

# Evaluating the Energy-Saving Effects of a Utility Demand-Side Management Program: A Difference-in-Difference Coarsened Exact Matching Approach

## Online Appendix

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While we use census tracts as neighborhoods in the Coarsened Exact Matching (CEM) methodology in the main paper, this online appendix shows the results when we use zip codes as neighborhoods in the CEM methodology. These results provide robustness checks to the estimated effects in the main paper. This online appendix also includes other results omitted from the main text, such as the effects of the high-efficiency AC program on winter peak energy demand.

### **Annual Effects of The High-Efficiency AC Rebate Program**

Table A1 shows that when we use zip codes as neighborhoods in the CEM methodology, the AC rebate program leads to annual energy savings of about 8.6% per year. In the main paper, the DD CEM with census tracts as neighborhoods gives a relatively higher savings of 9.5% per treated household, while the regular DD regression produces an average energy savings of about 8.5%. The treatment effects from all three regressions are not very different from each other. All three regressions lead to a savings of about 2000 kWh per year.

### **Summer Peak Effects**

Table A2 displays the results of the summer peak effects of the program under the CEM methodology with zip codes as neighborhoods. The table shows that the high-efficiency AC rebate program reduced summer peak energy consumption by about 17%. Again this estimated effect lies between the effects estimated with the DD CEM methodology with census tracts as neighborhoods (20.6%) and the regular DD methodology (16.7%), but relatively closer to the estimated effects of the regular DD methodology.

### **Winter Peak and Non-Peak Months Effects**

Tables A3 and A4 shows the results of the winter peak and non-peak months effects of the high-efficiency AC rebate program. There are no statistically significant winter peak effects of the program under the DD CEM with census tracts as neighborhoods. The regular DD and the DD CEM (with zipcodes as neighborhoods), however, produced statistically significant but relatively lower winter peak effects of about 4%. The effects of the program in the non-peak months is also about 4.8% and is statistically significant in all three regressions.

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Table A1: DD CEM (with Zip Codes as Neighborhoods) Estimate of the Effects of the 2009 High Efficiency AC Program

| $\Delta\log(\text{Energy Usage})$   | I                     | II                   | III                 |
|-------------------------------------|-----------------------|----------------------|---------------------|
| Treat                               | -0.0858***<br>(-5.15) | -0.1382**<br>(-2.83) | -0.1048<br>(-1.59)  |
| Treat*Heated Area(1000 square feet) |                       | 0.0262<br>(1.32)     | 0.0240<br>(1.22)    |
| Treat*Age                           |                       |                      | -0.0012<br>(-0.63)  |
| Bedrooms                            | 0.0100<br>(0.69)      | 0.0100<br>(0.69)     | 0.0100<br>(0.69)    |
| Stories                             | -0.0007<br>(-0.04)    | -0.0007<br>(-0.04)   | -0.0007<br>(-0.04)  |
| Heated Area (1000 square feet)      | -0.0049<br>(-0.32)    | -0.0056<br>(-0.37)   | -0.0055<br>(-0.36)  |
| Age                                 | 0.0003<br>(0.35)      | 0.0003<br>(0.35)     | 0.0003<br>(0.38)    |
| Pool                                | -0.0279<br>(-1.83)    | -0.0278<br>(-1.83)   | -0.0278<br>(-1.83)  |
| Electric and Gas                    | 0.0991***<br>(7.80)   | 0.0991***<br>(7.81)  | 0.0990***<br>(7.80) |
| Mean Income (\$1000)                | -0.0006*<br>(-2.36)   | -0.0006*<br>(-2.35)  | -0.0006*<br>(-2.36) |
| Mean Household Size                 | 0.0276<br>(0.92)      | 0.0275<br>(0.92)     | 0.0275<br>(0.92)    |
| Hot Tub                             | 0.0327<br>(0.83)      | 0.0331<br>(0.84)     | 0.0331<br>(0.84)    |
| cons                                | 0.0311<br>(0.38)      | 0.0325<br>(0.39)     | 0.0318<br>(0.38)    |
| N                                   | 7843                  | 7843                 | 7843                |

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ . t-statistics are in parenthesis.

### Effects on Electric-Only Households

Table A5 show the results of the AC rebate program for the electric-only households using the DD CEM methodology with zip codes as neighborhoods. The table shows summer peak effects and winter peak effects of 13% and 7.5%, respectively. These values are marginally lower than the effects obtained under the DD CEM regression with census tracts as neighborhoods (14% in the summer and 8% in the winter) presented in the main paper.

### Graphical Analysis of the Rebound Effect

Figures A1 and A2 shows the graph of average energy consumption of the treated and control consumers who were matched in the CEM methodology when zip codes were used as neighborhoods and when no matching methodology was used respectively. While the two figures differ slightly from Figure 4 in the main paper and from each other, the main observation from Figure 4 that the program participants even increased their energy savings much higher in the subsequent years after the program is present in all three figures. The two figures, thus, reinforces the suggestion that there are no rebound effects of the high-efficiency AC rebate program.

Table A2: Summer Peak Effects of the 2009 AC rebate program

| $\Delta\log(\text{Energy Usage})$ | DD CEM<br>(Zip Codes)<br>III |
|-----------------------------------|------------------------------|
| Treat                             | -0.1710***<br>(-8.09)        |
| Bedrooms                          | 0.0245<br>(1.25)             |
| Stories                           | 0.0252<br>(1.22)             |
| Heated Area<br>(1000 square feet) | -0.0380<br>(-1.87)           |
| Age                               | -0.0002<br>(-0.20)           |
| Pool                              | 0.0168<br>(0.93)             |
| Electric and Gas                  | 0.0199<br>(1.26)             |
| Mean Income<br>(\$1000)           | -0.0009**<br>(-2.68)         |
| Mean Household Size               | 0.0495<br>(1.18)             |
| Hot Tub                           | 0.0320<br>(0.58)             |
| cons                              | -0.0435<br>(-0.41)           |
| N                                 | 7843                         |

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .  
t-statistics are in parenthesis.

### “Rebound” Effects

Table A6 gives an estimate of the rebound effect of the high-efficiency rebate program using the DD CEM with zip codes as neighborhoods. The negative sign on the coefficient on the treatment group aligns with the results of DD CEM regression and the regular DD regression in the main paper. All three regressions show there is no rebound effect of the high-efficiency AC rebate program. The estimated effects in Table A6 is statistically significant at the 5% level, which implies that there were even more energy reductions even after the first full year of program participation.

Table A3: Winter Peak Effects of the 2009 AC Rebate Program

| $\Delta \log(\text{Energy Usage})$ | DD CEM (Census Tract)<br>(I) | Regular DD<br>(II)     | DD CEM (Zip Codes)<br>(III) |
|------------------------------------|------------------------------|------------------------|-----------------------------|
| Treat                              | -0.0404<br>(-1.44)           | -0.0403*<br>(-2.26)    | -0.0432*<br>(-2.14)         |
| Bedrooms                           | 0.0556<br>(1.78)             | -0.0043<br>(-0.86)     | 0.0054<br>(0.37)            |
| Stories                            | 0.0081<br>(0.24)             | -0.0159**<br>(-2.70)   | -0.0198<br>(-0.87)          |
| Heated Area<br>(1000 square feet)  | -0.0453<br>(-1.19)           | 0.0171***<br>(3.56)    | 0.0098<br>(0.61)            |
| Age                                | 0.0015<br>(0.90)             | 0.0004<br>(1.62)       | 0.0007<br>(0.88)            |
| Pool                               | -0.0530<br>(-1.15)           | -0.0532***<br>(-8.15)  | -0.0589**<br>(-2.97)        |
| Electric and Gas                   | 0.1567***<br>(4.07)          | 0.1375***<br>(25.24)   | 0.1590***<br>(10.72)        |
| Mean Income<br>(\$1000)            | -0.0010<br>(-1.63)           | -0.0009***<br>(-10.08) | -0.0009***<br>(-3.81)       |
| Mean Household Size                | 0.0979<br>(1.15)             | -0.0235*<br>(-2.16)    | -0.0273<br>(-0.83)          |
| Hot Tub                            | -0.0048<br>(-0.07)           | -0.0017<br>(-0.16)     | -0.0085<br>(-0.23)          |
| cons                               | -0.0195<br>(-0.09)           | 0.3742***<br>(12.15)   | 0.3675***<br>(3.64)         |
| N                                  | 1552                         | 24010                  | 7843                        |

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ . t-statistics are in parenthesis.

Figure A1: Average Energy Consumption by Participants and Non-Participants

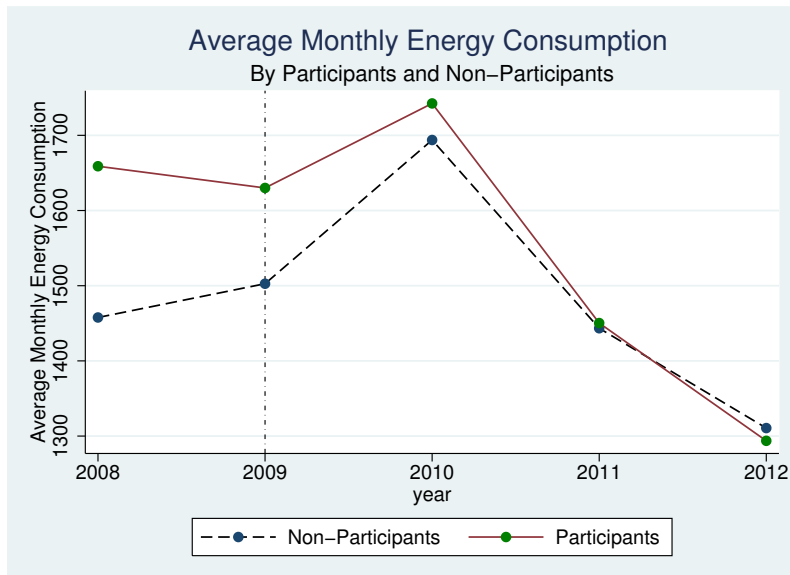


Table A4: Non-Peak Months Effects of The 2009 AC Rebate Program

| $\Delta \log(\text{Energy Usage})$ | DD CEM (Census Tract)<br>(I) | Regular DD<br>(II)    | DD CEM (zipcodes)<br>(III) |
|------------------------------------|------------------------------|-----------------------|----------------------------|
| Treat                              | -0.0488*<br>(-2.15)          | -0.0487***<br>(-3.36) | -0.0461**<br>(-2.69)       |
| Bedrooms                           | 0.0433<br>(1.47)             | -0.0050<br>(-1.06)    | 0.0211<br>(1.41)           |
| Stories                            | 0.0237<br>(0.96)             | -0.0056<br>(-1.04)    | 0.0134<br>(0.86)           |
| Heated Area<br>(1000 square feet)  | -0.0401<br>(-1.42)           | 0.0109*<br>(2.40)     | -0.0251<br>(-1.71)         |
| Age                                | 0.0016<br>(1.21)             | -0.0004<br>(-1.83)    | -0.0006<br>(-0.73)         |
| Pool                               | -0.0639*<br>(-2.04)          | -0.0340***<br>(-5.36) | -0.0153<br>(-0.91)         |
| Electric and Gas                   | 0.0729*<br>(2.43)            | 0.0528***<br>(10.33)  | 0.0572***<br>(4.11)        |
| Mean Income (\$1000)               | 0.0015**<br>(2.88)           | 0.0005***<br>(6.40)   | 0.0003<br>(1.21)           |
| Mean Household Size                | 0.0574<br>(0.94)             | 0.0255*<br>(2.50)     | 0.0529<br>(1.73)           |
| Hot Tub                            | -0.0182<br>(-0.43)           | -0.0164<br>(-1.63)    | 0.0131<br>(0.43)           |
| cons                               | -0.4047*<br>(-2.47)          | -0.1076***<br>(-3.68) | -0.1896*<br>(-2.19)        |
| N                                  | 1552                         | 24010                 | 7843                       |

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ . t-statistics are in parenthesis.

Figure A2: Average Energy Consumption by Participants and Non-Participants

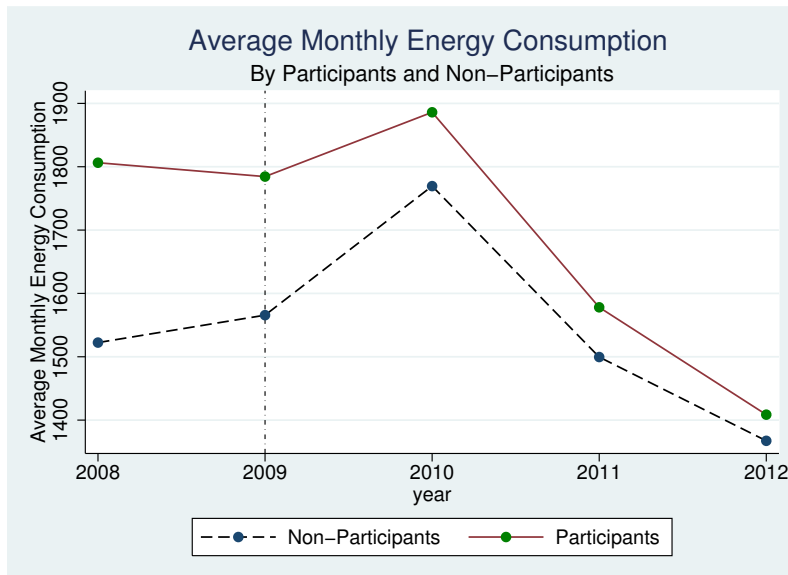


Table A5: Summer, Winter, and Non-Peak Months Effects of the High Efficiency AC program for Households with Electricity but No Natural Gas using the DD CEM with Zip Codes as Neighborhoods

| $\Delta\log(\text{Energy Usage})$ | Summer                | Winter                | Non-Peak Months     |
|-----------------------------------|-----------------------|-----------------------|---------------------|
| Treat                             | -0.1307***<br>(-3.72) | -0.0753**<br>(-2.85)  | -0.0524*<br>(-2.23) |
| Bedrooms                          | -0.0003<br>(-0.02)    | 0.0188<br>(1.05)      | 0.0154<br>(1.03)    |
| Stories                           | 0.0032<br>(0.19)      | -0.0220<br>(-1.06)    | -0.0057<br>(-0.36)  |
| Heated Area (1000 square feet)    | 0.0283<br>(0.91)      | 0.0005<br>(0.03)      | 0.0106<br>(0.78)    |
| Age                               | 0.0011<br>(0.90)      | 0.0018*<br>(1.96)     | 0.0003<br>(0.39)    |
| Pool                              | -0.0466<br>(-1.45)    | -0.0613**<br>(-2.68)  | -0.0493*<br>(-2.33) |
| Mean Income \$1000)               | -0.0002<br>(-0.63)    | -0.0009***<br>(-3.43) | 0.0002<br>(0.81)    |
| Mean Household Size               | 0.0150<br>(0.38)      | 0.0366<br>(1.16)      | 0.0127<br>(0.45)    |
| Hot Tub                           | -0.0282<br>(-0.68)    | 0.0201<br>(0.46)      | -0.0127<br>(-0.30)  |
| cons                              | -0.0454<br>(-0.37)    | 0.1639<br>(1.69)      | -0.1280<br>(-1.48)  |
| N                                 | 3407                  | 3407                  | 3407                |

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ . t-statistics are in parenthesis.

Table A6: Effect of the 2009 High Efficient Rebate Program on 2011 Energy Savings

| $\Delta\log(\text{Energy Usage})$ | <b>DD CEM<br/>zip codes</b> |
|-----------------------------------|-----------------------------|
| Treatment group                   | -0.0300*<br>(-2.30)         |
| Bedrooms                          | 0.0005<br>(0.03)            |
| Stories                           | -0.0143<br>(-0.57)          |
| Heated Area (1000 square feet)    | -0.0037<br>(-0.21)          |
| Age                               | -0.0014*<br>(-2.25)         |
| Pool                              | -0.0036<br>(-0.20)          |
| Electric and Gas                  | -0.0674***<br>(-6.15)       |
| Mean Income (\$1000)              | 0.0004<br>(1.58)            |
| Mean Household Size               | -0.0599<br>(-1.76)          |
| Hot Tub                           | -0.0666<br>(-1.88)          |
| cons                              | 0.0543<br>(0.53)            |
| N                                 | 7843                        |

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .  
t-statistics are in parenthesis.