. This mapping may not be perfect due to inevitable problems with real-world data. Still, inspection of the mapping between the coarse categories in the primary dataset and the detailed descriptions in the secondary dataset shows convincing matches in the vast majority of cases.

For further information on the mapping between the rebate categories in the primary dataset and the efficiency measure descriptions in the secondary dataset, see the “Category composition” section below.

###### Further description of rebate programs

**Rebates:** Customers were able to apply for rebates after the purchase of energy-efficient appliances, or efficiency upgrades for existing household energy services, such as heating, ventilation, and air conditioning systems. Households were eligible to submit rebate applications within 60 days of purchase of an efficiency measure.

**Outreach:** PG&E’s marketing for energy efficiency rebates relied on partnerships with retailers, including point-of-sale promotional materials, signage on applications and brochures, and assistance completing rebate applications. Marketing for energy efficiency rebates during the period of study did not include direct mail, email, or other forms of proactive outreach. In the dataset, a table of 39,829 communications to customers includes email, direct mail, and telephone outreach for utility programs such as Climate Smart, but does not include any outreach for energy efficiency programs.

**Length of observation:** Usingthe “Rebates” table and the “Smart meter first billed date” field from the “Premise” table, 2,831 dwellings had occupants that both applied for a rebate had at least one valid electricity reading from their smart-meter. Some of these households may have moved dwellings during the study period, leading to a number slightly higher than the 2,804 dwellings that received rebates in the panel data. Of these dwellings, 1,527 had at least one year of data after their first rebate application. 1,005 had at least one year of data before applying for a rebate. 547 had at least one year of data before and after the rebate.

**Recycling:** Recycling of old appliances was generally not required during the study period, except for refrigerator and freezer recycling rebates, which disposed of an old refrigerator or freezer, at times in conjunction with the purchase of a new efficient refrigerator or freezer. There were also rebates for new refrigerators that did not require recycling. An exception is a relatively brief period after 2009 during which the California Energy Commission (CEC) took over an expansion of energy efficiency programs using funds from the American Recover and Reinvestment Act, and required recycling of all existing appliances (CEC, 2014). However, these CEC-administered rebates are not captured in our dataset.

**Category composition:** We use a supplementary dataset provided by PG&E to further understand the composition of the rebate categories in the main dataset. Because the dataset does not give the date at which an efficiency measure was applied for or installed, we cannot do a perfect one-to-one mapping with the energy efficiency rebates in the main dataset. To get an approximation of the composition of the categories from the main dataset, we consider only cases in which a dwelling applied for or received only one energy efficiency measure in either dataset. Assuming the datasets both capture the same energy efficiency rebates, this gives a rough picture of the composition of the categories in the main dataset.

Of all 1,392 rebates labeled **appliances**, 50 are unlabeled, 1,071 are for clothes washers, 210 are for dishwashers, 19 are for refrigerators, 6 of which involve recycling, 4 are for freezers, 2 of which involve recycling. There are 4 room air conditioners. The remaining 34 are miscellaneous, and may be mislabeled. Of all 215 **appliance recycling** rebates, 103 are refrigerators whose description does not mention recycling, 42 replace and recycle an existing refrigerator, 25 recycle but do not appear to replace an existing refrigerator, 12 are for freezers whose description does not mention recycling, 7 remove and appear not to replace a freezer, 7 replace and recycle a freezer. The remaining 19 are miscellaneous, and may be mislabeled. Of all 177 **HVAC** rebates, 65 are for natural gas furnaces, 23 are for seal testing, 22 are for whole-house fans, 18 are for duct testing, 13 are for Energy Star room air conditioners, and the remainder are miscellaneous and may be mislabeled. Of all 51 lighting rebates, 37 are for compact fluorescent bulbs, 12 are for other types of bulb, and the remainder are unlabeled. Of all 42 **building shell** rebates, 17 are for wall insulation, 14 are for attic insulation, 2 are for windows, and the remainder are miscellaneous. Of all 29 **water heating** rebates 17 are for water heaters, 6 are unlabeled, and the remainder are miscellaneous and may be mislabeled. Of all 110 **customized measure** rebates, 78 are unlabeled, 19 are for clothes washers, and the remainder are miscellaneous. Of all 24 **pumps/motors** rebates, 22 are for pool pumps and 2 are for clothes washers. Of all 414 rebates labelled **unknown** in the main dataset, 205 are for dishwashers, 73 are for furnaces, 21 are for clothes washers, 16 are for attic insulation, 43 are unlabeled, and the remainder are miscellaneous.

We suspected that perhaps unknown rebates were those covered by the Energy Savings Assistance Program (ESAP). Upon further analysis of the supplementary dataset described in above in the subsection labelled “Fine-grained energy efficiency information”, we found that among households that only applied for one rebate, only 43 of 414 rebates labelled as unknown in the main dataset were labelled as ESAP in the supplementary dataset. Thus, ESAP measures do not constitute a majority of “unknown” rebates.

###### Further description of other utility programs

**Table A2.** Description of PG&E programs and the total and maximum number of participants observed in the dataset. © 2020, Sherwin, E.D, Azevedo, I.M.L. Reproduced from Table S2 in (Sherwin and Azevedo, 2020). Originally published under a Creative Commons Attribution License 4.0.

|  |  |  |  |
| --- | --- | --- | --- |
| Program | Total Part. | Max Part. | Description |
| Rebates | 2,804 | 2,773 | Energy efficiency rebates subsidize the purchase of efficient appliances, services, and household equipment through an after-purchase mail-in rebate. |
| BPP | 2424 | 1,574 | Balanced Payment Plan: Provides a bill smoothing service, in which PG&E calculates the household’s average monthly utility bill and the customer pays a flat amount for each monthly billing cycle. This amount is an average annualized value |
| CARE | 10,193 | 9,337 | California Alternate Rates for Energy: Subsidizes monthly energy bills based on income and occupant criteria such as enrollment in other means-tested programs. |
| Climate Smart | 147 | 147 | Households pay for carbon offsets through monthly utility bills |
| Direct Access (DirAccess) | 668 | 631 | Allows customers to purchase their electricity from alternative (non-PG&E) power providers, using PG&E as the distribution company. New customers have not been able to join the Direct Access program since the California energy crisis in 2001, though existing customers have been able to remain in the program. |
| Smart AC | 1,069 | 856 | Allows customers to opt in to a central air conditioning curtailment program during peak-load events during the summer cooling season. |
| Smart Rate | 154 | 117 | Lower average electricity tariff (3¢/kWh reduction) in exchange for accepting a higher rate (60¢/kWh) during peak hours in some days during the summer cooling months. These days are communicated to the consumer a day ahead via text, email, or phone |

##### Regression results and robustness checks

**Table A3** reports the full set of regression results from Equation (3) in the main text, reproduced below as Eq. (5). In addition to that which was reported above, this table shows the coefficients estimates associated with the day and month dummies as well as the set of daily temperature controls included in the model.

|  |  |
| --- | --- |
|  | (5) |

Sunday, excluded to avoid collinearity among the indicators, is the day associated with the highest average electricity consumption as can be inferred from the statistically significant and negative coefficients associated with each of the included day of the week dummies. This is as anticipated, more in-home activity is expected on non-weekdays—Saturday is the day with the next highest average daily electricity consumption. December is also excluded to prevent collinearity. Although all other monthly coefficients are negative for Equation (5), in-sample peak electricity consumption is in July for the full dataset, as shown in Table S2. This is because the summer full-sample peak is largely due to air conditioning in the Central Valley, which is partially captured by temperature coefficients. As a result, the secondary peak in December is the largest among the month fixed effects coefficients.

**Table A3.** Change in electricity consumption associated with PG&E demand-side programs, coefficient estimates for all controls.

|  |  |
| --- | --- |
|  | Dependent Variable is ln(kWh/day) |
| Independent Variable | Equation S1 |
| Rebate Participation | 7.0e-02\*\*\* (1.3e-02) |
| BPP | 6.9e-02\*\*\* (2.1e-02) |
| CARE | 1.2e-01\*\*\* (1.2e-02) |
| Climate Smart | -2.2e-01  (1.9e-01) |
| Direct Access | 8.7e-02\*\*  (3.2e-02) |
| Smart AC | 5.3e-02  (2.8e-02) |
| Smart Rate | 1.3e-02  (4.3e-02) |
| Rebate \* BPP | -6.7e-02\*\*  (2.4e-02) |
| Rebate \* CARE | 6.3e-03  (3.1e-02) |
| Rebate \* Climate Smart | 1.6e-03  (8.8e-02) |
| Rebate \* Direct Access | -5.8e-02  (3.2e-02) |
| Rebate \* Smart AC | -4.6e-02  (2.6e-02) |
| Rebate \* Smart Rate | 1.0e-01\*\*\* (2.7e-02) |
| Linear Time Trend | -2.0e-05\*  (7.8e-06) |
| Daily High Temp | -3.4e-03\*\*\* (4.6e-05) |
| Daily High Temp2 | 3.0e-05\*\*\* (2.8e-07) |
| Daily Low Temp | -2.0e-03\*\*\* (1.5e-04) |
| Daily Low Temp2 | 7.5e-06\*\*\* (6.7e-07) |
| Mon | -3.5e-02\*\*\* (8.7e-04) |
| Tue | -5.3e-02\*\*\* (9.6e-04) |
| Wed | -5.7e-02\*\*\* (9.5e-04) |
| Thu | -5.5e-02\*\*\* (9.4e-04) |
| Fri | -5.6e-02\*\*\* (8.9e-04) |
| Sat | -2.0e-02\*\*\* (6.1e-04) |
| Jan | -3.8e-02\*\*\* (2.6e-03) |
| Feb | -8.5e-02\*\*\* (2.9e-03) |
| Mar | -1.3e-01\*\*\* (3.2e-03) |
| Apr | -1.9e-01\*\*\* (3.2e-03) |
| May | -1.9e-01\*\*\* (3.3e-03) |
| Jun | -1.5e-01\*\*\* (3.4e-03) |
| Jul | -1.3e-01\*\*\* (3.6e-03) |
| Aug | -1.3e-01\*\*\* (3.4e-03) |
| Sep | -1.6e-01\*\*\* (3.3e-03) |
| Oct | -1.7e-01\*\*\* (2.6e-03) |
| Nov | -1.1e-01\*\*\* (1.8e-03) |
| Intercept | 2.7e+00\*\*\* (1.1e-02) |
| Observations | 18,306,105 |
| # of groups, total | 30,349 |
| *R2* within | 0.057 |
| *R2* between | 0.031 |
| *R2* overall | 0.045 |

Robust standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling.

\*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.1

The temperature controls show the relationship of household HVAC system efficiency as a function of temperature. Both the daily high and low temperature display a similar relationship in which the linear term has a negative coefficient estimate and the quadratic term has positive coefficient estimate. The interpretation of this finding is that as the temperature deviates from the set-point temperature (18°C, as described above) household energy consumption increases at an increasing rate—reflecting the fact that electric heat pumps become thermodynamically less efficient as the temperature sink to which they reject (in the cooling season) or absorb (in the heating season) heat diverges from the desired indoor air temperature.

The time trend of -2.0x10-5 [-4.6x10-5,-3.5x10-5] translates to a decline in electricity consumption of -2.0x10-3% [-4.6x10-4%, -3.5x10-4%] per day. This corresponds to an average annual change of -0.7% [-1.3%, -0.2%] per year, an order of magnitude below the observed increase in electricity consumption in the main regression specification. This suggests that the secular time trend, distinct from the seasonal and weather-related patterns captured by day-of-week and month-of-year fixed effects and temperature controls, is small compared to the increase in electricity consumption associated with participation in rebate programs. As a result of this small time trend, a difference-in-differences model would likely produce essentially the same result as a fixed effects model.

**Table A4** displays results from Eq. (5) by region. We find that participation in a rebate program has a positive and significant coefficient, which suggests that, on average, following participation in an efficiency rebate program, household energy consumption increases by 7.2% [4.5%, 10.1%] in the full sample (converting logarithmic coefficients into percentages using the formula 100(ex – 1), where x is the coefficient), 12.8% [6.0%, 20.0%] on the Coast, 7.9% [4.2%, 11.7%] in the Inland Hills, and 3.5% [-1.4%, 8.6%] in the Central Valley, although this coefficient is not statistically significant. The larger coefficient on the Coast may be due in part to the smaller baseline level of electricity consumption. Demographic differences may also be driving these results, as there are statistically significant differences between the three regions in terms of home values, income, poverty levels, education, and average electricity consumption.

These results suggest that the unbalanced nature of the panel is likely not the explanation for the observed increase in electricity consumption. There is a larger increase associated with rebate participation in the Coast and Inland Hills than in the Central Valley, where the increase is not statistically significant. Given that the Central Valley is oversampled in the panel, the full sample regression may even underestimate the increase that would be estimated in a fully balanced representative panel of PG&E customers.

**Table A4.** Association between PG&E demand-side programs and average household electricity consumption, coefficient estimates by region. Rebates are associated with significant increases in electricity consumption in all cases except the Central Valley.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Dependent Variable: ln(kWh/day) |  |  |  |
| Independent Variable | Full sample | Central Valley | Inland Hills | Coast |
| Rebate | 7.0e-02\*\*\* (1.3e-02) | 3.4e-02 (2.5e-02) | 7.6e-02\*\*\* (1.8e-02) | 1.2e-01\*\*\* (3.2e-02) |
| BPP | 6.9e-02\*\*\* (2.1e-02) | 3.5e-02 (2.6e-02) | 1.7e-01\*\*\* (4.1e-02) | 1.5e-01\*\*  (5.2e-02) |
| CARE | 1.2e-01\*\*\* (1.2e-02) | 1.2e-01\*\*\* (1.7e-02) | 1.6e-01\*\*\* (2.0e-02) | 1.1e-01\*\*\* (3.2e-02) |
| Climate Smart | -2.2e-01 (1.9e-01) | -1.7e-01 (1.9e-01) | Omitted | Omitted |
| Direct Access | 8.7e-02\*\* (3.2e-02) | 1.0e-01\* (4.9e-02) | 1.2e-02 (3.4e-02) | 1.2e-01  (7.8e-02) |
| Smart AC | 5.3e-02 (2.8e-02) | 5.8e-02 (3.7e-02) | 3.4e-02 (3.2e-02) | 3.4e-01  (3.2e-01) |
| Smart Rate | 1.3e-02 (4.3e-02) | 3.4e-02 (6.3e-02) | -3.5e-02 (4.2e-02) | 7.4e-02  (8.8e-02) |
| Rebate \* BPP | -6.7e-02\*\* (2.4e-02) | -7.3e-02\* (3.4e-02) | -8.4e-02\* (4.2e-02) | -1.2e-01\*  (5.9e-02) |
| Rebate \* CARE | 6.3e-03 (3.1e-02) | 2.0e-02 (4.9e-02) | 1.0e-02 (4.6e-02) | -3.8e-02  (4.9e-02) |
| Rebate \* Climate Smart | 1.6e-03 (8.8e-02) | -7.3e-02\*\* (2.5e-02) | -9.2e-02 (7.5e-02) | 5.4e-02  (1.4e-01) |
| Rebate \* Direct Access | -5.8e-02 (3.2e-02) | -2.1e-02 (5.5e-02) | -5.7e-02 (4.7e-02) | -9.4e-02  (6.4e-02) |
| Rebate \* Smart AC | -4.6e-02 (2.6e-02) | -2.1e-02 (3.7e-02) | -4.6e-02 (3.4e-02) | -3.4e-01  (3.2e-01) |
| Rebate \* Smart Rate | 1.0e-01\*\*\* (2.7e-02) | Omitted | 1.1e-01\*\* (3.6e-02) | Omitted |
| Linear Time Trend by Day | -2.0e-05\* (7.8e-06) | 3.8e-06 (1.2e-05) | -2.9e-05\*\* (1.1e-05) | -2.1e-06  (2.3e-05) |
| Daily Temperature Controls | Included | Included | Included | Included |
| Month Dummies | Included | Included | Included | Included |
| Day of Week Dummies | Included | Included | Included | Included |
| Intercept | 2.7e+00\*\*\* (1.1e-02) | 2.8e+00\*\*\* (1.4e-02) | 2.7e+00\*\*\* (1.3e-02) | 2.2e+00\*\*\* (2.8e-02) |
| Observations | 18,306,105 | 7,209,199 | 7,317,450 | 3,655,242 |
| # of groups, total | 30,349 | 8,572 | 11,368 | 10,190 |
| *R2* within | 0.057 | 0.104 | 0.026 | 0.025 |
| *R2* between | 0.031 | 0.002 | 0.005 | 0.023 |
| *R2* overall | 0.045 | 0.055 | 0.012 | 0.023 |

Robust and clustered standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling. \*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.10

**Table A5** regresses month of the year on daily log electricity consumption for the full sample and each individual climate region using household-level cluster-robust standard errors, following the specification in Eq. (6):

|  |  |
| --- | --- |
|  | (6) |

Where ln(*kWhi,t*) is the log of daily electricity consumption in household *i* on day *t*, and *monthk* is the month of the year (excluding December to avoid collinearity). Note that peak consumption occurs in December in the Coast and Inland Hills, and in July in the Central Valley. In aggregate, the peak occurs in July, due to the magnitude of the summer peak in the Central Valley, primarily due to air conditioning.

**Table A5.** Log of daily electricity consumption by month of the year, from (6).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Dependent Variable is ln(kWh/day) |  |  |  |
| Independent Variable | Full sample | Coast | Inland Hills | Central Valley |
| Jan | -5.3e-02\*\*\* (2.4e-03) | -3.0e-02\*\*\* (6.4e-03) | -3.4e-02\*\*\* (3.5e-03) | -5.6e-02\*\*\* (4.0e-03) |
| Feb | -1.0e-01\*\*\* (2.8e-03) | -5.0e-02\*\*\* (7.0e-03) | -8.2e-02\*\*\* (4.0e-03) | -1.2e-01\*\*\* (4.5e-03) |
| Mar | -1.6e-01\*\*\* (2.9e-03) | -1.0e-01\*\*\* (6.8e-03) | -1.4e-01\*\*\* (4.2e-03) | -1.9e-01\*\*\* (4.9e-03) |
| Apr | -2.2e-01\*\*\* (3.0e-03) | -1.8e-01\*\*\* (6.4e-03) | -2.1e-01\*\*\* (4.3e-03) | -2.2e-01\*\*\* (5.2e-03) |
| May | -2.0e-01\*\*\* (3.1e-03) | -2.1e-01\*\*\* (6.2e-03) | -2.5e-01\*\*\* (4.4e-03) | -1.4e-01\*\*\* (5.7e-03) |
| Jun | -8.5e-02\*\*\* (3.6e-03) | -2.4e-01\*\*\* (6.1e-03) | -2.1e-01\*\*\* (4.6e-03) | 1.2e-01\*\*\* (6.5e-03) |
| Jul | 2.8e-02\*\*\* (4.2e-03) | -2.5e-01\*\*\* (5.8e-03) | -1.9e-01\*\*\* (4.9e-03) | 3.9e-01\*\*\* (7.1e-03) |
| Aug | -1.8e-03 (3.9e-03) | -2.3e-01\*\*\* (5.3e-03) | -2.0e-01\*\*\* (4.6e-03) | 3.3e-01\*\*\* (6.8e-03) |
| Sep | -2.6e-02\*\*\* (3.4e-03) | -2.2e-01\*\*\* (5.0e-03) | -1.6e-01\*\*\* (4.4e-03) | 2.3e-01\*\*\* (6.1e-03) |
| Oct | -1.7e-01\*\*\* (2.5e-03) | -1.9e-01\*\*\* (4.5e-03) | -2.0e-01\*\*\* (3.7e-03) | -1.3e-01\*\*\* (4.7e-03) |
| Nov | -1.2e-01\*\*\* (1.7e-03) | -1.0e-01\*\*\* (3.4e-03) | -1.2e-01\*\*\* (2.5e-03) | -1.4e-01\*\*\* (3.0e-03) |
| Intercept | 2.5e+00\*\*\* (5.1e-03) | 2.3e+00\*\*\* (9.1e-03) | 2.6e+00\*\*\* (7.5e-03) | 2.7e+00\*\*\* (9.6e-03) |
| Observations | 18,306,105 | 3,655,242 | 7,317,450 | 7,209,199 |
| # of groups, total | 30,349 | 10,190 | 11,368 | 8,572 |
| *R2* within | 0.016 | 0.022 | 0.016 | 0.073 |
| *R2* between | 0.012 | 0.001 | 0.004 | 0.002 |
| *R2* overall | 0.006 | 0.009 | 0.007 | 0.038 |

Robust standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling.

\*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.1

Eq. (7), (8), (9), and (10) are alternative specifications based on our primary equation, S1. Each follows the same fixed effects functional form. Eq. (7) excludes the other PG&E programs, including only a single indicator for participation in the rebate programs.

|  |  |
| --- | --- |
|  | (7) |

Eq. (8) is similar to Eq. (7) except that *m* = 4 rebate applications are allowed for each household to capture the energy effect of subsequent rebate applications originating from the same household.

|  |  |
| --- | --- |
|  | (8) |

Eq. (9) modifies Eq. (7) by introducing an interaction term, *π*, between household rebate participation and the synthetic time trend variable. This allows the energy effect of the rebate to decay or grow over time following the application date.

|  |  |
| --- | --- |
|  | (9) |

Eq. (10) disaggregates the rebate application indicator from Eq. (3) by including *n* indicators for each of the reported rebate categories in the PG&E dataset.

|  |  |
| --- | --- |
|  | (10) |

The results of Eq. (7), (8), (9), and (10) are reported in **Table 6**. The results for (7), including the rebate programs but excluding the other utility-sponsored programs, show a slightly smaller estimate for the increase in electricity consumption following rebate participation (5.9%) and no statistically significant effect of the synthetic linear time trend.

The results from the model for Eq. (8) show little average energy effect from subsequent participation events in the rebate programs; each of the coefficients for second, third, and fourth rebate applications are not statistically significant.

The results for Eq. (9), which includes the interaction term of the time trend and the indicator for rebate participation, show that this interaction is not statistically significant suggesting that there is not a substantial non-cyclical time trend associated with magnitude of the energy effect on households following participation in the rebate programs.

In the results for Eq. (10), the appliance rebateshave a strongly positive estimate; and since this is also the largest portion of the rebate programs (about 45% of all applications) this seems to be the primary driver of the energy effect associated with the rebate application in Eq. (5) and (7). The coefficients for building shell and unknown rebate categorizations are the other two with statistically significant values (at 95%, but not 99%).

**Table A6.** Change in electricity consumption associated with PG&E energy efficiency rebate programs; Results for Equations S3-S6.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Dependent Variable is ln(kWh/day) | | | |
| Independent Variable | Eq. (7) | Eq. (8) | Eq. (9) | Eq. (10) |
| Rebate | 5.9e-02\*\*\* (1.3e-02) | 5.6e-02\*\*\* (1.3e-02) | 4.0e-02\* (1.9e-02) |  |
| Linear Time Trend | 1.2e-06 (7.7e-06) | 1.1e-06 (7.7e-06) | 4.6e-07 (8.1e-06) | 1.2e-06  (7.7e-06) |
| Rebate (second) |  | 1.0e-02 (2.6e-02) |  |  |
| Rebate (third) |  | 6.5e-02 (5.1e-02) |  |  |
| Rebate (fourth) |  | -6.0e-02 (1.6e-01) |  |  |
| Rebate \* Linear Time Trend |  |  | 1.6e-05 (1.3e-05) |  |
| Appliance Recycling |  |  |  | -6.3e-02  (4.6e-02) |
| Appliance |  |  |  | 9.3e-02\*\*\* (1.8e-02) |
| Building Shell |  |  |  | 1.3e-01\*  (6.3e-02) |
| HVAC |  |  |  | Omitted |
| Lighting |  |  |  | 7.6e-02  (9.8e-02) |
| Pumps/Motors |  |  |  | Omitted |
| Unknown |  |  |  | 5.0e-02  (7.0e-02) |
| Water Heating |  |  |  | -2.0e-02  (7.6e-02) |
| Daily Temperature Controls | Included | Included | Included | Included |
| Month Dummies | Included | Included | Included | Included |
| Day of Week Dummies | Included | Included | Included | Included |
| Intercept | 2.7e+00\*\*\* (1.1e-02) | 2.7e+00\*\*\* (1.1e-02) | 2.7e+00\*\*\* (1.1e-02) | 2.7e+00\*\*\* (1.1e-02) |
| Observations | 18,306,105 | 18,306,105 | 18,306,105 | 18,306,105 |
| # of groups, total | 30,349 | 30,349 | 30,349 | 30,349 |
| *R2* within | 0.056 | 0.056 | 0.056 | 0.056 |
| *R2* between | 0.036 | 0.037 | 0.036 | 0.034 |
| *R2* overall | 0.044 | 0.044 | 0.044 | 0.044 |

Robust standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling.

\*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.1

In our main analysis, we do not differentiate between households that received rebate payment, and those that simply applied for a rebate, but may not have received payment. Table A7 shows apparent discrepancies in the number of valid values that appear in the dataset for dates of participation in the rebate programs, particularly the values for “check issues” which is inexplicably larger than the corresponding values for “approvals”.

**Table A7.** Rebate program participation data description.

|  |  |
| --- | --- |
| Observations (household-day pairs) | 18,580,095 |
| # of groups (households) | 30,426 |
|  |  |
| Rebate applications (# of rebates) | 5,904 |
| Rebate approvals (# of rebates) | 3,493 |
| Rebate check issues (# of rebates) | 5,253 |
|  |  |
| Rebate application households (# of households) | 3,476 |
| Rebate approval households (# of households) | 2,712 |
| Rebate check households (# of households) | 3,386 |
|  |  |
| Rebate application households with smart-meter data (# of households) | 2,804 |
| Rebate approval households with smart-meter data (# of households) | 1,984 |
| Rebate check households with smart-meter data (# of households) | 2,559 |
|  |  |

**Table A8**, **Table A9**, **Table A10,** and **Table A11** show the results of robustness checks on the primary result found for Equation (5). **Table A8** and **Table A9** display the results for Equation (5)alongside results for restricted sample implementations of that model. The column labeled “Only Confirmed Rebates” restricts the policy indicator to cases in which either a valid rebate approval date or check issue date is found in the dataset. This is to correct for the potential issue described above in which there are several apparently missing values in these fields. The column labeled “Excluding <5th and >95th consumption percentiles” restricts the sample to households with median electricity consumption between the 5th and 95th percentile of median Census block household electricity consumption for each region.

**Table A8.** Association between PG&E demand-side programs and average household electricity consumption, coefficient estimates. Restricted sample results for Equation (5).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Dependent Variable is ln(kWh/day) | | |
| Independent Variable | Full-Sample As Reported | Only Confirmed Rebates | Excluding <5th and >95th consumption percentiles |
| Rebate | 7.0e-02\*\*\* (1.3e-02) | 7.0e-02\*\*\* (1.4e-02) | 7.3e-02\*\*\* (1.4e-02) |
| BPP | 6.9e-02\*\*\* (2.1e-02) | 6.8e-02\*\*  (2.1e-02) | 7.5e-02\*\*  (2.3e-02) |
| CARE | 1.2e-01\*\*\* (1.2e-02) | 1.3e-01\*\*\* (1.2e-02) | 1.2e-01\*\*\* (1.3e-02) |
| Climate Smart | -2.2e-01 (1.9e-01) | -2.2e-01  (1.9e-01) | -2.2e-01  (1.9e-01) |
| Direct Access | 8.7e-02\*\* (3.2e-02) | 8.5e-02\*\*  (3.2e-02) | 8.7e-02\*\*  (3.3e-02) |
| Smart AC | 5.3e-02 (2.8e-02) | 5.3e-02  (2.8e-02) | 5.7e-02  (3.0e-02) |
| Smart Rate | 1.3e-02 (4.3e-02) | 1.2e-02  (4.3e-02) | 8.2e-04  (4.6e-02) |
| Rebate \* BPP | -6.7e-02\*\* (2.4e-02) | -6.4e-02\*  (2.5e-02) | -7.4e-02\*\*  (2.8e-02) |
| Rebate \* CARE | 6.3e-03 (3.1e-02) | -5.3e-03  (3.2e-02) | 9.9e-03  (3.2e-02) |
| Rebate \* Climate Smart | 1.6e-03 (8.8e-02) | 1.1e-03  (8.8e-02) | 8.7e-03  (9.6e-02) |
| Rebate \* Direct Access | -5.8e-02 (3.2e-02) | -4.2e-02  (3.3e-02) | -6.0e-02  (3.3e-02) |
| Rebate \* Smart AC | -4.6e-02 (2.6e-02) | -5.4e-02\*  (2.6e-02) | -6.4e-02\*  (2.7e-02) |
| Rebate \* Smart Rate | 1.0e-01\*\*\* (2.7e-02) | 1.1e-01\*\*\* (2.8e-02) | 1.2e-01\*\*\* (2.9e-02) |
| Linear Time Trend | -2.0e-05\* (7.8e-06) | -1.9e-05\*  (7.8e-06) | -1.6e-05  (8.3e-06) |
| Daily Temperature Controls | Included | Included | Included |
| Month Dummies | Included | Included | Included |
| Day of Week Dummies | Included | Included | Included |
| Intercept | 2.7e+00\*\*\* (1.1e-02) | 2.7e+00\*\*\* (1.1e-02) | 2.7e+00\*\*\* (1.2e-02) |
| Observations | 18,306,105 | 18,306,105 | 16,560,777 |
| # of groups, total | 30,349 | 30,349 | 26,867 |
| *R2* within | 0.057 | 0.057 | 0.059 |
| *R2* between | 0.031 | 0.030 | 0.029 |
| *R2* overall | 0.045 | 0.045 | 0.048 |

Robust standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling.

\*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.1

The column labeled “Only Confirmed Rebates” of **Table 8** shows the results of running the model with the restricted observation set. The results show that there is not a substantive difference between the implementation in which all identified rebate program participants are included in the program indicator (including some who may have attempted to participate but whose rebate application was not approved) and the implementation in which that indicator is restricted to confirmed households. Similarly, the “Excluding <5th and >95th consumption percentiles” column, which excludes the households in the sample with mean average daily energy consumption values in the tails of the sample distribution, does not substantially change the estimate of the “Rebate” coefficient.

**Table A9** shows the results from Equation (5) with the data split by Census block median household income quintile. The results show that the largest electricity increase associated with rebate program participation are in the 2nd and 4th neighborhood median income quintiles, with no identifiable electricity increase in the lowest neighborhood median income quintile.

**Table A9.** Association between PG&E demand-side programs and average household electricity consumption, coefficient estimates. Results by neighborhood median income quintile for Equation (5).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Dependent Variable is ln(kWh/day) | | | | | |
| Independent Variable | Full-Sample As Reported | Lowest Quintile | 2nd Quintile | Middle Quintile | 4th Quintile | Highest Quintile |
| Rebate | 7.0e-02\*\*\* (1.3e-02) | 3.4e-02 (4.0e-02) | 1.2e-01\*\* (4.5e-02) | 5.8e-02 (3.5e-02) | 1.0e-01\*\*\* (2.9e-02) | 5.4e-02\*\*  (1.8e-02) |
| BPP | 6.9e-02\*\*\* (2.1e-02) | 1.2e-01\*\*\* (3.5e-02) | 3.0e-02 (6.3e-02) | 3.7e-02 (3.4e-02) | 1.1e-01\* (4.5e-02) | 3.1e-02  (5.2e-02) |
| CARE | 1.2e-01\*\*\* (1.2e-02) | 1.1e-01\*\*\* (2.2e-02) | 1.3e-01\*\*\* (2.6e-02) | 1.4e-01\*\*\* (2.6e-02) | 1.3e-01\*\*\* (3.1e-02) | 1.3e-01\*\*\* (4.0e-02) |
| Climate Smart | -2.2e-01 (1.9e-01) | -6.1e-01\*\* (1.9e-01) | Omitted | Omitted | -3.3e-01 (2.3e-01) | 2.4e-01\*\*\* (1.3e-02) |
| Direct Access | 8.7e-02\*\* (3.2e-02) | 1.5e-01\* (6.2e-02) | 5.7e-02 (6.4e-02) | -6.2e-02 (7.3e-02) | 1.4e-01\* (5.6e-02) | 1.0e-01  (9.2e-02) |
| Smart AC | 5.3e-02 (2.8e-02) | 1.0e-01 (6.9e-02) | 2.7e-03 (6.0e-02) | 1.0e-01 (6.8e-02) | 4.3e-04 (6.8e-02) | 6.9e-02  (4.2e-02) |
| Smart Rate | 1.3e-02 (4.3e-02) | 4.4e-02 (6.9e-02) | 1.1e-01 (2.0e-01) | 2.5e-02 (5.3e-02) | -1.5e-02 (3.7e-02) | -6.1e-02  (4.8e-02) |
| Rebate \* BPP | -6.7e-02\*\* (2.4e-02) | -1.4e-01\*\* (5.3e-02) | -1.0e-01 (6.0e-02) | -1.3e-02 (4.7e-02) | -7.0e-02 (4.5e-02) | -3.1e-02  (6.1e-02) |
| Rebate \* CARE | 6.3e-03 (3.1e-02) | 1.1e-01 (7.2e-02) | -7.4e-02 (6.9e-02) | -4.7e-02 (4.1e-02) | 1.5e-02 (6.5e-02) | -4.7e-02  (8.8e-02) |
| Rebate \* Climate Smart | 1.6e-03 (8.8e-02) | Omitted | Omitted | -1.2e-01\*\*\* (3.5e-02) | -9.4e-02 (5.0e-02) | 2.2e-01  (1.4e-01) |
| Rebate \* Direct Access | -5.8e-02 (3.2e-02) | -2.1e-02 (5.4e-02) | -2.4e-01\* (1.2e-01) | 5.3e-03 (5.7e-02) | -9.6e-02 (5.8e-02) | -5.0e-02  (9.2e-02) |
| Rebate \* Smart AC | -4.6e-02 (2.6e-02) | -6.5e-02 (6.7e-02) | -1.8e-02 (6.2e-02) | -1.3e-01\* (6.1e-02) | 2.6e-02 (6.1e-02) | -6.7e-02  (4.4e-02) |
| Rebate \* Smart Rate | 1.0e-01\*\*\* (2.7e-02) | Omitted | -7.2e-03 (7.3e-02) | Omitted | Omitted | Omitted |
| Linear Time Trend | -2.0e-05\* (7.8e-06) | 4.8e-06 (1.8e-05) | -7.7e-07 (1.9e-05) | 1.2e-05 (1.7e-05) | -4.3e-05\* (1.7e-05) | -6.6e-05\*\*\* (1.6e-05) |
| Daily Temperature Controls | Included | Included | Included | Included | Included | Included |
| Month Dummies | Included | Included | Included | Included | Included | Included |
| Day of Week Dummies | Included | Included | Included | Included | Included | Included |
| Intercept | 2.7e+00\*\*\* (1.1e-02 | 2.5e+00\*\*\* (2.3e-02) | 2.6e+00\*\*\* (2.3e-02) | 2.7e+00\*\*\* (2.4e-02) | 2.8e+00\*\*\* (2.2e-02) | 3.0e+00\*\*\* (2.1e-02) |
| Observations | 18,306,105 | 3,717,189 | 3,515,238 | 3,616,531 | 3,681,799 | 3,775,348 |
| # of groups, total | 30,349 | 5,998 | 6,008 | 6,013 | 6,016 | 6,314 |
| *R2* within | 0.057 | 0.074 | 0.054 | 0.055 | 0.054 | 0.045 |
| *R2* between | 0.031 | 0.078 | 0.053 | 0.054 | 0.067 | 0.010 |
| *R2* overall | 0.045 | 0.072 | 0.055 | 0.062 | 0.061 | 0.028 |

Robust standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling.

\*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.1

**Table A10** reports results restricting the sample by household use of the MyEnergy web-portal provided by PG&E to allow customers to view summary data from their household smart-meter installation. We estimate the association between rebate participation electricity consumption separately for households that logged into the MyEnergy web-portal at least once and for those than never logged into the web-portal. Unfortunately the data on customer interaction with the web-portal is limited to the date of last log-on in the sample period, and does not track those households with multiple or consistent log-on characteristics. We do not find a substantive difference in the coefficient estimates in either of these tables.

**Table A10.** Association between PG&E demand-side programs and average household electricity consumption, coefficient estimates. Sample restricted by participation in the MyEnergy web-portal allowing customers to access their own smart-meter readings and estimated using Equation (5).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Dependent Variable is ln(kWh/day) | | |
| Independent Variable | Full-Sample As Reported | Households that logged in to the web-portal at least once | Households that never logged in to the web-portal |
| Rebate | 7.0e-02\*\*\* (1.3e-02) | 7.4e-02\*\*\* (2.0e-02) | 5.9e-02\*\*  (1.8e-02) |
| BPP | 6.9e-02\*\*\* (2.1e-02) | 9.4e-02\*\*\* (2.7e-02) | 4.5e-03  (3.1e-02) |
| CARE | 1.2e-01\*\*\* (1.2e-02) | 1.1e-01\*\*\* (2.0e-02) | 1.4e-01\*\*\* (1.6e-02) |
| Climate Smart | -2.2e-01 (1.9e-01) | -2.4e-01 (2.0e-01) | -1.2e-01\*  (5.1e-02) |
| Direct Access | 8.7e-02\*\* (3.2e-02) | 1.4e-01\* (6.8e-02) | 6.0e-02  (3.3e-02) |
| Smart AC | 5.3e-02 (2.8e-02) | 5.4e-02 (4.1e-02) | 5.1e-02  (3.7e-02) |
| Smart Rate | 1.3e-02 (4.3e-02) | 5.8e-03 (7.6e-02) | 1.7e-02  (3.2e-02) |
| Rebate \* BPP | -6.7e-02\*\* (2.4e-02) | -6.5e-02\* (3.1e-02) | -7.1e-02  (4.0e-02) |
| Rebate \* CARE | 6.3e-03 (3.1e-02) | -1.8e-02 (4.3e-02) | 3.3e-02  (4.3e-02) |
| Rebate \* Climate Smart | 1.6e-03 (8.8e-02) | -1.4e-02 (8.9e-02) | Omitted |
| Rebate \* Direct Access | -5.8e-02 (3.2e-02) | -8.1e-02 (5.7e-02) | -4.8e-02  (4.0e-02) |
| Rebate \* Smart AC | -4.6e-02 (2.6e-02) | -7.3e-02\* (3.2e-02) | -1.9e-02  (4.0e-02) |
| Rebate \* Smart Rate | 1.0e-01\*\*\* (2.7e-02) | Omitted | 9.7e-02\*  (4.2e-02) |
| Linear Time Trend | -2.0e-05\* (7.8e-06) | 1.3e-05 (1.3e-05) | -4.3e-05\*\*\* (1.0e-05) |
| Daily Temperature Controls | Included | Included | Included |
| Month Dummies | Included | Included | Included |
| Day of Week Dummies | Included | Included | Included |
| Intercept | 2.7e+00\*\*\* (1.1e-02) | 2.7e+00\*\*\* (1.8e-02) | 2.7e+00\*\*\* (1.4e-02) |
| Observations | 18,306,105 | 7,695,701 | 10,610,404 |
| # of groups, total | 30,349 | 12,682 | 17,667 |
| *R2* within | 0.057 | 0.055 | 0.058 |
| *R2* between | 0.031 | 0.051 | 0.020 |
| *R2* overall | 0.045 | 0.055 | 0.038 |

Robust standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling. \*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.1

A small fraction of temperature values fall outside the range of temperatures normally experienced in California, lower than -20°F (-29°C) or greater than 120°F (49°C) (Borgeson, 2013). These readings are likely erroneous. In the panel, 0.000003% of all temperatures are greater than 49°C, and 0.004% are less than -29°C. In Table S9, we reproduce the main model specification while excluding all temperatures above 49°C or below -29°C. The results are essentially identical to those of the main specification.

We consider the difference between Census blocks with higher or lower renter populations. **Table A11** shows the main regression specification, applied only to dwellings in Census blocks with ≤50% renters or >50% renters. We find that households in neighborhoods with higher rates of renting see a larger increase (10.4% [3.4%, 17.9%] vs. 6.9% [3.9%, 10.0%]) in electricity consumption when they apply for energy efficiency rebates. This is likely because renters live disproportionately on the Coast, where baseline electricity consumption is lower and the increase in electricity consumption associated with rebates is higher on average for all dwellings (see **Table A4**).

**Table A11.** The main regression specification applied to households from Census blocks with greater or less than 50% renters. The increase in electricity consumption associated with rebates is higher for high-renter Census blocks, likely because these households are disproportionately on the Coast, which has lower baseline electricity consumption and a higher average increase in electricity consumption associated with rebates.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Dependent Variable: ln(kWh/day) |  |  |
| Independent Variable | Full sample | % renters ≤50% | % renters > 50% |
| Rebate | 7.0e-02\*\*\* (1.3e-02) | 6.7e-02\*\*\* (1.5e-02) | 9.9e-02\*\*  (3.4e-02) |
| BPP | 6.9e-02\*\*\* (2.1e-02) | 7.7e-02\*\* (2.4e-02) | 5.5e-02  (3.9e-02) |
| CARE | 1.2e-01\*\*\* (1.2e-02) | 1.4e-01\*\*\* (1.7e-02) | 9.7e-02\*\*\* (1.8e-02) |
| Climate Smart | -2.2e-01 (1.9e-01) | -2.1e-01 (2.0e-01) | -2.4e-01  (1.4e-01) |
| Direct Access | 8.7e-02\*\* (3.2e-02) | 9.3e-02\* (3.9e-02) | 6.9e-02  (5.5e-02) |
| Smart AC | 5.3e-02 (2.8e-02) | 5.7e-02 (3.2e-02) | 4.2e-02  (5.7e-02) |
| Smart Rate | 1.3e-02 (4.3e-02) | -3.2e-02 (2.6e-02) | 1.3e-01  (1.3e-01) |
| Rebate \* BPP | -6.7e-02\*\* (2.4e-02) | -6.0e-02\* (2.6e-02) | -1.3e-01\*  (5.1e-02) |
| Rebate \* CARE | 6.3e-03 (3.1e-02) | -1.0e-02 (3.5e-02) | 4.1e-02  (6.5e-02) |
| Rebate \* Climate Smart | 1.6e-03 (8.8e-02) | 1.1e-02 (8.7e-02) | Omitted |
| Rebate \* Direct Access | -5.8e-02 (3.2e-02) | -3.4e-02 (3.5e-02) | -2.1e-01\*\*  (8.1e-02) |
| Rebate \* Smart AC | -4.6e-02 (2.6e-02) | -4.4e-02 (2.9e-02) | -6.1e-02  (4.8e-02) |
| Rebate \* Smart Rate | 1.0e-01\*\*\* (2.7e-02) | Omitted | 5.4e-02  (5.2e-02) |
| Linear Time Trend by Day | -2.0e-05\* (7.8e-06) | -3.1e-05\*\* (9.7e-06) | 2.9e-06  (1.3e-05) |
| Daily Temperature Controls | Included | Included | Included |
| Month Dummies | Included | Included | Included |
| Day of Week Dummies | Included | Included | Included |
| Intercept | 2.7e+00\*\*\* (1.1e-02) | 2.9e+00\*\*\* (1.3e-02) | 2.4e+00\*\*\* (1.7e-02) |
| Observations | 18,306,105 | 11,876,198 | 6,429,907 |
| # of groups, total | 30,349 | 18,743 | 11,606 |
| # of groups with rebate | 0.057 | 0.062 | 0.050 |
| *R2* within | 0.031 | 0.025 | 0.045 |
| *R2* between | 0.045 | 0.044 | 0.056 |
| *R2* overall | 18,306,105 | 11,876,198 | 6,429,907 |
|  |  |  |  |

Robust standard errors in parentheses. An observation is a day of electricity consumption for a single dwelling.

\*\*\* *p*<0.01, \*\**p*<0.05, \**p*<0.1

In our sample, 30,000 accounts were randomly selected from PG&E’s 4.5 million residential electric customers. Some of these accounts, such as those corresponding to landlords, are associated with different service points, i.e. dwellings. In our sample, 4,200 accounts are associated with 10,065 dwellings, roughly one third of the sample. The remaining accounts are associated with only one dwelling. Because of the sampling method, we cannot distinguish a household moving from one dwelling to another from an account that simply covers multiple dwellings, e.g. an apartment building. On average, 10% of US households moved within the same state in 2011, 80% of whom stayed within the same county (Census, 2018). This translates to roughly 20-30% of our sample moving within the study period (the number is rough due to the staged deployment of smart-meters). This suggests that the majority of the 10,065 dwellings above were the result of moves within PG&E territory, rather than landlords with multiple units. Post-move households will be followed for a shorter period of time, making it more difficult to determine changes in electricity consumption associated with rebate participation. Also, we acknowledge that households may experience changes in electricity consumption during the first year in a new dwelling, as they purchase new appliances and learn to operate the building more efficiently, potentially introducing a temporary negative trend in electricity consumption during the first year or two of occupancy.

##### Rebate application breakdown over time



**Figure A3.** Energy efficiency rebate applications over time by category.

**Table A12.** Rebate counts by appliance type and region. A disproportionate number of HVAC rebates are in the Central Valley.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Central Valley | Coast | Inland Hills | Total |
| Water Heating | 11 | 21 | 21 | 53 |
| Unknown | 326 | 217 | 392 | 935 |
| Pump/Motor | 23 | 4 | 18 | 45 |
| Lighting | 260 | 217 | 88 | 561 |
| Integrated Building | 6 | 18 | 0 | 24 |
| HVAC | 459 | 41 | 212 | 712 |
| Custom | 44 | 33 | 75 | 152 |
| Building Shell | 13 | 31 | 55 | 99 |
| Appliance | 391 | 837 | 1201 | 2429 |
| Appliance Recycling | 117 | 139 | 218 | 474 |
| Total | 1650 | 1554 | 2280 | 5484 |

##### Online household survey results

In the panel regressions in this paper, we observe an increase in electricity consumption associated with participation in energy efficiency rebate programs. This motivates several hypotheses:

1. Households that apply for rebates keep and continue to use an existing older, less efficient version of the same appliance.
2. Households use rebates to purchase appliances they did not already possess.
3. Households purchase appliances at the same time as increases in household size.
4. Households purchase appliances at the same time as major building renovations or additions.
5. Households use rebates to purchase more consumptive, but more efficient appliances, e.g. refrigerators with ice-makers.
6. Households purchase additional appliances or equipment at the same time as any rebates.

We investigate the first four hypotheses using a survey of California residents using Amazon’s Mechanical Turk platform.

###### Methodological details

The survey was collected in two batches with the first collecting 101 samples, and the second 564 samples. This fell short of the planned 1000 responses. We terminated data collection after not receiving new responses after a full week. Respondents were required to have a Human Intelligence Task rating of 90% or greater.

The second round of the survey asked an additional set of questions about household renovations and changes in household size, which were not asked in the first 101 samples.

###### Summary statistics and demographics

39% of the sample is between the ages of 21 and 30. 72% of the sample is between 21 and 40. 53% of the sample is female. 54% of the sample is white and reports no other race or ethnicity. A further 18% report Asian, 11% report Hispanic or Latino, and 6% report Black as their race or ethnicity (while reporting no other race or ethnicity). 59% of the sample has annual household income between $21,000 and $80,000, while 21% has annual income of $81,000-$160,000. 11% has income below $20,000 per year. 58% of the sample has at least a bachelor’s degree, and 33% has attended some college. The median household size is three, with 44% at one or two occupants and 53% with three or more occupants (the remaining 3% declined to respond). 66% of respondents pay their own electricity bill, while in 24% of households the bill is paid by a spouse, domestic partner or roommate. In 5% of cases the landlord pays the electric bill.

58% of respondents who pay their own electricity bill applied for rebates. 46% of respondents whose landlord pays their electricity bill applied for rebates. This may be an indication of a split incentive, discouraging investment in energy efficiency because the household will not benefit from the electric bill savings. See Table A13 for further summary statistics from our sample.

**Table A13.** Demographic and other summary statistics from the survey sample. The first 101 respondents were not asked questions about building retrofits and changes in household size. CARE is the fraction of the sample enrolled in the California Alternate Rates for Energy program. ESAP is the fraction enrolled in the Energy Savings Assistance Program. PG&E is the fraction served by PG&E. White is the fraction reporting their race or ethnicity as “White” and nothing else. “Age ≤ 30” is the fraction aged 30 years or younger. “Income ≤ $80k$ is the fraction with income at or below $80,000. “≥ Bachelor’s” is the fraction with a bachelor’s degree or higher. “Hhld size ≤ 2” is households consisting of two or fewer people. “Pays bill” is the fraction of respondents that pay their own electricity bill (for most of the remainder, 24%, the bill is paid by a spouse, domestic partner, or roommate). Results for the first 101 respondents are similar to the full set of respondents.

|  |  |  |
| --- | --- | --- |
|  | % of sample | First 101 respondents |
| CARE | 20% | 24% |
| ESAP | 10% | 13% |
| PG&E | 31% | 36% |
| Age ≤ 30 | 39% | 40% |
| White | 54% | 51% |
| Income ≤ $80k | 70% | 70% |
| ≥ Bachelor’s | 58% | 58% |
| Hhld size ≤ 2 | 44% | 44% |
| Pays bill | 67% | 66% |
| Sample size | 665 | 101 |

31% of the sample is served by Pacific Gas and Electric, 35% by Southern California Edison, 13% by the Los Angeles District of Water and Power, 10% by San Diego Gas and Electric, and 6% by the Sacramento Municipal Utility District. This roughly corresponds to the distribution of utility customers in California.

20% of the survey sample report enrollment in the California Alternate Rates for Energy (CARE) low-income subsidy, while just under 1/3 are enrolled in the data provided by PG&E. 10% of the sample reports participation in the Energy Savings Assistance Program, free energy efficiency measures for low-income households.

These responses are similar for the first 101 respondents, who were not asked questions about renovations and changes in household size. The primary deviations between samples are modestly higher enrollment enrollment (up to 30%) in low-income energy assistance programs, which may simply be explained by the larger proportion of respondents in the PG&E service territory (36% v. 31%), which has higher rates of enrollment in its low-income energy assistance programs (Evergreen, 2013; Sherwin and Azevedo, 2020). There is almost perfect agreement between samples for household size, income, education, and who pays the bill. This suggests that combining these responses with the remaining 564 responses is justified for questions asked to all respondents.

Households that apply for multiple rebates tend to do so in the same year. 357 of 665 households applied for at least one rebate. Of these, 109 applied for more than one rebate. Of these, only thirty-four, just over 5% of all households that applied for rebates, did so in different years. This suggests that our use of only the most recent rebate in analysis of the timing of rebates to test hypotheses 3 and 4 is reasonable.

###### Limitations

The sample of California respondents was collected through the Amazon Mechanical Turk online platform, and thus may not be representative of the general population, e.g. because respondents must have access to a computer and the internet.

Of the 208 respondents in Pacific Gas & Electric (PG&E) territory, thirty-four report applying for utility rebates for refrigerators less than one year ago. Refrigerator rebates were discontinued at the beginning of 2016 in PG&E territory. We suspect respondents may have confused utility rebates with manufacturer or retailer rebates. Still insights about behavior associated with retailer or manufacturer rebates, which may or not be associated with increased efficiency, provide some insight into behavior associated with utility rebates for efficient appliances.

###### Assessing hypothesis 1: Households keep old appliances

The survey asks respondents about appliance purchases in the past ten years, rebate participation, and what they did with any old versions of the purchased appliances. **Table A14** shows the breakdown of appliance ownership, purchasing, rebate application, and the presence of a corresponding old and functioning appliance.

**Table A14.** Reported appliance ownership, purchasing, rebate application, and presence of an old and functioning appliance in the case of rebate application for six major household appliances, reported as a percent of the total of 665 respondents. Nearly half of those that bought a refrigerator applied for a rebate. Less than half of those had an old working refrigerator.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Have | Bought | Rebate | Had old |
| Refrigerator | 99% | 69% | 30% | 11% |
| Window AC | 30% | 25% | 6% | 6% |
| Clothes dryer | 85% | 62% | 15% | 5% |
| Clothes washer | 88% | 62% | 17% | 7% |
| Water heater | 82% | 29% | 9% | 4% |
| Pool pump | 14% | 8% | 2% | 1% |

99% of respondents had a refrigerator in their home, while a substantial majority had a clothes washer, clothes dryer, and water heater in their home. A smaller number had a window air conditioning unit or pool pump. The survey did not ask about the presence of central air conditioning, as the probability of a household retaining an old central air conditioning unit at the same dwelling after procuring a new unit is very low.

For households that applied for energy efficiency rebates and report having an old version of the same appliance, **Table A15** shows what households report doing with the old appliance.

**Table A15.** A count of the actions that households that applied for a rebate and report having an old and working version of the same appliance report taking with the old appliance. In the vast majority of cases, respondents report not keeping old appliances. Roughly a quarter of households that had applied for a rebate and had an old refrigerator report keeping the old appliance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Kept | Recycled | Scrapped | Sold | Total |
| Refrigerator | 14 | 38 | 6 | 17 | 75 |
| Window AC | 7 | 21 | 6 | 4 | 38 |
| Clothes dryer | 3 | 11 | 8 | 10 | 32 |
| Clothes washer | 2 | 19 | 7 | 17 | 45 |
| Water heater | 1 | 11 | 6 | 7 | 25 |
| Pool pump | 0 | 6 | 1 | 0 | 7 |
| Total | 27 | 106 | 34 | 55 | 222 |

14 of 200 households that applied for a refrigerator rebate report keeping the old appliance. 61 of these households disposed of an old, working refrigerator. Given the 99% penetration of refrigerators, purchases of refrigerators where households did not have an old working refrigerator likely took place after an old refrigerator broke down, or shortly after moving into a new residence.

Refrigerators constitute the plurality of cases in which a rebate applicant had an old and working version of the same appliance. In 51% of cases where a household applied for a rebate and had an old working refrigerator, respondents report recycling it. Replacement of an older, less efficient refrigerator with a new, more efficient version should result in household energy savings, unless the new version is larger or more consumptive, e.g. if it has an ice-maker.

In only 27 of 222 cases in which a household had an old and working appliance did respondents report keeping it after applying for a rebate. Paired with the energy savings from refrigerator recycling, this relatively small number of cases in which households kept older appliances likely would not result in the observed increase in household electricity consumption associated with participation in rebate programs.

7 of 38 households that applied for window air conditioner rebates report keeping the old appliance. For all other appliances, only one to three of the full sample report keeping the old appliance. This suggests that it is unlikely that the observed increase in electricity consumption associated with rebate participation is due to households keeping and using an old version of the same appliance.

###### Assessing hypothesis 2: Purchase of new appliances not previously in the household

One possible explanation for the observed increase in electricity consumption is that households used rebates to acquire appliances that they did not own previously. For only 42% of rebates did the household have a working version of the same appliance.

Our survey does not differentiate between households that had a broken version of the purchased appliance, and households that did not have the appliance before purchase. 99% of households report having a refrigerator, while 88% report owning a clothes washer, 85% report owning a clothes dryer, and 82% report owning a water heater. These high rates of ownership suggest that purchases of these appliances likely replaced old, perhaps broken, versions of the same appliance

Still, with these data, we cannot reject the hypothesis that the observed increase in electricity consumption associated with rebates is due at least in part to the purchase of new appliances not previously owned by the household.

###### Assessing hypothesis 3: Simultaneous increases in household size

One possible explanation for the observed increase in electricity consumption is that households tend to apply for rebates simultaneously with increases in household size. Within the sample, 20% of respondents who were asked questions about changes in household size report an increase in household size over the past ten years, while 14% report a decrease. Only 13 of these 564 respondents reported an increase in household size during the same period they applied for a rebate, with 13 also reporting a simultaneous decrease, or 2.3% in each case. Questions about changes in household size and building renovations were added after the first 101 responses had been collected. These questions were asked to only the final 562 respondents. Only thirteen of 562 respondents who were asked questions about changes in household size report applying for their most recent rebate within the same period (<1 year, 1-3 years, 4-6 years, or 7-10 years) as an increase in household size, while thirteen report applying for a rebate during the same period as a decrease in household size.

These results suggest that households do not tend to apply for rebates disproportionately during times of increasing household size. It is unlikely that this hypothesis explains the observed increase in electricity consumption.

###### Assessing hypothesis 4: Simultaneous renovations

A similar potential explanation for the observed increase in electricity consumption is that households tend to apply for rebates simultaneously with building renovations. 20% of respondents report renovations, such as room remodels and building additions, with 12% reporting both renovations and energy efficiency rebates.

Building renovations generally did not occur at the same time as appliance rebates. Only 25 respondents had their most recent appliance rebates and building upgrades in the same time period (less than 1 year, 1-3 years, 4-6 years or 7-10 years).

The remaining renovations took place either before or after application for appliance rebates. Several of the 111 respondents that report renovations also report applying for rebates for building-related energy efficiency measures, such as building insulation. Several respondents report efficiency upgrades, such as installing efficient windows, and upgrading the home AC system. As a result, it is unclear whether renovations would tend to increase or decrease household electricity consumption.

Given the relatively small number of households that applied for appliance rebates and report simultaneous renovations, and the ambiguous direction of the effect of renovations on household electricity consumption, it is unlikely that simultaneous renovations explain the observed increase in electricity consumption associated with rebate participation.

###### Assessing hypotheses 5 and 6

We do not have data to assess the effect of increasing appliance electricity consumption, or simultaneous purchase of other new appliances or equipment.

##### Approximate lognormality of electricity consumption

We use log electricity consumption in our model because the distribution of household electricity consumption, shown in Figure A4, more closely approximates a normal distribution when in log form. Neither log or untransformed electricity consumption is perfectly normal, and our sample size of over 30,000 dwellings means that any standard statistical test will reject normality in both cases.

One metric that demonstrates that log electricity consumption is closer to normal is a comparison of skewness and kurtosis of both distributions. A normal distribution has zero skewness, and kurtosis of three. We compute the skewness and kurtosis of average daily household electricity consumption, and the log of average daily household electricity consumption. We use average daily dwelling electricity consumption to test normality, rather than daily or hourly interval data from the panel because average dwelling data more fully represents the actual distribution of electricity consumption across our sample, as our panel is unbalanced across regions.



**Figure A4.** A) A histogram of average daily dwelling electricity consumption from the full panel, with a cutoff at 100 kWh/day. B) A histogram of the log of average daily dwelling electricity consumption, with no cutoff and a fitted normal distribution for comparison. © 2020, Sherwin, E.D., Azevedo, I.M.L. Adapted from Figure S6 in (Sherwin and Azevedo, 2020). Originally published under a Creative Commons Attribution License 4.0.

We find that the distribution of average daily electricity consumption across all dwellings in the sample has skewness 142 and kurtosis 23,076. The distribution of log average daily electricity consumption has skewness -3, and kurtosis 37. In both cases, these parameters are different than their counterparts in a normal distribution, but the log parameters are two to three orders of magnitude closer than their untransformed counterparts. Therefore, we conclude that log electricity consumption more closely matches a normal distribution, and therefore is more correct as the independent variable in our analysis.

##### Online household survey instrument

Q1 **Welcome to our survey!**  
    
 We are studying what people do when they buy new household appliances.   
    
 You will receive $1 in compensation for participating in our survey even if there are some questions in the survey that do not apply to you. We expect the survey to take about ten minutes to complete.

Your response will assist ongoing research at Carnegie Mellon University.

All responses will remain anonymous, and will be used only for research purposes.

Participation in the survey is voluntary. You may stop at any time.

Thank you!

|  |  |
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| Page Break |  |

Q42 Let's get started! Which of the following appliances do you have in your home (primary residence)? You can select multiple appliances, including those you own or rent, and also those that belong to your landlord or someone else.

* Window Air Conditioner (3)
* Clothes Dryer (4)
* Clothes Washer (5)
* Water Heater (6)
* Pool pump/motor (7)
* Refrigerator (2)
* I do not have any of these (8)

|  |  |
| --- | --- |
| Page Break |  |

Q45 Between 2007 and now, have you or someone in your household purchased any of the following appliances? Please select appliances you purchased even if you do not own them anymore. You can select multiple appliances, so please select all that apply.

* Window Air Conditioner (3)
* Clothes Dryer (4)
* Clothes Washer (5)
* Water Heater (6)
* Pool pump/motor (7)
* Refrigerator (2)
* I did not purchase any of these (8)

|  |  |
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Q35   
**Background Information: Energy efficiency rebates**   
  Your electric and natural gas utility (or utilities) may offer rebates, which reduce the amount you pay for an appliance you purchase. You generally have to fill out a form online or on paper to get the amount of the rebate back.   
  
  
The forms look roughly like the one shown below, but forms may differ from utility to utility.

Q41

Graphical user interface, text, application

Description automatically generated

Q45 Please press "Next Page" to continue the survey.

|  |  |
| --- | --- |
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Q3 You just told us that you, or someone in your household, bought the appliance(s) below. For which appliance(s) do you recall applying for a utility rebate? If you bought more than one of an appliance, please consider the most recent purchase. Please select all that apply.

* Window Air Conditioner (11)
* Clothes Dryer (13)
* Clothes Washer (18)
* Water Heater (14)
* Pool pump/motor (15)
* Refrigerator (10)

|  |  |
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Q37 Before taking this survey, were you aware of the rebate programs offered by electric and gas utilities?

* Yes (1)
* No (2)

Q38 Do you think there were times when you were eligible for an appliance rebate, but did not apply? If so, what were the reasons?

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Q25 Please tell us a bit more about these rebates:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | How long ago did you apply? | Did you already have another working appliance of this type in your home? | | What was the rebate amount? | How long after purchase did you apply for the rebate? | Did you receive the rebate payment? | |
|  |  | Yes (1) | No (2) |  |  | Yes (1) | No (2) |
| ⊗Window Air Conditioner (3) | ▼ Less than 1 year (1) ... Don't remember (5) |  |  | ▼ $50 or less (1) ... Don't remember (5) | ▼ 0-30 days (1) ... Don't remember (4) |  |  |
| Clothes Dryer (33) | ▼ Less than 1 year (1) ... Don't remember (5) |  |  | ▼ $50 or less (1) ... Don't remember (5) | ▼ 0-30 days (1) ... Don't remember (4) |  |  |
| Clothes Washer (37) | ▼ Less than 1 year (1) ... Don't remember (5) |  |  | ▼ $50 or less (1) ... Don't remember (5) | ▼ 0-30 days (1) ... Don't remember (4) |  |  |
| ⊗Water Heater (6) | ▼ Less than 1 year (1) ... Don't remember (5) |  |  | ▼ $50 or less (1) ... Don't remember (5) | ▼ 0-30 days (1) ... Don't remember (4) |  |  |
| ⊗Pool pump/ motor (7) | ▼ Less than 1 year (1) ... Don't remember (5) |  |  | ▼ $50 or less (1) ... Don't remember (5) | ▼ 0-30 days (1) ... Don't remember (4) |  |  |
| ⊗Refrigerator (2) | ▼ Less than 1 year (1) ... Don't remember (5) |  |  | ▼ $50 or less (1) ... Don't remember (5) | ▼ 0-30 days (1) ... Don't remember (4) |  |  |

Q34 What did you do with your old working appliance?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | | | |
|  | Kept it (1) | Scrapped it (2) | Recycled it (3) | Sold it (4) |
| ⊗Window Air Conditioner (3) |  |  |  |  |
| Clothes Dryer (33) |  |  |  |  |
| Clothes Washer (37) |  |  |  |  |
| ⊗Water Heater (6) |  |  |  |  |
| ⊗Pool pump/ motor (7) |  |  |  |  |
| ⊗Refrigerator (2) |  |  |  |  |

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Q36 Do you own or rent your home?

* Own (1)
* Rent (2)
* Other (3) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q30 Have you moved residences since 2007?

* Yes (1)
* No (2)
* Prefer not to answer (3)

Q31 When did you move to your current residence?

▼ 2007 (1) ... Prefer not to answer (12)

Q39 Are the major appliances in your home (the appliances we asked about in this survey) mostly newer or older?

* Mostly newer (5 years old or less) (1)
* Mostly older (more than 5 years) (2)
* Don't know (4)
* Prefer not to answer (3)

|  |  |
| --- | --- |
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Q48 Since 2007, have there been any major renovations to your home?   
E.g. a room remodel or an addition to the building.

* Yes (1)
* No (2)
* Prefer no to answer (3)

Q49 How long ago did these renovations take place? If there was more than one set of renovations, when did the most recent set take place?

▼ Less than 1 year (1) ... Prefer not to answer (6)

Q50 Did you apply for any energy efficiency rebates from your utility, e.g. for building insulation, as part of these renovations?

* Yes (1)
* No (2)
* Prefer not to answer (3)

Q51 How large were these renovation-related rebates?

▼ $50 or less (1) ... Prefer not to answer (6)

Q53 Did you receive the rebate payment?

* Yes (1)
* No (2)
* Prefer not to answer (3)

Q55 Please briefly describe these renovation-related rebates.

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Q17 Please specify your electric utility:

* Pacific Gas and Electric Company (PG&E) (32)
* San Diego Gas & Electric (SDG&E) (33)
* Southern California Edison (SCE) (34)
* Sacramento Municipal Utility District (SMUD) (36)
* Los Angeles Department of Water and Power (LADWP) (37)
* Other (35)

Q18 Please specify your utility:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Q9 Please specify any utility program(s) that you are currently enrolled in:

* California Alternate Rates for Energy (CARE) (4)
* Energy Savings Assistance Program (6)
* SmartAC (1)
* SmartRate (2)
* AC Quality Care Program (3)
* Family Electric Rate Assistance (FERA) (5)
* Other (7)

Q32 Please specify the program(s):

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Q47 How long ago did you first enroll in CARE?

▼ 1-6 months (1) ... 10+ years (7)

Q31 Please specify any utility program(s) that you are currently enrolled in:

* California Alternate Rates for Energy (CARE) (1)
* Energy Savings Assistance Program (3)
* Family Electric Rate Assistance (FERA) (2)
* New Solar Homes Partnership (NSHP) (4)
* Energy Upgrade California® Home Upgrade (5)
* Other (6)

Q33 Please specify the program(s):

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Q48 How long ago did you first enroll in CARE?

▼ 1-6 months (1) ... 10+ years (7)

Q34 Please specify any utility program(s) that you are currently enrolled in:

* California Alternate Rates for Energy (CARE) (2)
* Energy Savings Assistance Program (1)
* Family Electric Rate Assistance (FERA) (3)
* Other (4)

Q35 Please specify the program(s):

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Q49 How long ago did you first enroll in CARE?

▼ 1-6 months (1) ... 10+ years (7)

Q19 Who is responsible for the electricity bill payment for your household?

* You (1)
* Spouse, domestic partner, or roommate (2)
* Landlord (3)
* Other (4)

Q20 Please specify:

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End of Block: Introduction

Start of Block: Block 3

Q37 What is your age?

▼ Under 20 years old (1) ... Prefer not to answer (8)

Q38 Please select your gender:

▼ Male (1) ... Prefer not to answer (4)

Q39 Please specify your race or ethnicity:

* White (1)
* Hispanic or Latino (2)
* Black or African American (3)
* American Indian or Alaska Native (4)
* Asian (5)
* Other (6)
* Prefer not to answer (7)

Q40 What is your annual household income?

▼ (1) ... Prefer not to answer (5)

Q44 What is your highest level of education attained?

▼ 8th grade or less (1) ... Prefer not to answer (6)

Q41 What is your household size?

▼ 1 (1) ... Prefer not to answer (6)

Q56 Has your household size changed since 2007?

* Yes (1)
* No (2)
* Prefer not to answer (3)

Q58 When was the most recent change in your household size?

▼ 2007 (1) ... Prefer not to answer (12)

Q57 What was your household size before the most recent change?

▼ 1 (1) ... Prefer not to answer (6)

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Q42 Please provide your zip code:

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Q43 Is there anything else you would like to tell us?

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Q43 Please enter your MTurk ID:

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End of Block: Block 3

Start of Block: Block 2

Q30 You have reached the end of the survey. Feel free to go back and review or update your answers using the "Previous Page" buttons. When you are ready, please click “Submit” to record your response and receive your MTurk verification code.

End of Block: Block 2

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