# Opower Model Calibration Study

Presentation to Energy Optimization Collaborative

June 16, 2015





## Content of Report

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June 16, 2015

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The following individuals from Navigant also provided critical guidance and advice contributing to this report:

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Navigant also acknowledges the timely assistance and openness of the program implementer, Opower:

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Opower has begun using and reporting savings based *only* on the Post Only model, and suggests calibrating MEMD values to be Post Only savings estimates. They claim the model is more precise than Fixed Effects.

- Opower's Reasoning
  - Based on experience with programs across the country, Opower feels Post Only *on average* provides tighter confidence intervals (smaller standard errors) on savings estimates

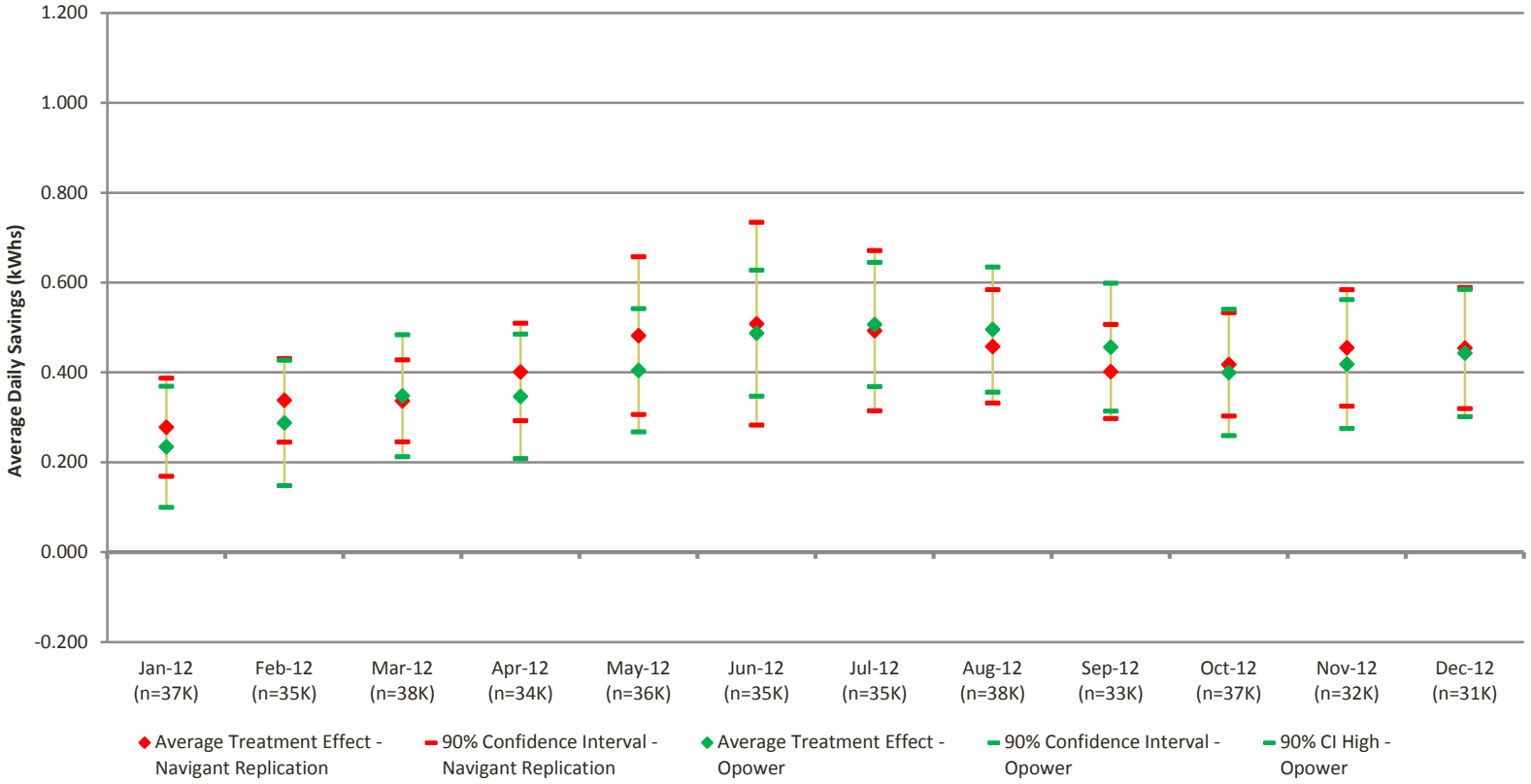
- Navigant and Cadmus' roles
  - Provide unbiased and impartial guidance for DTE and EOC on Opower's proposed model changes and implications and help DTE, Consumers Energy and the EOC to understand the logic and econometrics behind model choice

- What is at stake for Michigan?
  - Michigan utilities claim savings based on MEMD values—Opower's proposed changes could affect savings
  - The EOC must determine if Opower has strong enough evidence for changing the way MEMD savings values are calculated going forward, and to potentially change *existing* MEMD values to align with Post Only values

- Calibration study research steps:
  (1) Recreate Opower's results for pilot groups using Opower's specified Post Only model and their prepared data
  (2) Provide desktop review of Opower's own regression results and method, showing whether or not standard errors are indeed smaller using the Post Only model, how savings values are affected, and whether the model is valid.
  (3) Estimate various years' savings for pilot groups using Navigant's own Post Only and Fixed Effects models for comparison (i.e.—do we also find smaller standard errors when using the Post Only model?)

Navigant's DTE Electric PO model replication results closely replicate Opower's results, with some slight differences.

## Figure 1. Opower DTE Electric 2012, Post Only Model Replication Results, using Opower Prepared Data

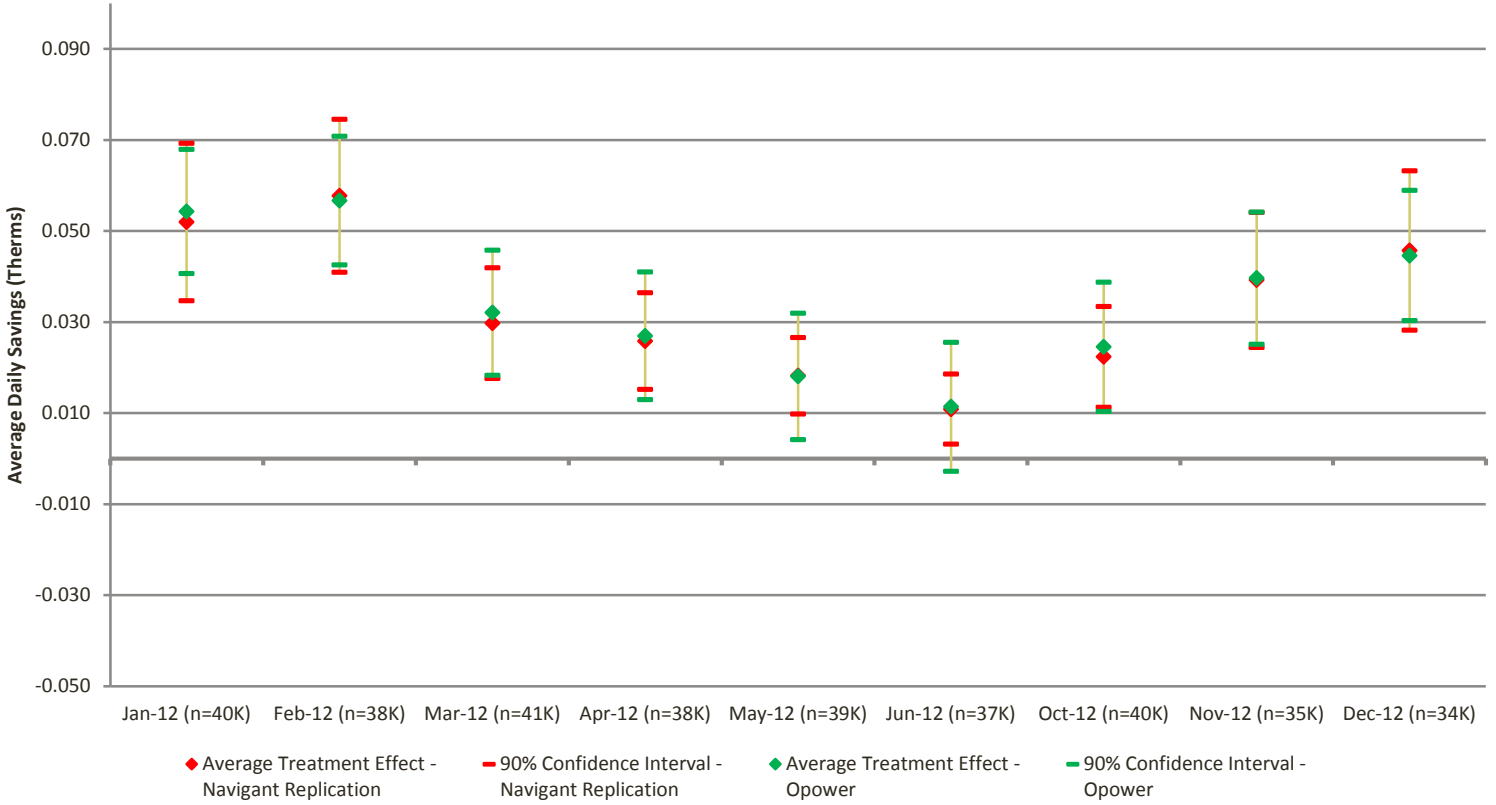



- Remaining differences between our replication and Opower's results may be explained by the fact that the regression results Opower provided may have been generated using a slightly different dataset. Navigant and Cadmus are actively investigating this possibility.

Note: Due to presentation time constraints, only a snapshot of replication results for 2012 are presented here. The full results from electric and gas replications for all years by Navigant are Included in Appendix A.

Navigant's DTE Gas PO model replication results are closely aligned with Opower's results, with small differences.

## Figure 2. Opower DTE Gas 2012, Post Only Model Replication Results, using Opower Prepared Data




- Remaining differences between our replication and Opower's results may be explained by the fact that the regression results Opower provided may have been generated using a slightly different dataset. Navigant and Cadmus are actively investigating this possibility.

Note: Due to presentation time constraints, only a snapshot of replication results for 2012 are presented here. The full results from electric and gas replications for all years by Navigant are Included in Appendix A.

Desktop review of Opower's monthly savings regression results suggest Opower's PO model generally produces larger, but not statistically different, savings estimates compared with FE. PO generally produces smaller standard errors.

Table 1. Desktop Review Key Findings

| |
|---|
| Choice between Post Only and Fixed Effects is a question of precision—both take different approaches to increase precision of results. Theoretically, neither is superior and both produce unbiased estimates. |
| Opower's recent changes to data preparation and reporting practices are likely to have a trivial effect on savings estimates and standard errors. |
| For DTE's electric cohort, the PO model produces consistently higher average annual savings estimates compared with the FE model, though each savings estimate generally falls within the confidence bounds of the other. |
| For Consumers Energy's electric cohort, the PO model produces nearly identical, and sometimes smaller, average annual savings compared with FE, though each savings estimate generally falls within the confidence bounds of the other. |
| PO gas savings tend to be larger for DTE, but are nearly identical to FE estimates for Consumers. Gas PO and FE savings estimates tend to fall within the confidence bounds of one another. |
| Comparing the average of all standard errors reported by Opower in monthly savings regressions across all years, all cohorts, PO standard errors are consistently smaller than FE standard errors--especially for gas models. |

According to the SEEAction report on EM&V of residential behavior programs, when using data from a well-implemented RCT, many slightly different models with "good controls" will generate unbiased estimates of savings. [1]

- A well-designed and implemented RCT reduces the concern over unobserved differences between the treatment and control groups that might bias results, allowing unbiased estimates of savings
  - Fixed Effect and Post Only models are designed to control for remaining unwanted variation due to chance
  - Repeated sampling using ***either*** method (PO or FE) will result in their estimates converging to the same number
  - This is what we mean by "unbiased"

Why the need for different models (Post Only and Fixed Effects)?

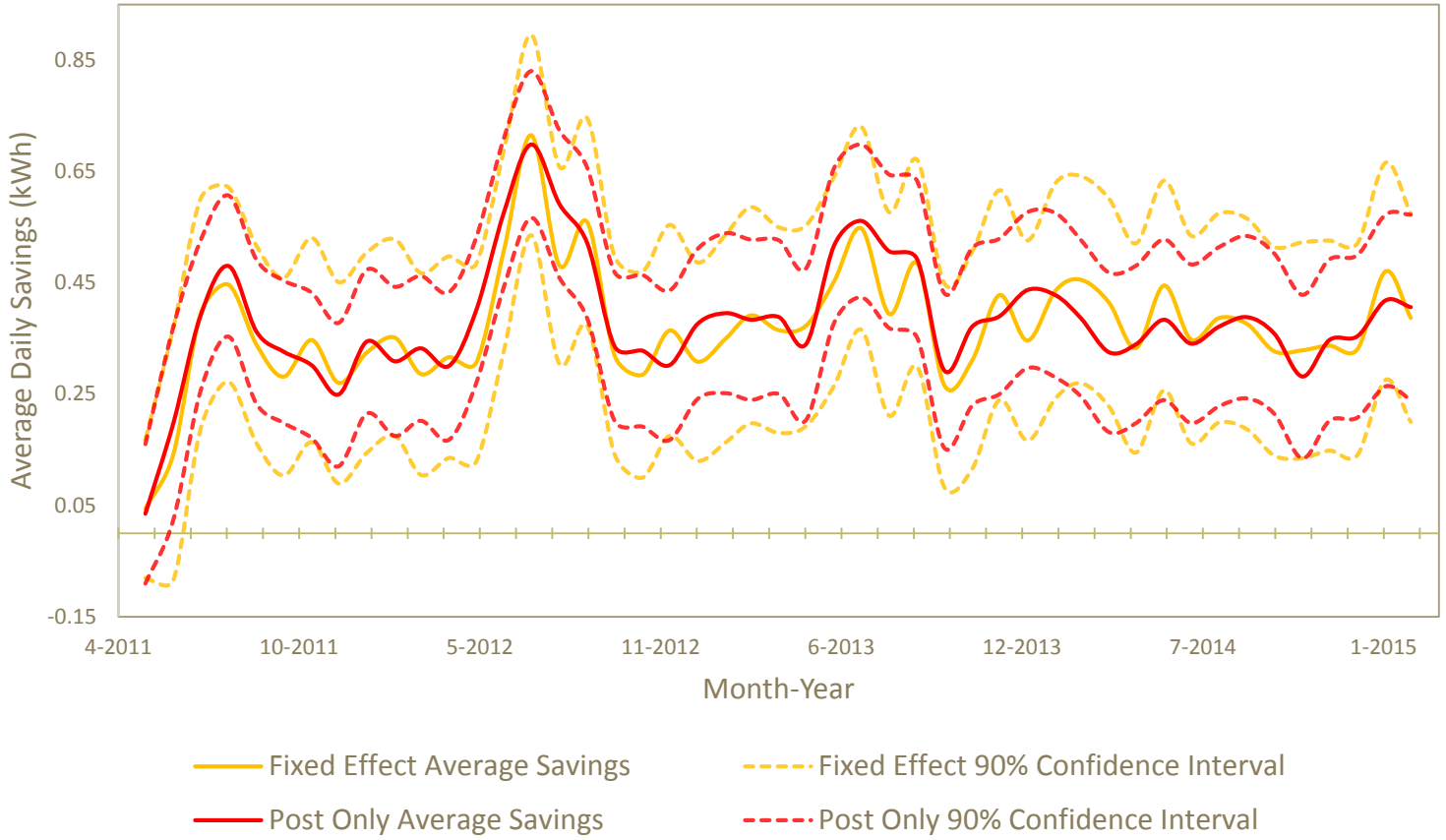
- Differences in model design simply attempt to control for as much unwanted variation as possible in different ways—*in order to increase precision*
  - The Post Only model controls for remaining unwanted variation at the customer level by controlling for within-customer variation over time using the customer's pre-period energy use as a control
  - The Fixed Effects model controls for remaining unwanted variation between customers using a customer-specific intercept (customer-specific constant term)

- Post Only models are not new, and not a special method used just by Opower—Navigant and other independent evaluators have been using versions of the Post Only model for many years.

1.Evaluation, Measurement and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations," Customer Information and Behavior Working Group Evaluation, Measurement and Verification Working Group, SEEAction, State & Local Energy Efficiency action Network, May 2012.

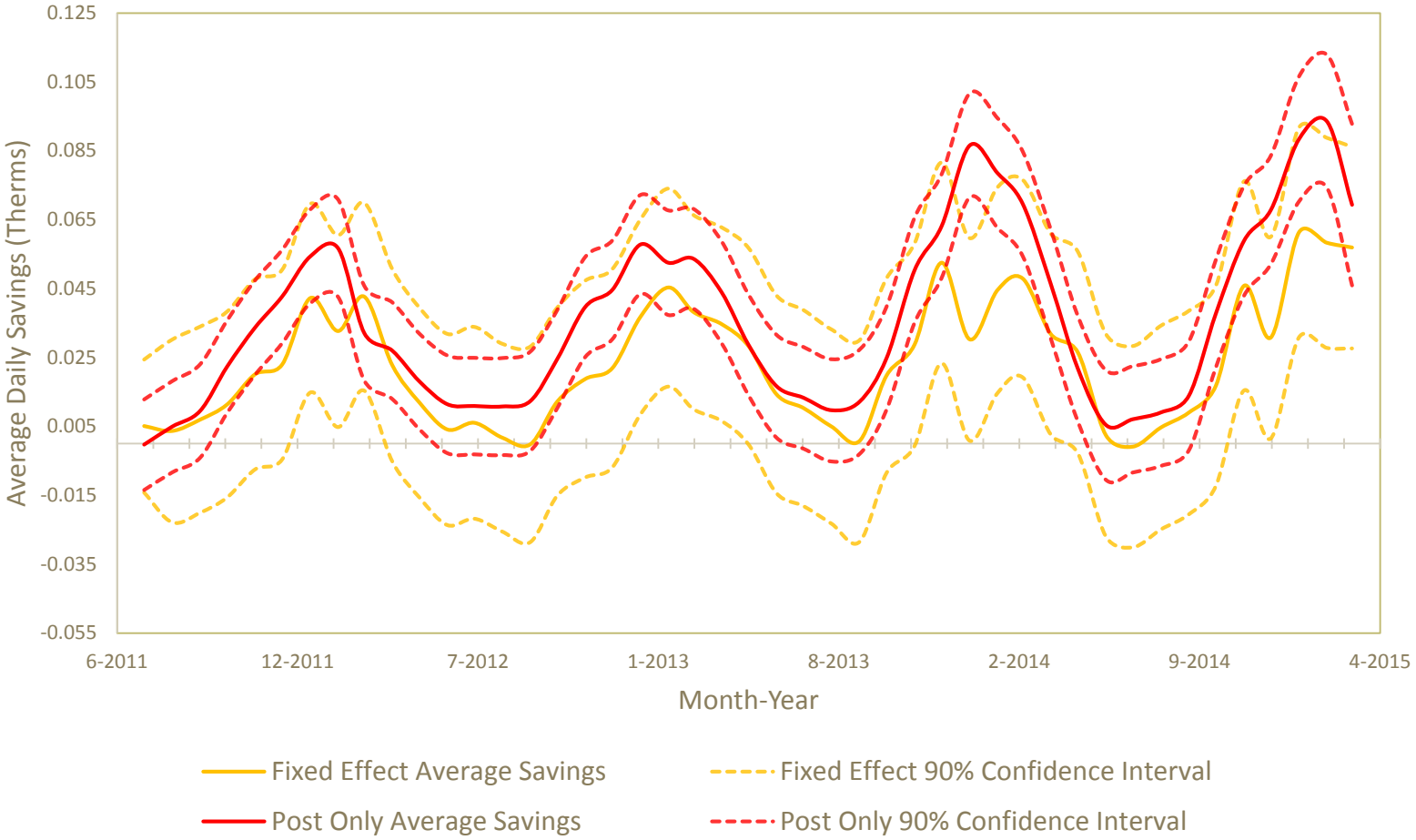
For Consumers Energy electric cohort, Opower's PO and FE kWh/day savings estimates are very similar, but the PO confidence intervals are tighter, reflecting smaller standard errors.

Figure 3. FE and PO Savings and Confidence Interval Comparison, Consumers Electric Cohort



For the DTE gas cohort, Opower's PO model generally produces larger savings estimates relative to FE, though differences are rarely statistically significant. PO confidence intervals are tighter, reflecting smaller standard errors.

Figure 4. FE and PO Savings and Confidence Interval Comparison, DTE Gas Cohort



Opower's Post Only regression results exhibit smaller standard errors associated with the savings coefficient estimate for both DTE's and Consumers Energy's electric cohorts when averaged across all months and years.

Figure 5. DTE Electric Cohort FE and PO Average Standard Error Comparison Across all Years

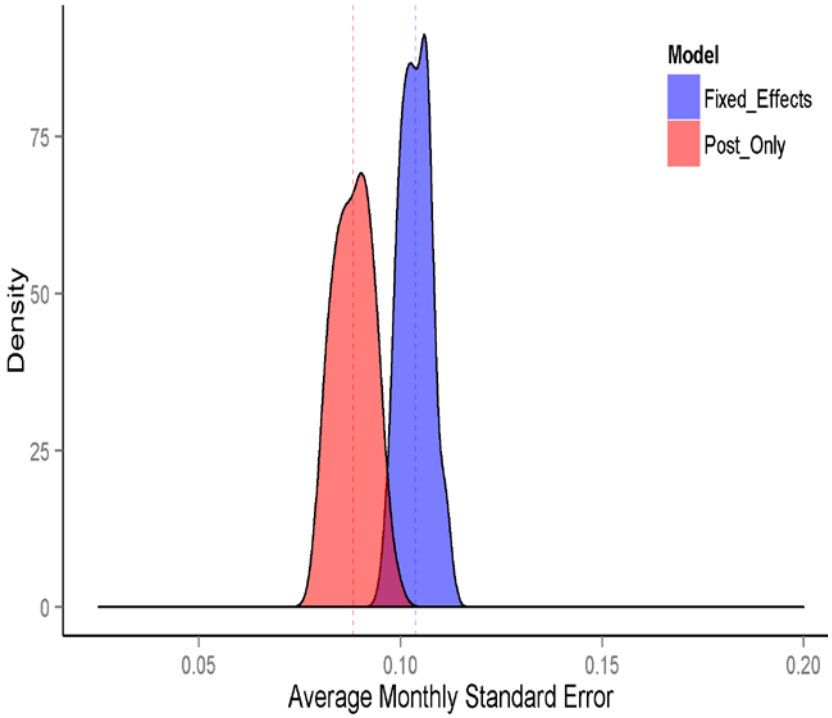
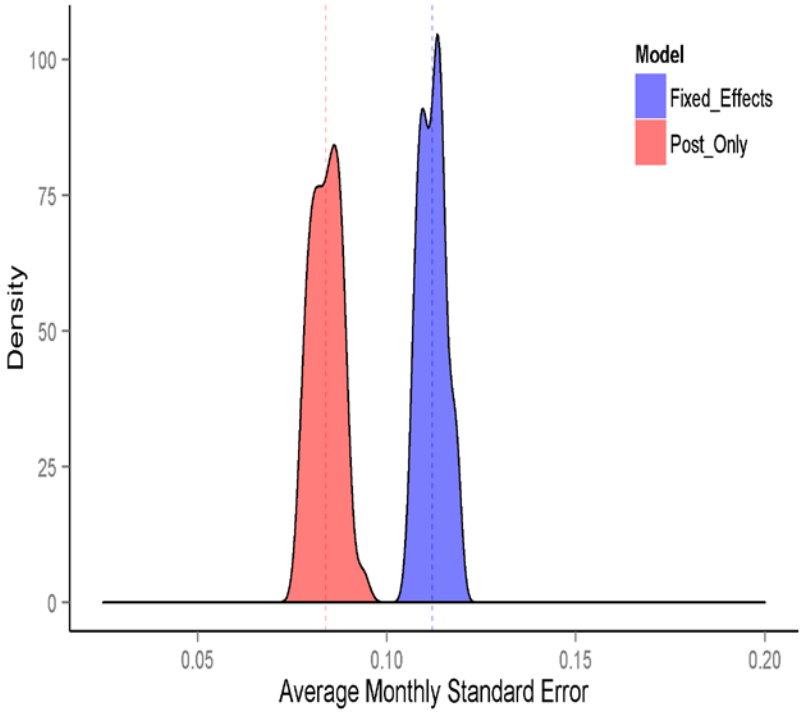



Figure 6. Consumers Electric Cohort FE and PO Average Standard Error Comparison, Across all Years




- Area under density curves must always sum to one—as a result, the Y-axis values are the values that, when compared with the standard error values on the X-axis, cause the area under each curve to sum to 1.

Opower's Post Only regression results exhibit smaller standard errors associated with the savings coefficient estimate for both DTE's and Consumers Energy's gas cohorts when averaged across all months and years.

Figure 7. DTE Gas Cohort FE and PO Average Standard Error Comparison, Across all Years

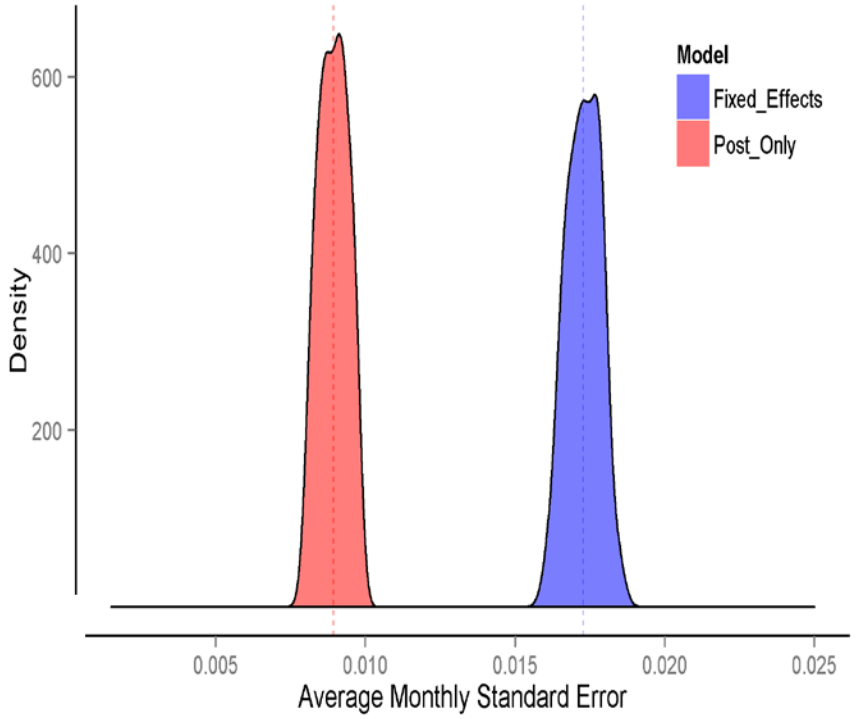
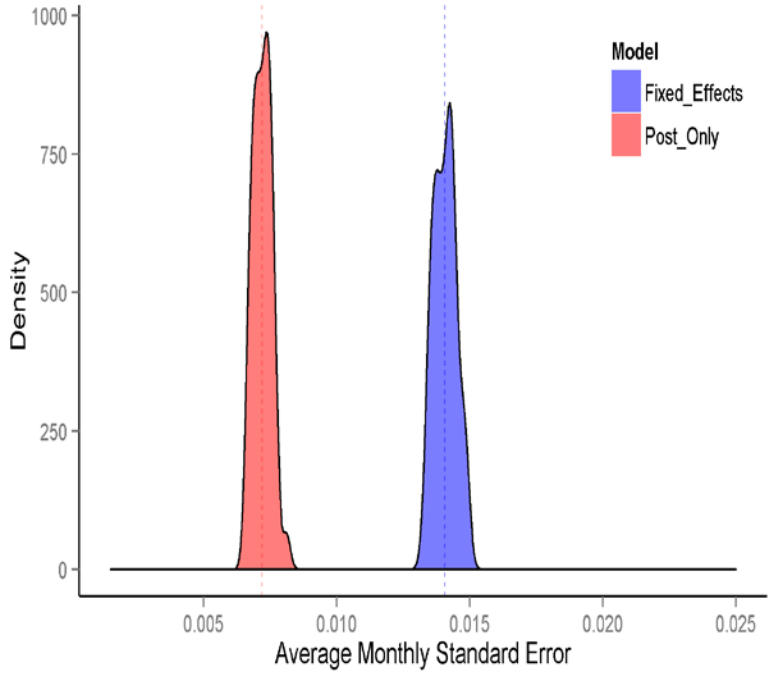



Figure 8. Consumers Gas Cohort FE and PO Average Standard Error Comparison, Across all Years



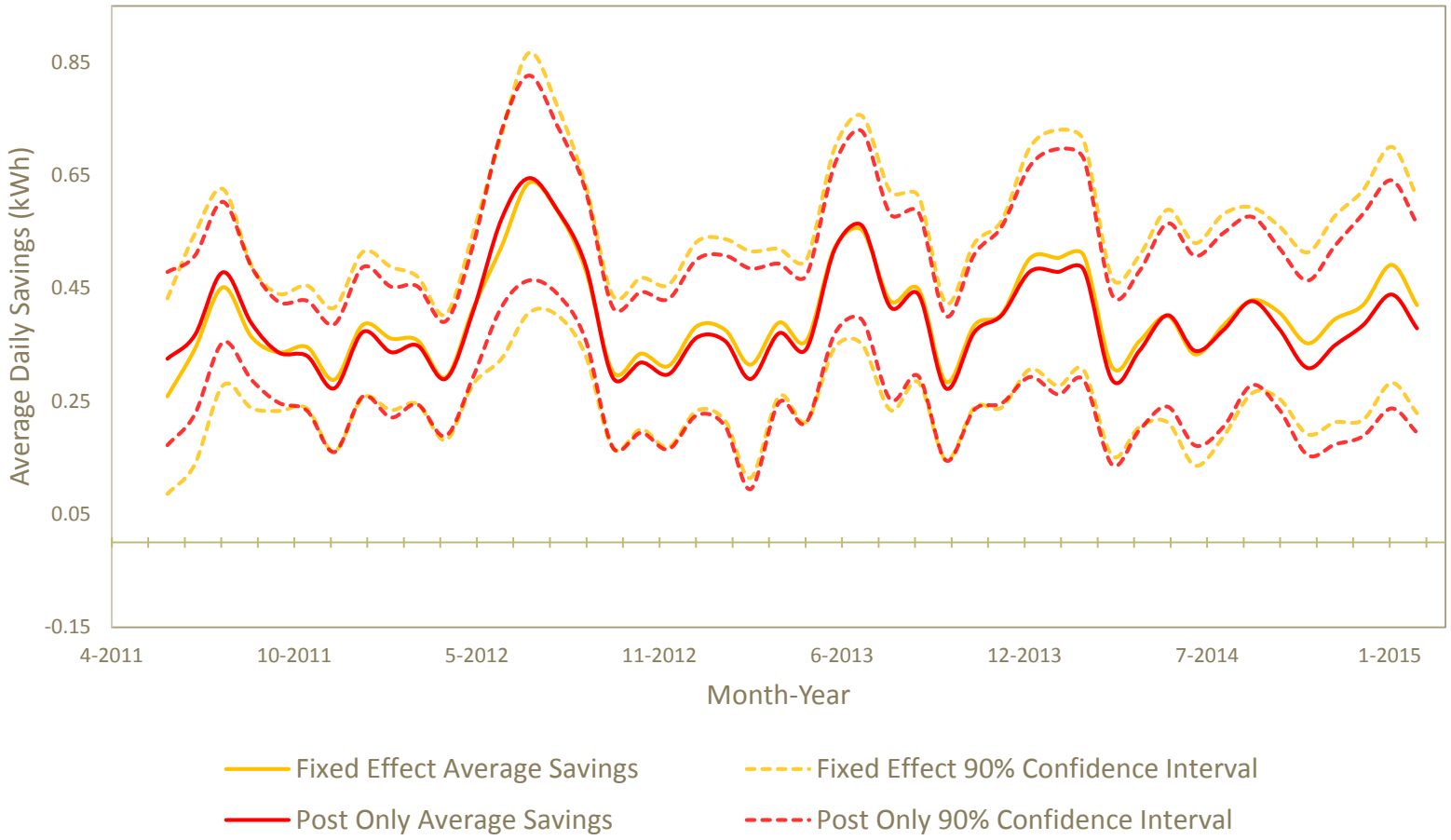
With DTE electric Opower raw data, using Navigant's typical data cleaning process, Navigant's PO and FE models produce similar savings estimates which nearly always fall within each other's confidence intervals. PO standard errors are not consistently smaller than FE.

Figure 9. Navigant In-House Model, DTE Electric, PO versus FE Results, using Opower Raw Data


Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With Consumers Energy electric Opower raw data, using Cadmus' typical data cleaning process, the FE and PO models are nearly identical in terms of point estimates and precision. In most months, PO has slightly improved precision though never by a large degree. In some months, PO has higher savings estimates, and in other months, FE estimates are higher. Overall, differences are very small.

Figure 10. Cadmus' In-House Model, Consumers Energy Electric, PO versus FE Results, using Opower Raw Data




Note: Opower was able to provide all 12 months of pre-year usage data for the Consumers Energy customers. As a result, Cadmus' regression results are based on the full year of data and do not omit July, August and September of each year.

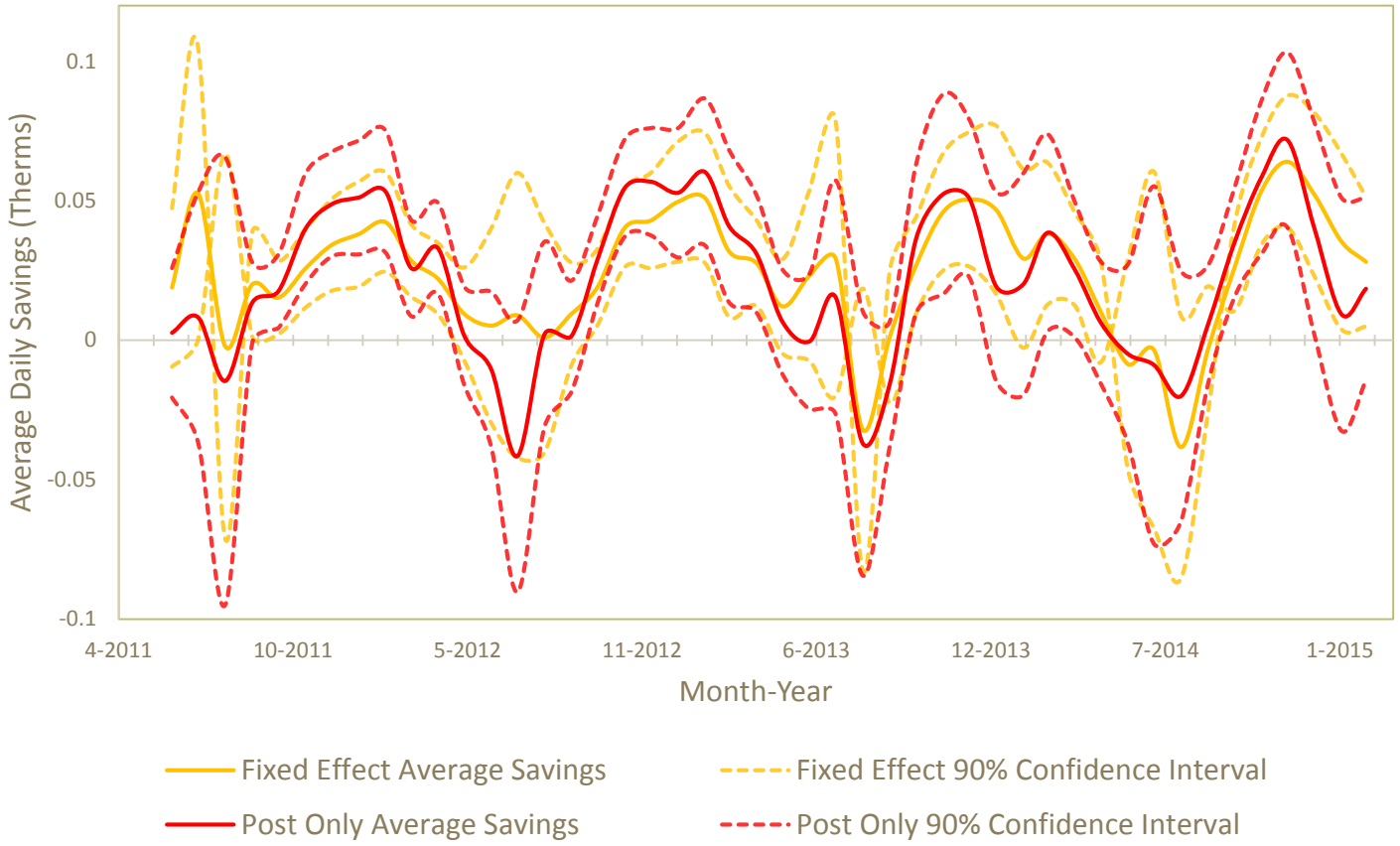
With DTE gas Opower raw data, using Navigant's typical data cleaning process, Navigant's FE models generally produce larger savings estimates than PO, though the savings estimates rarely fall outside of each other's confidence intervals. PO standard errors are smaller than FE.

Figure 11. Navigant In-House Model, DTE Gas, PO versus FE Results, using Opower Raw Data


Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With Consumers Energy gas Opower raw data, using Cadmus' typical data cleaning process, the point estimates between the two models are not as closely aligned as with electric. PO generally produces higher savings estimates in the winter and lower estimates in the summer, compared with FE—though the two estimates usually fall within each other's confidence bounds. The PO model generates marginally wider confidence intervals than the FE model in several months.

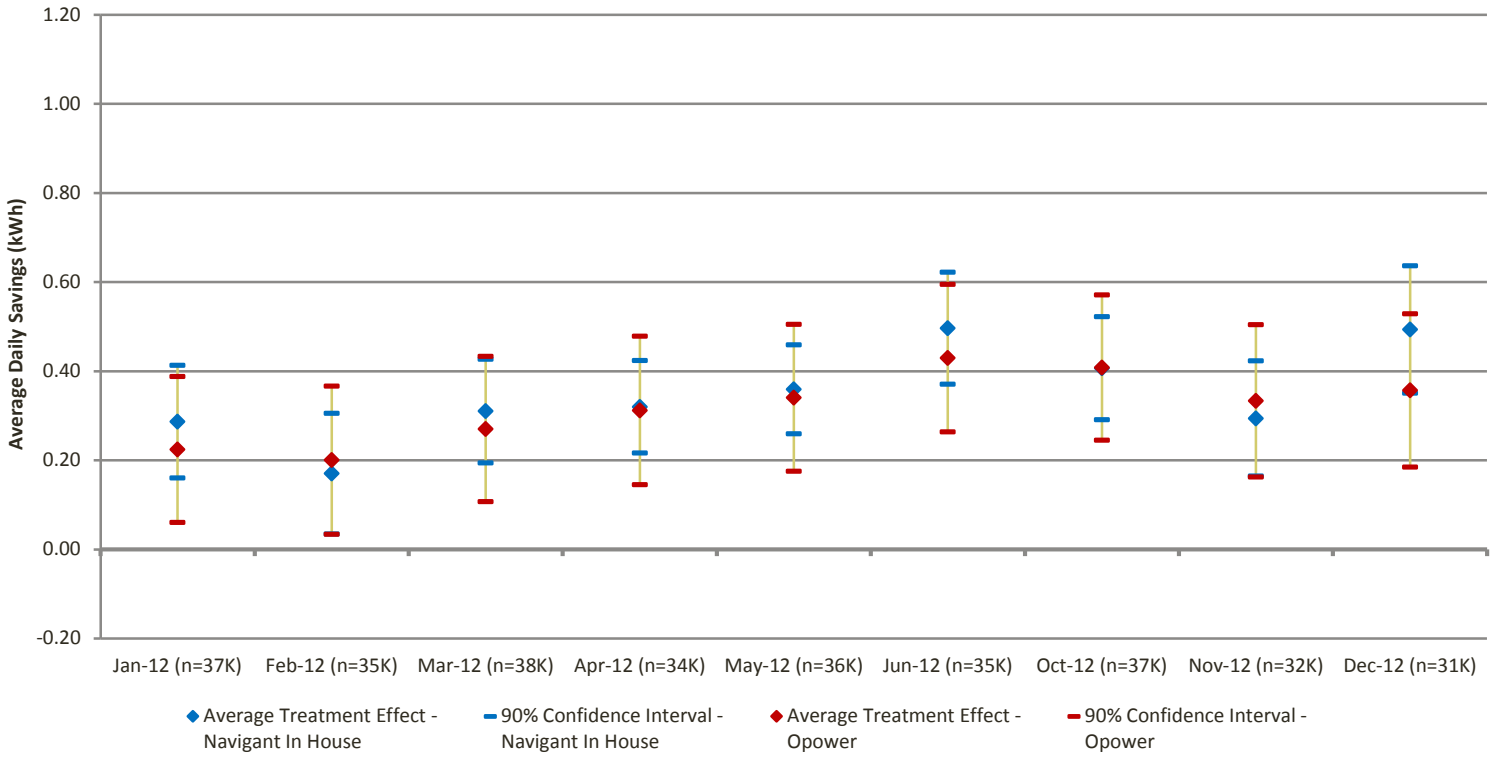
Figure 12. Cadmus' In-House Model, Consumers Energy Gas, PO versus FE Results, using Opower Raw Data




Note: Opower was able to provide all 12 months of pre-year usage data for the Consumers Energy customers. As a result, Cadmus' regression results are based on the full year of data and do not omit July, August and September of each year.

Navigant's in-house PO model generally produces results similar to Opower's PO results. Electric results are very similar. Gas PO results, slightly less similar to Opower's PO results, are reported in the Appendix.

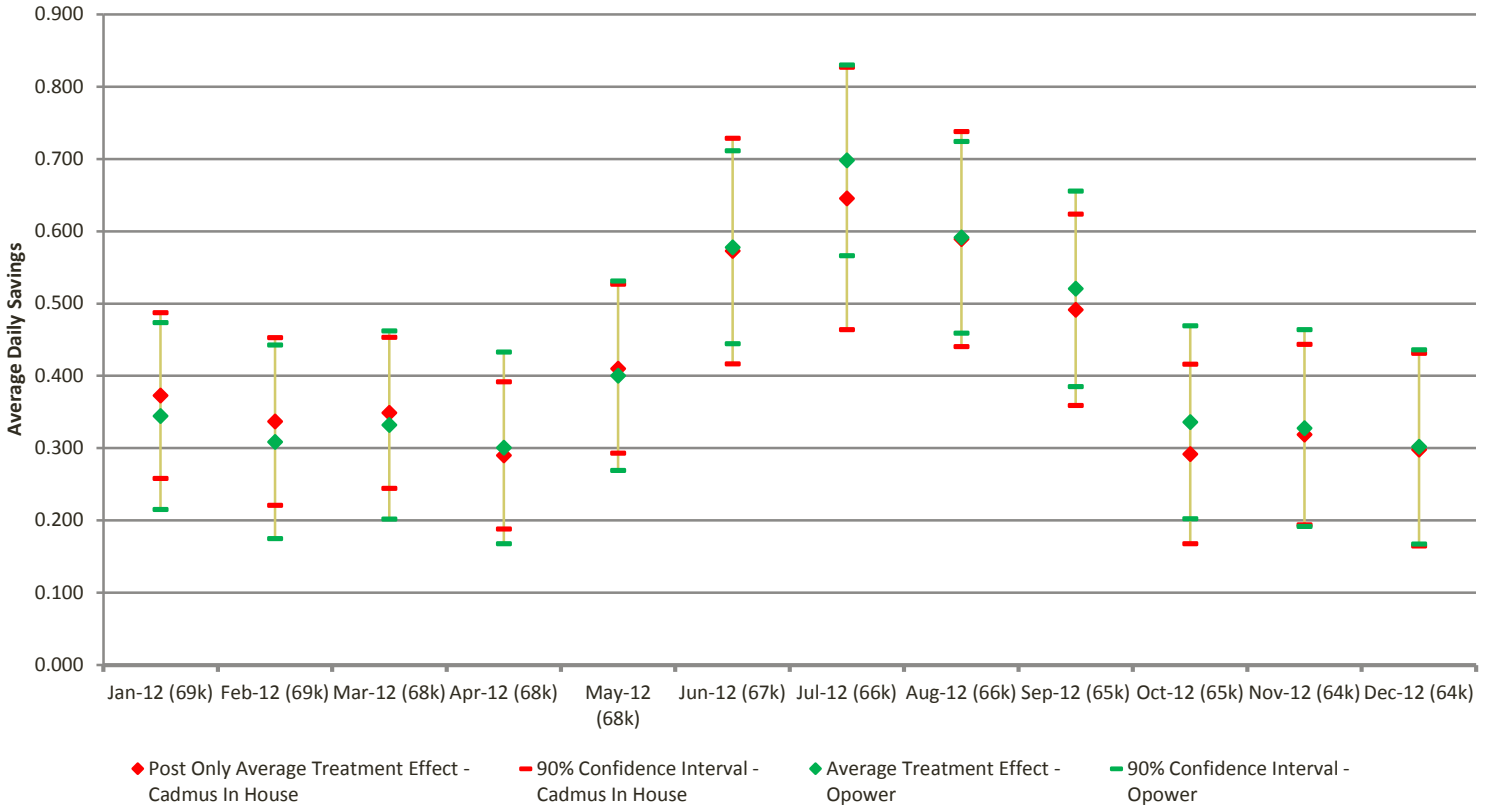
## Figure 13. Navigant In-House Model vs Opower Model Results Comparison, DTE Electric, 2012`




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

Cadmus' in-house PO model generally produces results similar to Opower's PO results. Electric results are very similar. Gas PO results, less similar to Opower's PO results, are reported in the Appendix.

Figure 14. Navigant In-House Model vs Opower Model Results Comparison, DTE Electric, 2012



Navigant's In-House Post Only regression results show little difference between the PO and FE model in terms of standard errors. While the FE model improves precision slightly for electric estimates, the opposite is true for gas.

Figure 15. DTE Electric Cohort FE and PO Average Standard Error Comparison, Across all Periods

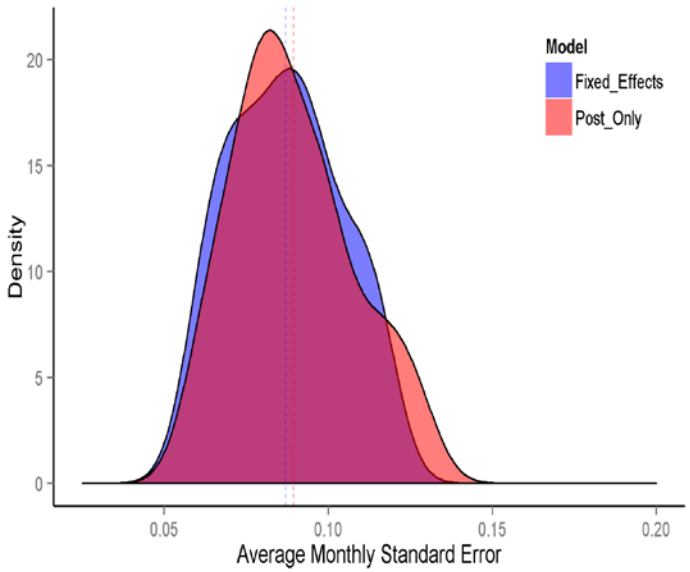
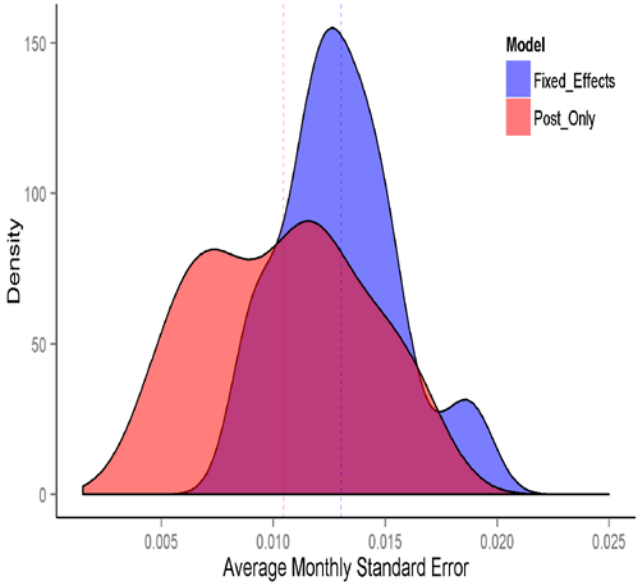



Figure 16. DTE Gas Cohort FE and PO Average Standard Error Comparison, Across all Periods




- The X-axis values for these figures are identical to those shown for Opower's standard errors
- Choice of model specification (additional control variables) influences standard errors
- Navigant's models are more general, which makes them more comparable in terms of standard errors, but also means the range of our standard errors is wider compared with Opower's
- Area under density curves must always sum to one—as a result, the Y-axis values for left figure (electric) are smaller than those on the right (gas) simply because standard errors in the electric model are smaller.

The EO Collaborative has many viable options in deciding how to handle Opower's request to adjust MEMD values to based on the Post Only model.

1. Change nothing, and continue using FE values in the MEMD

2. Change all savings years to PO values, both in the future, and for savings years already established in the MEMD

3. Leave already established MEMD values in place based on FE estimates, but use PO values moving forward

4. Leave already established MEMD values in place based on FE estimates, *but going forward consider both the FE and PO estimate and use the more conservative of the two as the MEMD value*

Navigant and Cadmus recommend Opower continue to report both PO and FE estimates of savings, and that MEMD values in each case reflect the more conservative (smaller) of the two values.

- There is no theoretical basis for preferring PO to FE in terms of modeling—both produce unbiased results, thus PO and FE serve as robustness checks for one another
- *On average,* Navigant does find across its evaluations that PO models tend to produce more precise estimates
- Opower's results show PO improves standard errors, while Navigant's and Cadmus' PO models do not improve standard errors
- Opower's PO model tends to produce larger savings than its FE model, but generally these savings estimates fall within each other's confidence bounds.
- Navigant's and Cadmus' PO models do not consistently produce larger savings than their FE models, and do not consistently produce smaller standard errors relative to FE
- Navigant's PO models produce slightly larger standard errors for electric models compared with FE, and the opposite for gas models—though the differences are modest
- On the basis of our findings, Navigant and Cadmus find no strong evidence that Michigan should move to all Post-Only values. We suggest Opower continue to report both PO and FE results, and that the MEMD values be based on the more conservative (smaller) savings estimate between the two

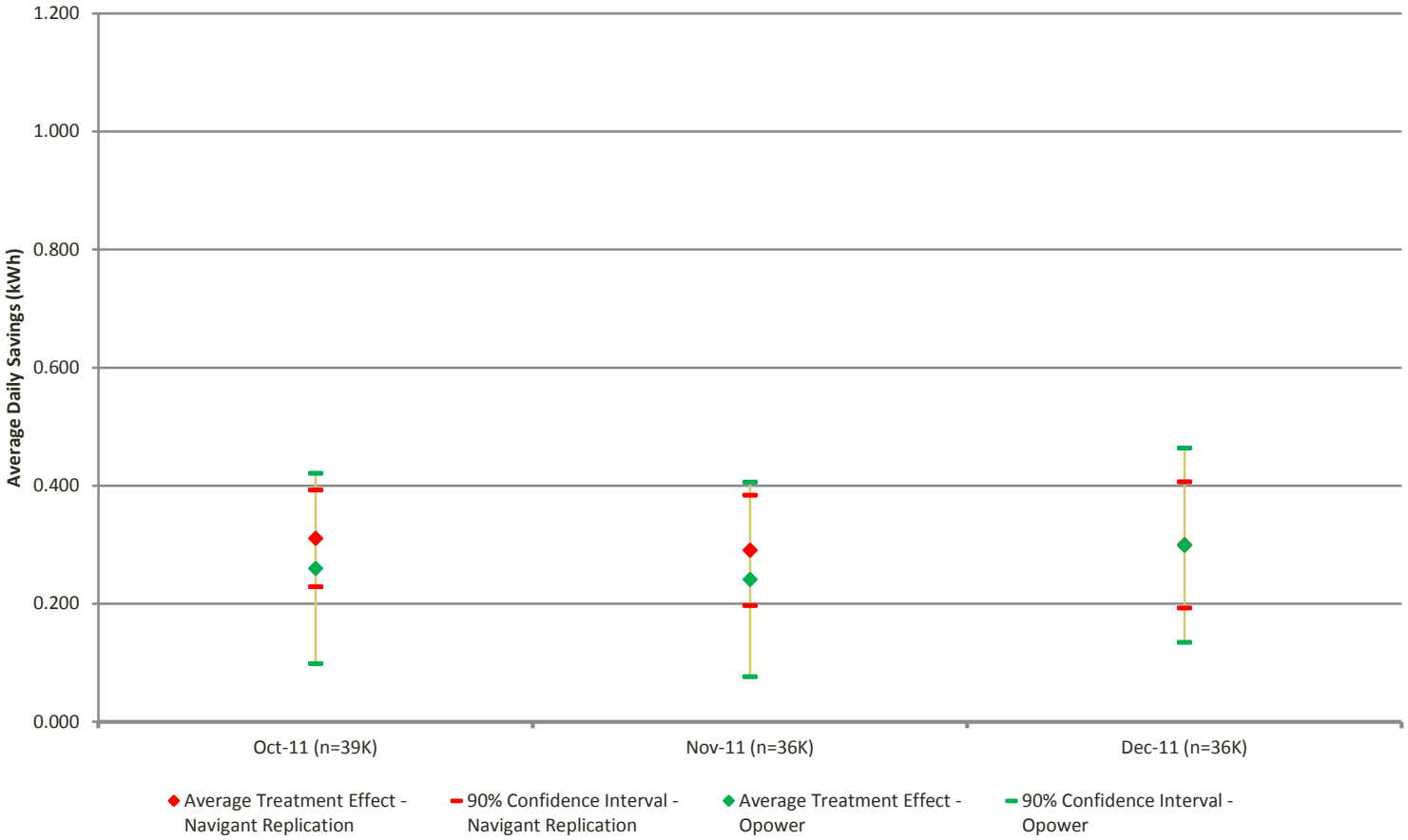
Based on Opower's most recent report, the following table compares PO with FE values proposed for Year 4 savings. Following the recommendation of the evaluation teams, the more conservative estimates (FE) would be adopted by the MEMD.

Table 2. Opower Year 4 Proposed MEMD Values, PO and FE Comparison

| COHORT | POST ONLY | FIXED EFFECTS |
|---|---|---|
| Electric-Average | 1.68% | 1.55% |
| Electric-High | 2.11% | 1.95% |
| Gas | 1.03% | 0.77% |

DTE Electric PO model replication results closely replicate Opower's results, with some slight differences.

## Figure A-1. Opower DTE Electric 2011, Post Only Model Replication Results, using Opower Prepared Data



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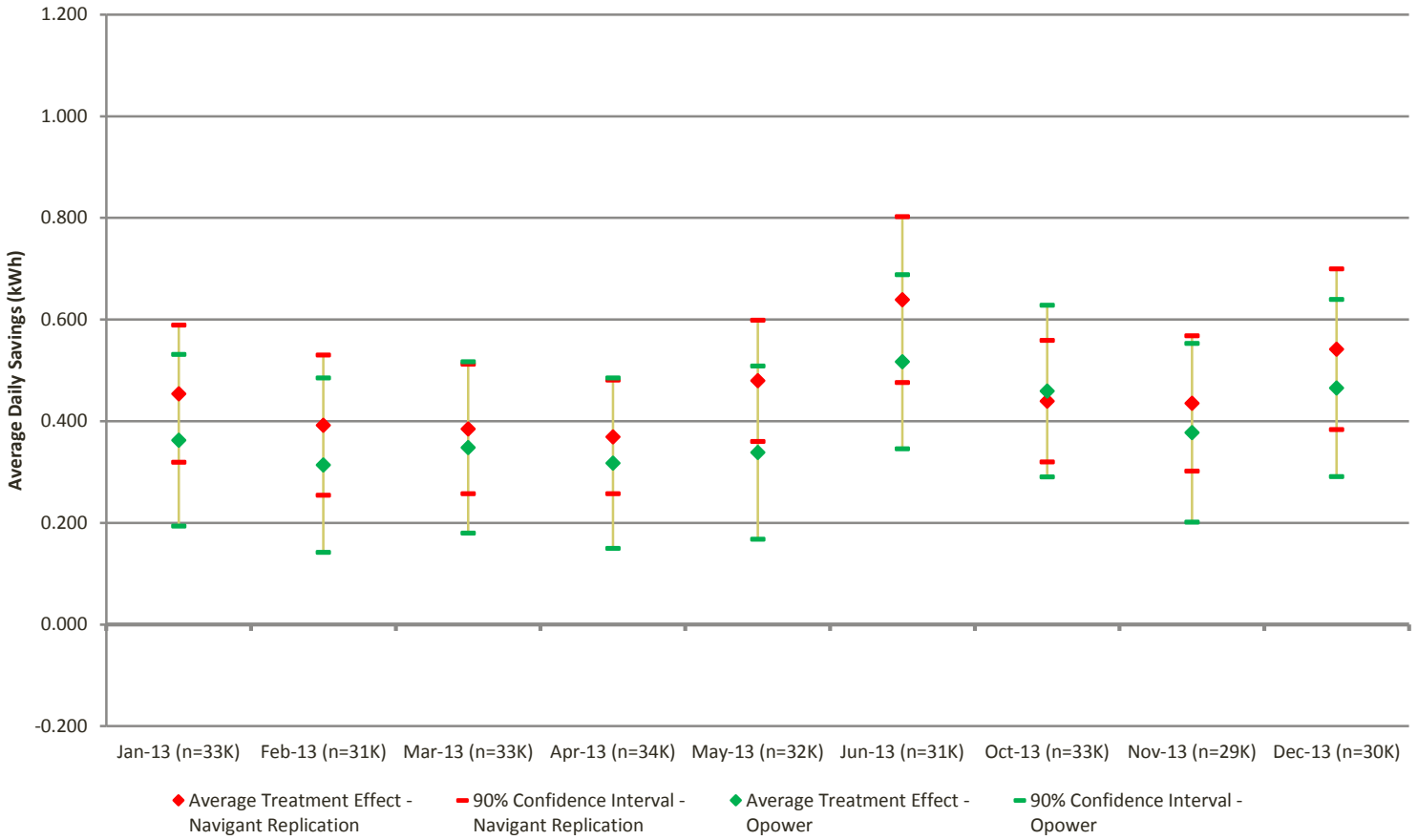
## Figure A-2. Opower DTE Electric 2013, Post Only Model Replication Results, using Opower Prepared Data



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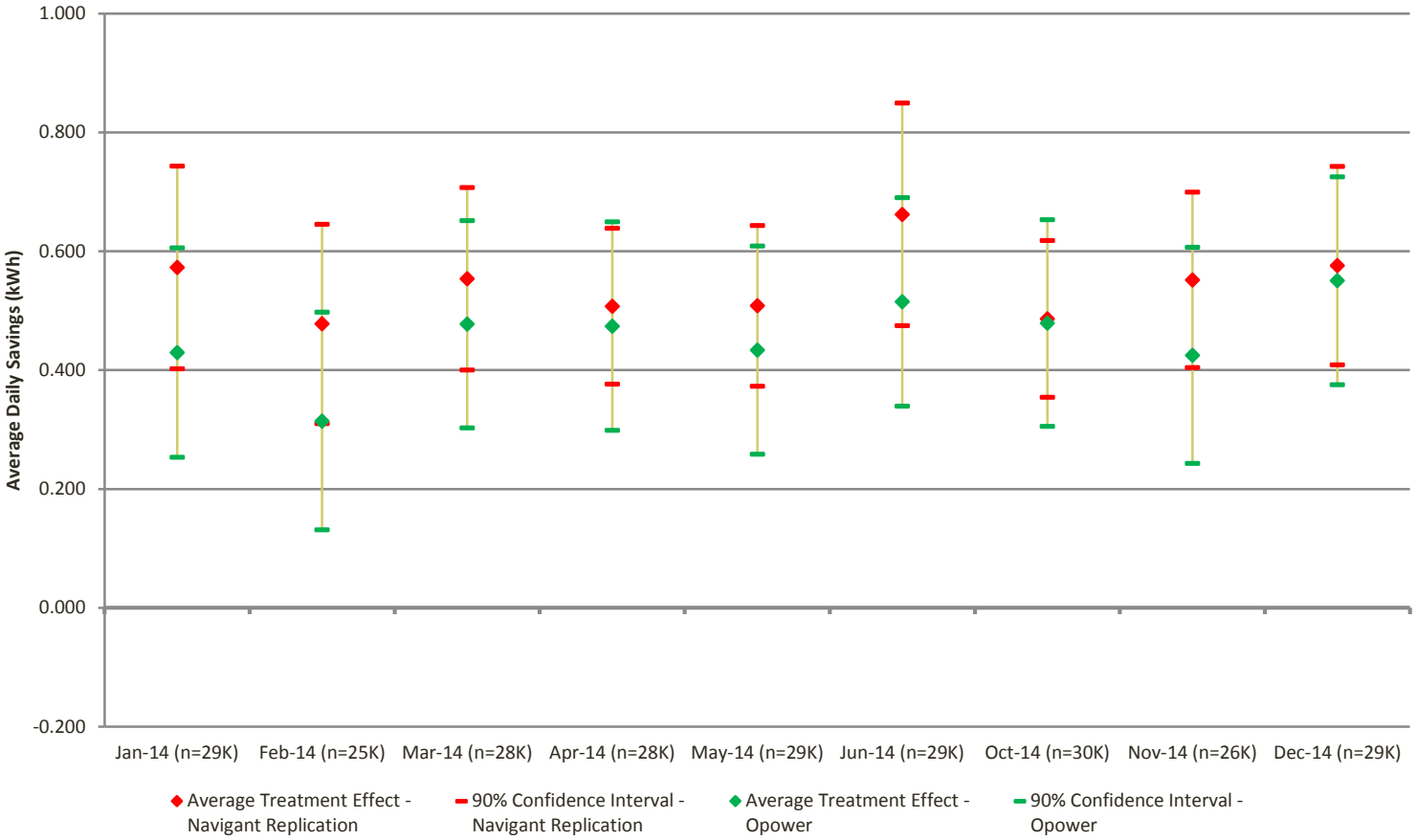
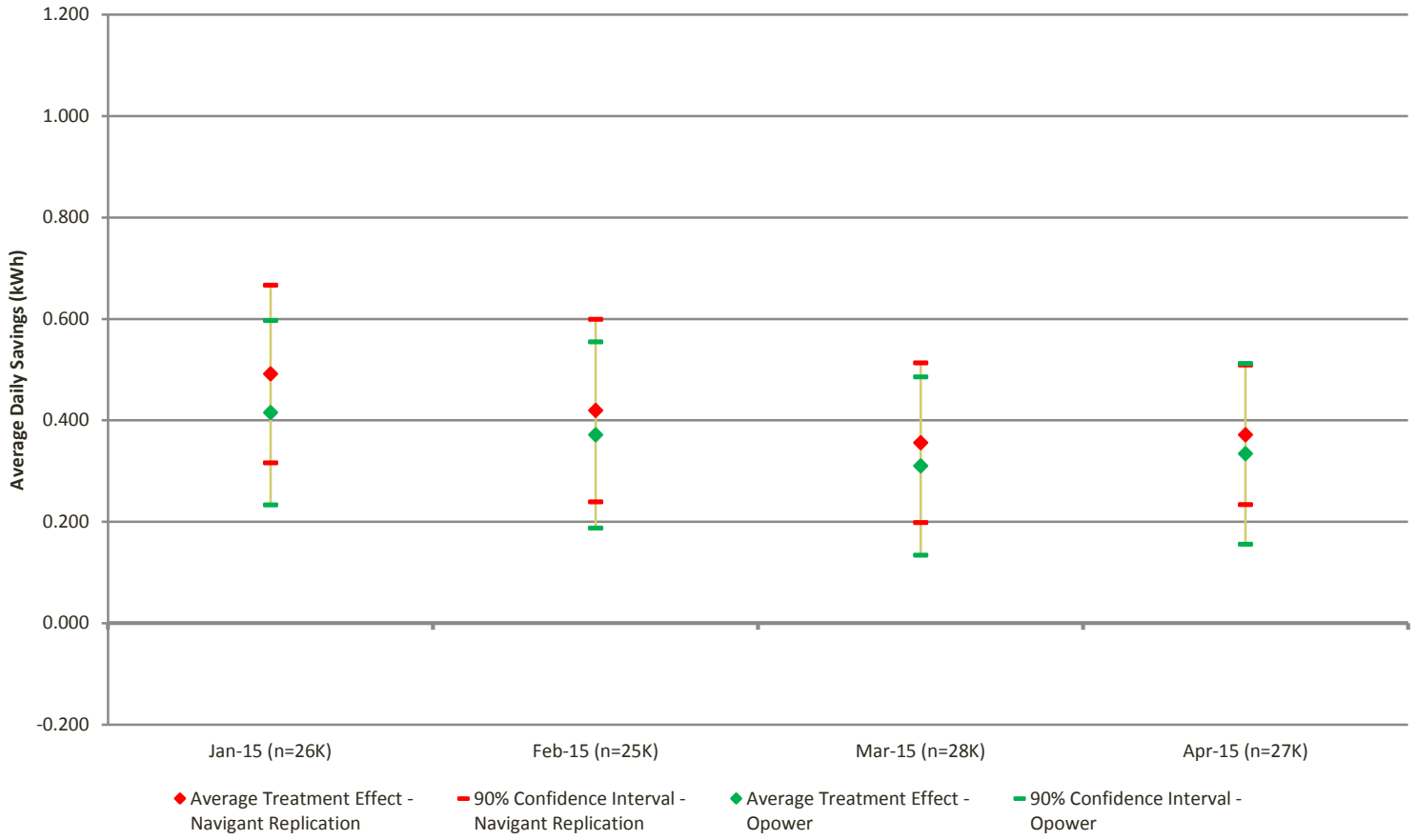
## Figure A-3. Opower DTE Electric 2014, Post Only Model Replication Results, using Opower Prepared Data



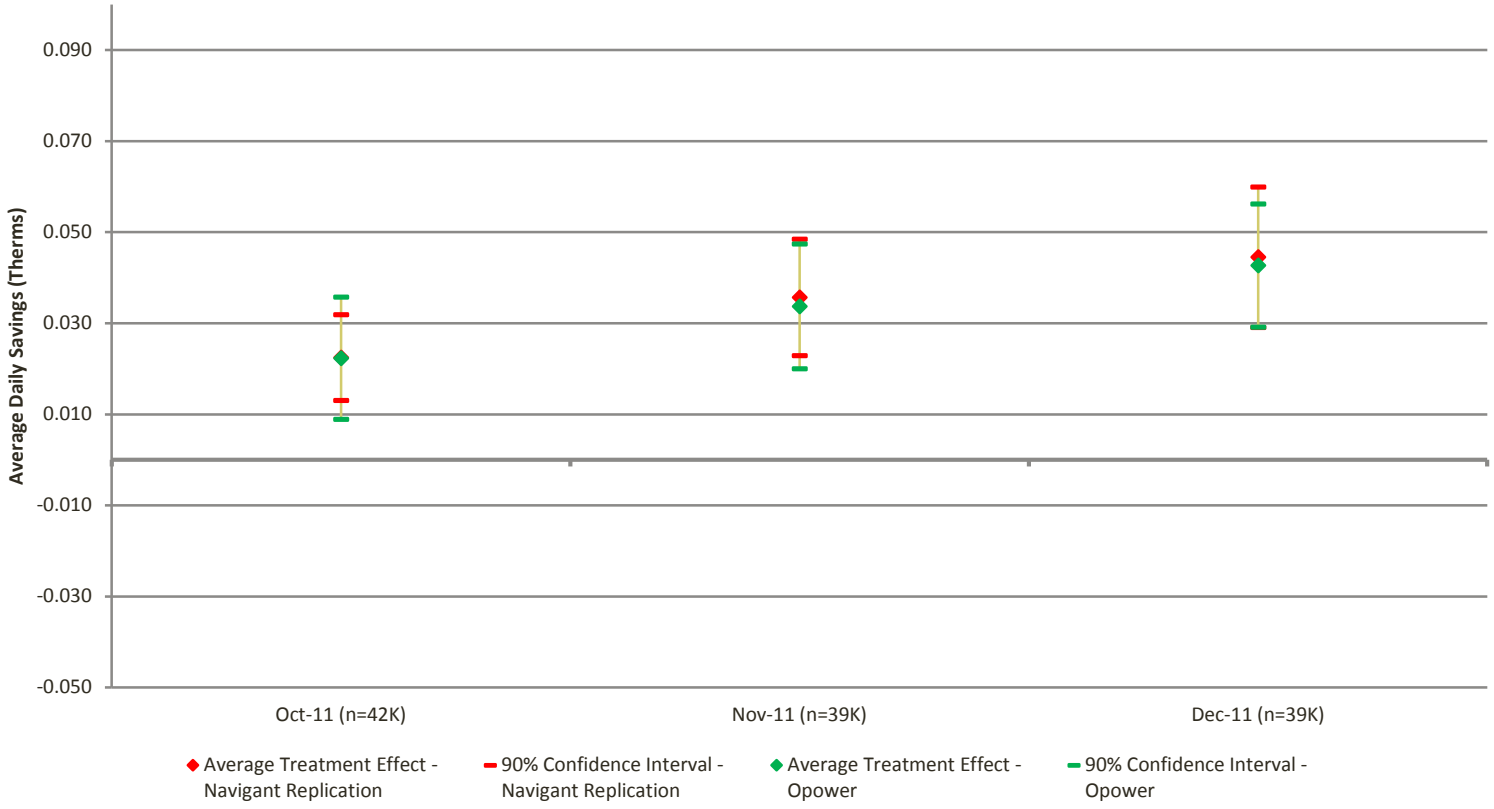
DTE Electric PO model replication results closely replicate Opower's results, with some slight differences.

## Figure A-4. Opower DTE Electric 2015, Post Only Model Replication Results, using Opower Prepared Data



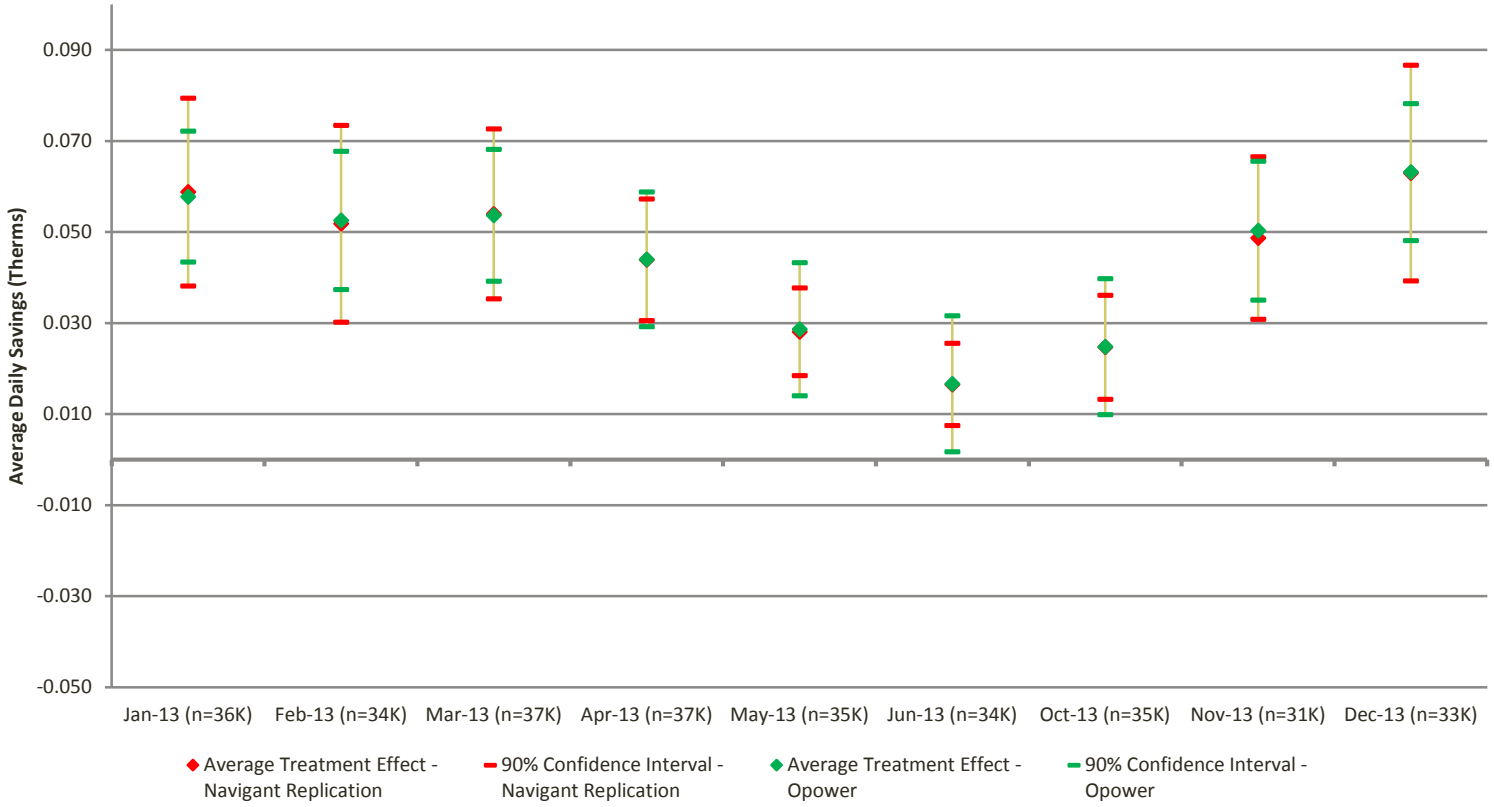
DTE Gas PO model replication results closely replicate Opower's results, with some slight differences.

## Figure A-5. Opower DTE Gas 2011, Post Only Model Replication Results, using Opower Prepared Data



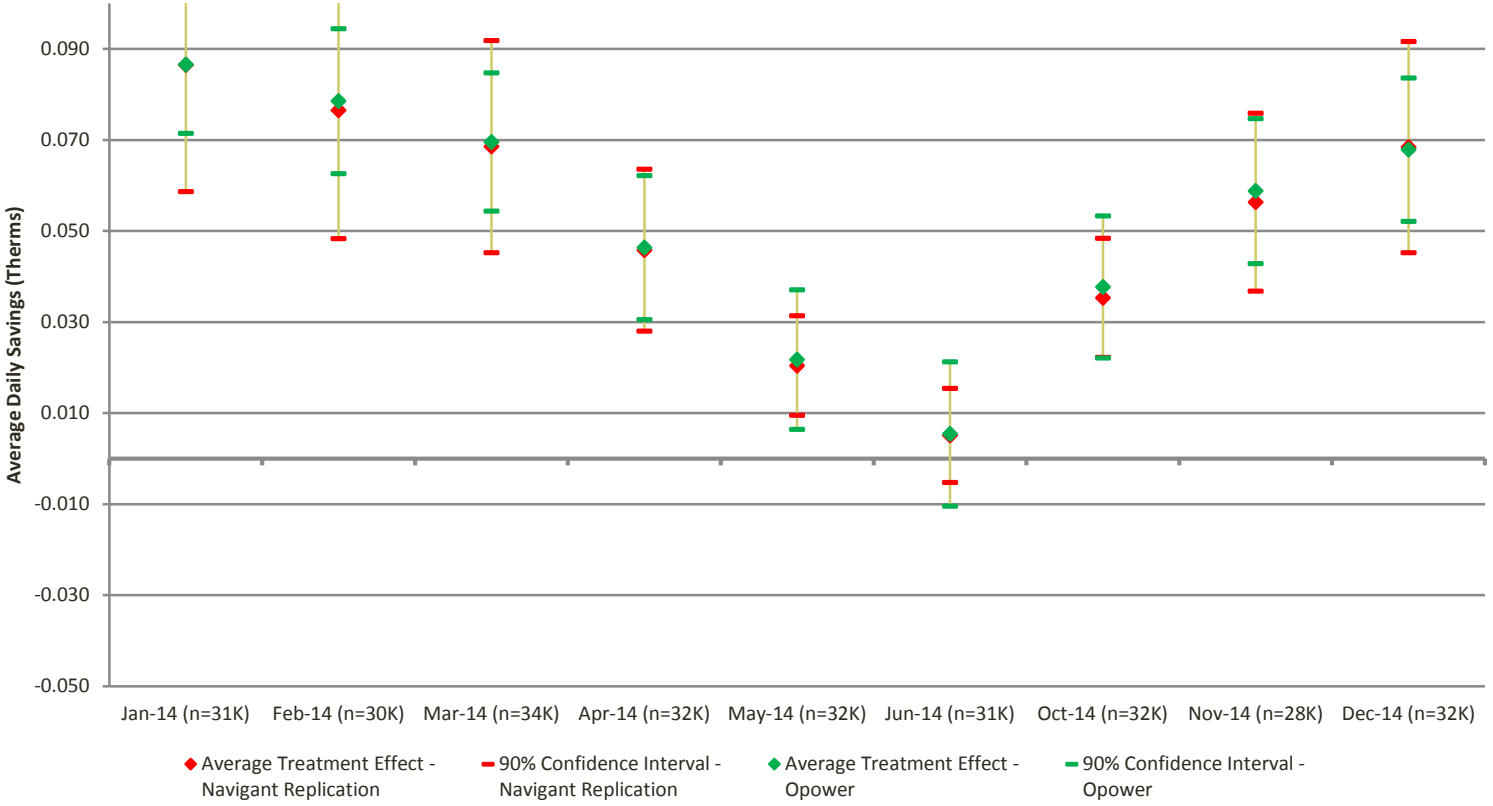
DTE Gas PO model replication results closely replicate Opower's results, with some slight differences.

## Figure A-6. Opower DTE Gas 2013, Post Only Model Replication Results, using Opower Prepared Data



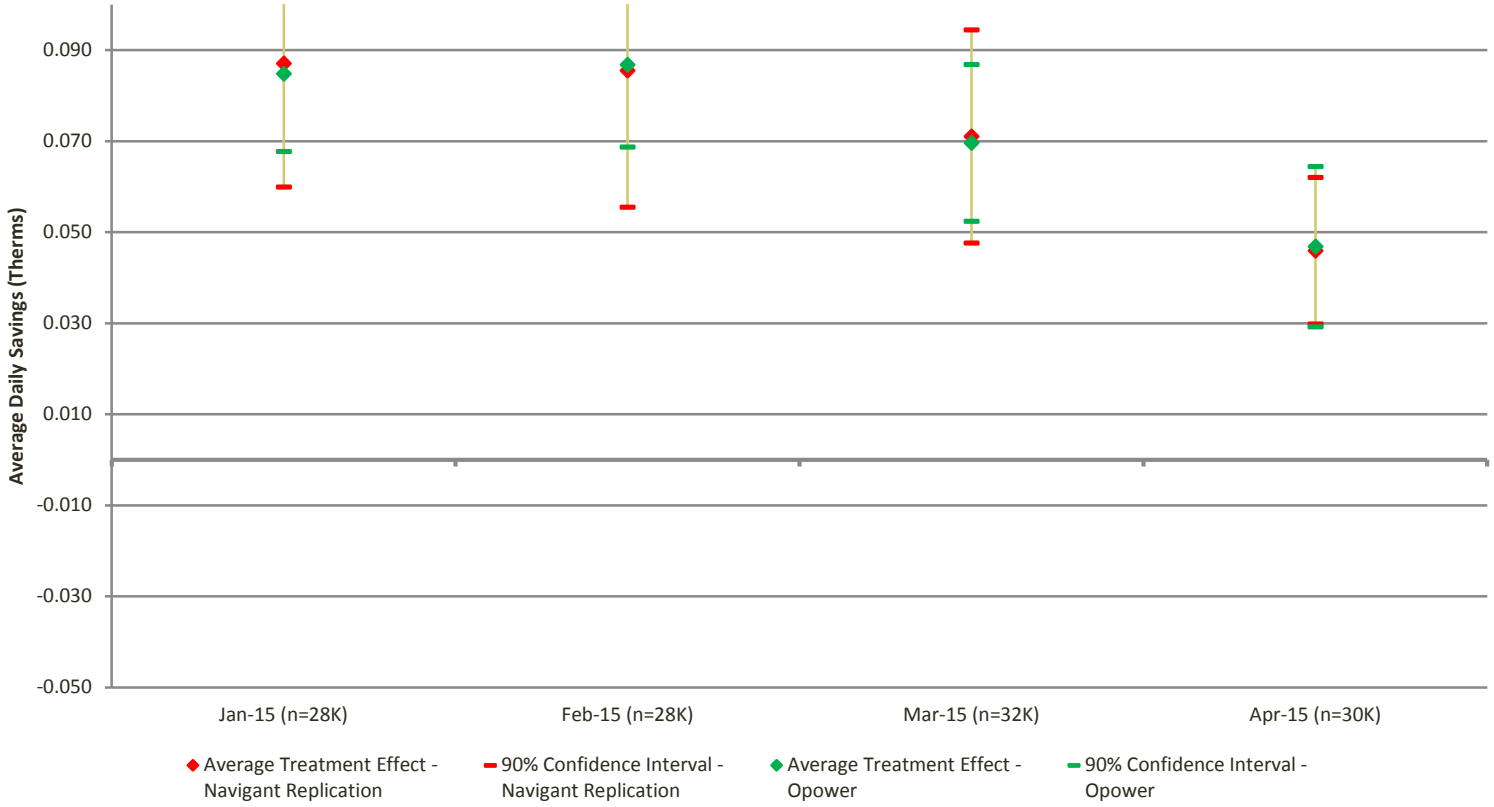
DTE Gas PO model replication results closely replicate Opower's results, with some slight differences.

## Figure A-7. Opower DTE Gas 2014, Post Only Model Replication Results, using Opower Prepared Data



DTE Electric PO model replication results closely replicate Opower's results, with some slight differences.

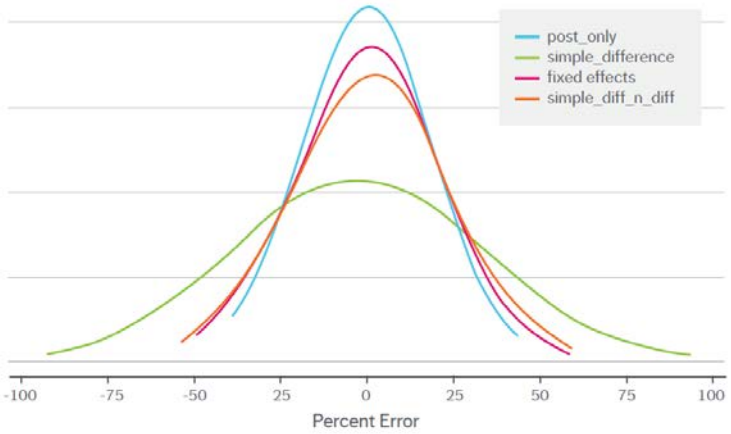
## Figure A-8. Opower DTE Gas 2015, Post Only Model Replication Results, using Opower Prepared Data



Opower's proposed shift away from FE to PO estimation of HER savings includes additional changes in data preparation. Opower's justification for the changes is that PO produces more reliable and precise savings estimates.

- Main changes proposed or made by Opower
  - Post Only (PO) alone rather than Fixed Effects (FE) and Post Only estimation of savings
  - Calendarization and truing up reads as changes to data preparation
  - Change in dates reported—now only reports wave start date, not actual receipt by household of first report
- Reasoning
  - Based on experience with programs across the country, Opower feels Post Only *on average* provides tighter confidence intervals (smaller standard errors) on savings estimates
  - Feels other data preparation changes also refine method and improve precision of results

Figure B-1. Precision of FE, PO and other Models—Comparison by Opower




*Source: "Updates to Opower's Energy Savings Estimation Model," white paper prepared by Opower, 2014.*

Post Only and Fixed Effects models are both commonly used to estimate HER program savings. They account for unobserved differences between the treatment and control group differently, but typically produce similar results.

- Below we present each model in its simplest form for comparison and discussion
- Fixed Effects:

$$ADU_{kt} = \alpha_{0k} + \alpha_1 Post_t + \alpha_2 Treatment_k \cdot Post_t + \varepsilon_{kt}$$

- Post Only:

$$ADU_{kt} = \beta_0 + \beta_1 ADUlag_{kt} + \beta_2 Treatment_k + \varepsilon_{kt},$$

- Both produce unbiased estimates of savings if used in the correct situation

In addition to moving to only a Post Only model, Opower has simultaneously undertaken several notable changes to the manner in which it prepares and reports data, which may also affect savings estimation results and precision.

Changes Opower has made to data preparation and reporting:

Calendarization

- Usage reads are prorated into calendar months in cases where billing cycle does not align with calendar month
- Navigant understands the virtue of calendarization for estimating monthly program savings. On the other hand, Navigant's econometric perspective [3] is that calendarization is not necessary for estimates of annual program savings, as it replaces "real" data with estimated data. Nonetheless, calendarization does not bias estimates of program annual energy savings, and would have a trivial effect on annual savings estimates and standard errors in any given sample.

Read True-up

- Estimated usage reads for given days are "trued up" using actual reads for non-estimated days
- Navigant's perspective is that truing-up in conjunction with calendarization is not necessary in an analysis of annual program savings, as it replaces one set of estimates of energy use with another. With both the original billing data and the calendarized/trued-up data, estimates of program annual savings that use estimated reads are unbiased under the weak condition that estimated bills are not correlated with energy use (i.e., basically random events). On the other hand, in both cases standard errors will be incorrect (probably biased downwards). Simply excluding billing data affected by estimated reads is a judgement call that weighs bias against efficiency with respect to the estimates of standard errors. In practice this is typically a trivial concern.

First Report Date

- Opower no longer reports the actual date a customer first received their HER report in its data extracts—instead it reports the official wave launch date as the program start date for all participants, regardless of whether they actually received their first report weeks or months later
- Navigant's perspective is that this will not bias the estimate of annual program savings.

3. Dr. Bill Provencher, Navigant senior advisor and economics professor at University of Wisconsin, Madison, published a memorandum in response to Opower's proposed model and data preparation changes in 2014, for the consideration of Navigant client, ComEd, which summarizes Navigant's position on various Opower model and data changes.

Both the FE and PO models can be altered or refined to better control for weather and other factors. Opower's preferred PO model includes controls for weather and seasonality in addition to basic model components.

- Both FE and PO models are continually refined and altered by users to better control for time varying unobserved factors to increase precision.
- The following is Opower's current Post Only model :

$$
\begin{aligned}
&ADU_{kt} \\
&= \alpha_0 + \alpha_1 Treatment_k + \delta \sum_t YMo_t + \beta_1 LagADUall_k + \beta_2 LagADUwinter_k \\
&+ \beta_3 LagADUsummer_k + \delta_1 \sum_t YMo_t LagADUall_k + \delta_2 \sum_t LagADUwinter_k \, YMo_t \\
&+ \delta_3 \sum_t YMo_t LagADUall_k + \varepsilon_{kt}
\end{aligned}
$$

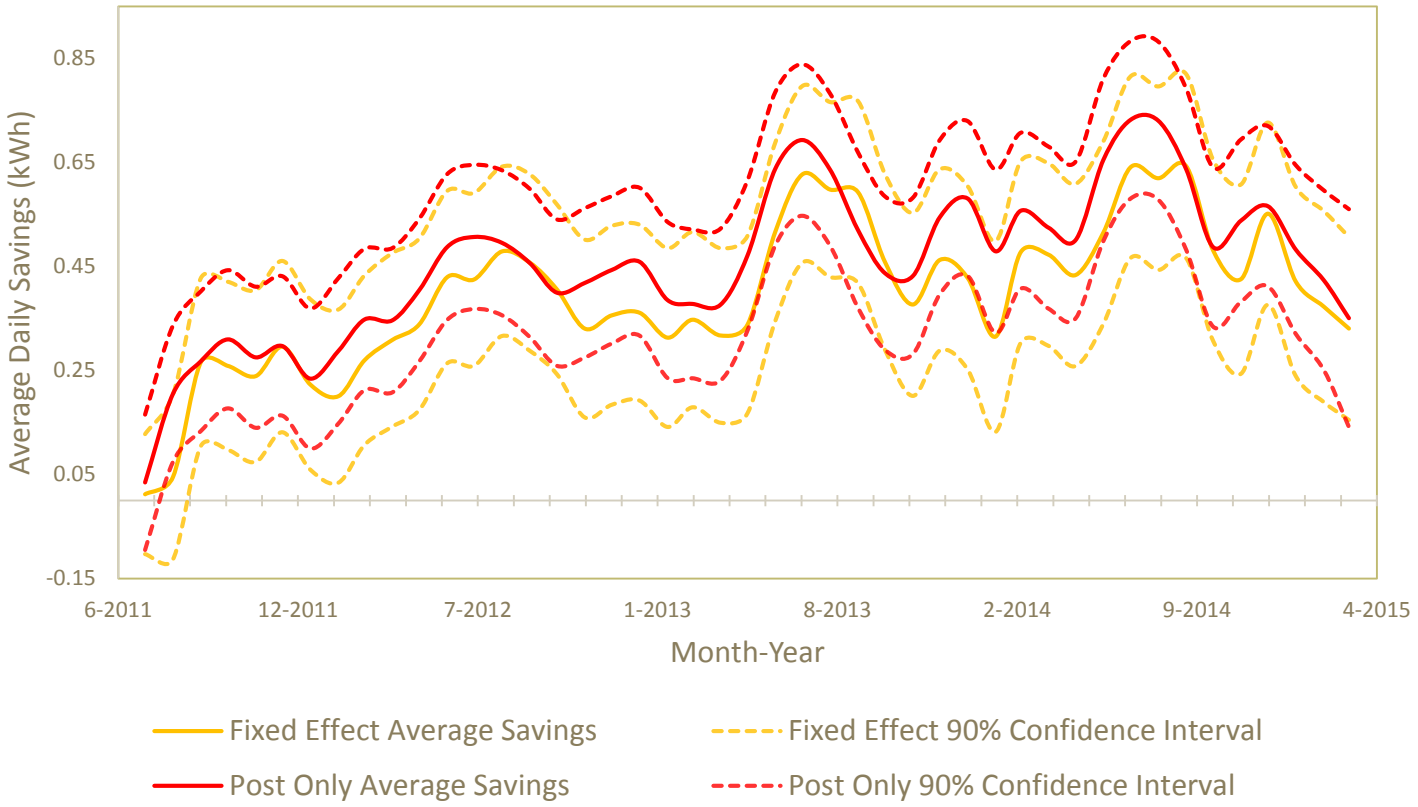
- This model includes some additional control terms explained on the following slide

The additional terms Opower has added to the basic Post Only model attempt to soak up as much unwanted variation as possible, particularly unobserved differences in the treatment and control groups that vary seasonally and with time.

- In addition to the basic PO components, this model includes
  - a set of year-month indicator variables
    - Controls for unobserved variation at the year-month level
  - *LagADUall*, average daily usage in the entire pre-treatment year for each customer
    - Is the same as *ADULag* in the basic PO model—uses pre-treatment year energy usage to control for unobserved differences between the control and treatment groups at the customer level
  - *LagADUwinter*, average daily usage during winter of the pre-treatment year for each customer
    - Uses pre-treatment year winter months energy usage to control for unobserved differences between the control and treatment groups at the customer level
  - *LagADUsummer*, average daily usage during summer of the pre-treatment year for each customer
    - Uses pre-treatment year summer months energy usage to control for unobserved differences between the control and treatment groups at the customer level
  - Sets of year-month indicator variables interacted with *LagADUall, LagADUwinter* and *LagADUsummer*
    - Each of these sets controls for additional unobserved differences in the treatment and control groups that may vary by specific months of the pre-treatment year

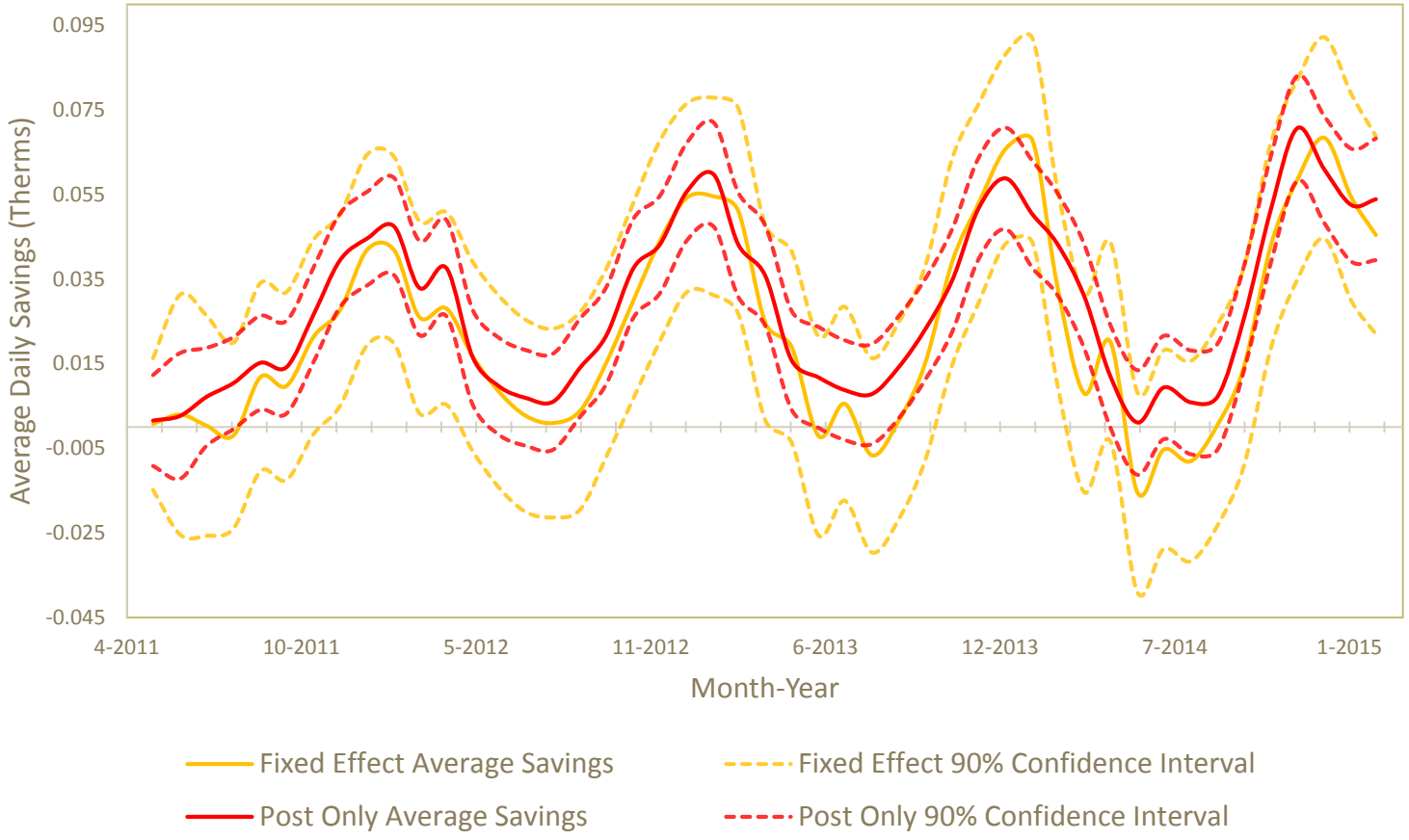
For the DTE Electric cohort, Opower's PO model generally produces larger estimates of kWh/day savings compared with FE. Post Only confidence intervals are tighter, reflecting smaller standard errors.

Figure B-2. FE and PO Savings and Confidence Interval Comparison, DTE Electric Cohort



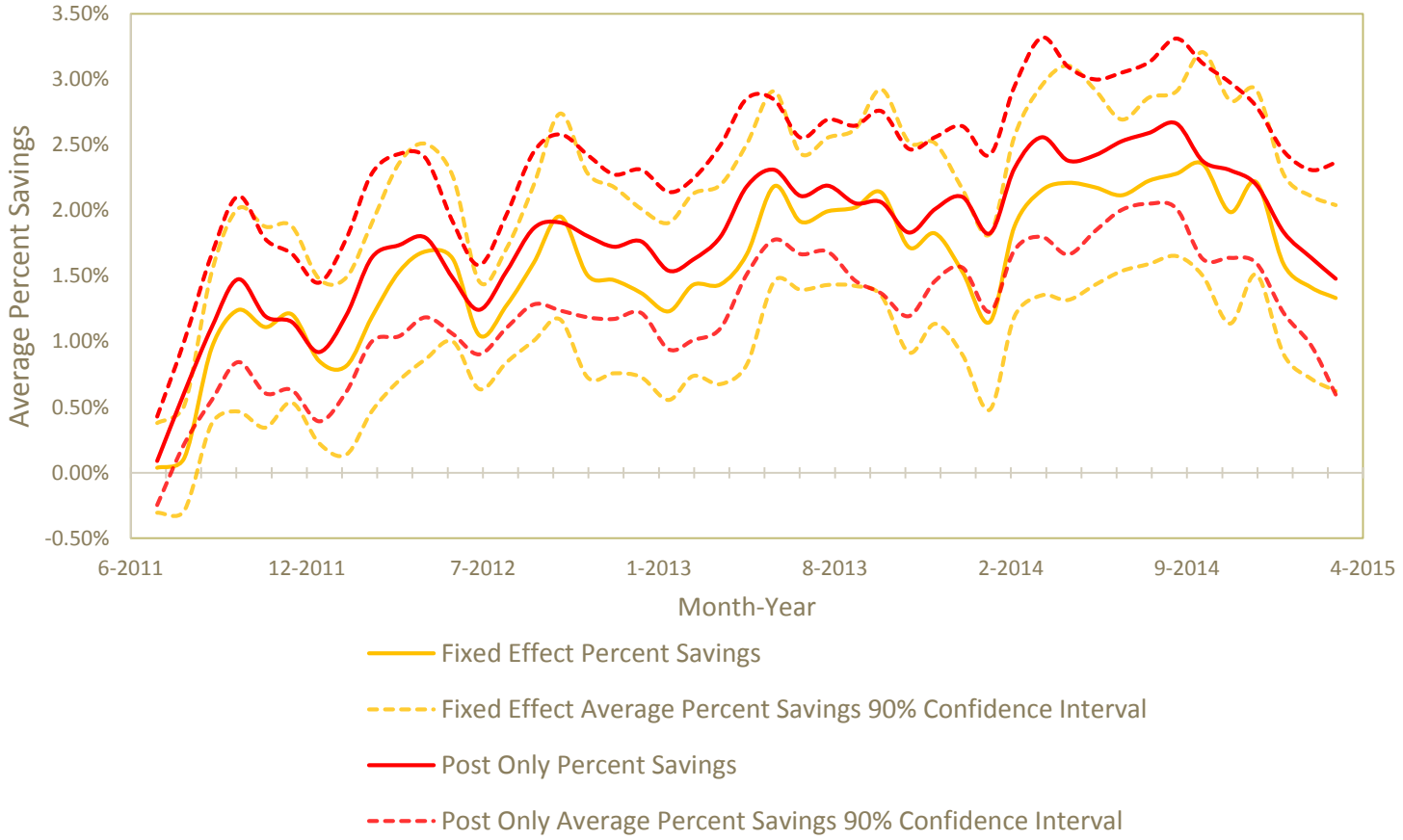
For the Consumers Energy gas cohort, Opower's PO model generally produces larger estimates of Therms/day savings compared with FE. PO confidence intervals are tighter, reflecting smaller standard errors.

Figure B-3. FE and PO Savings and Confidence Interval Comparison, Consumers Gas Cohort



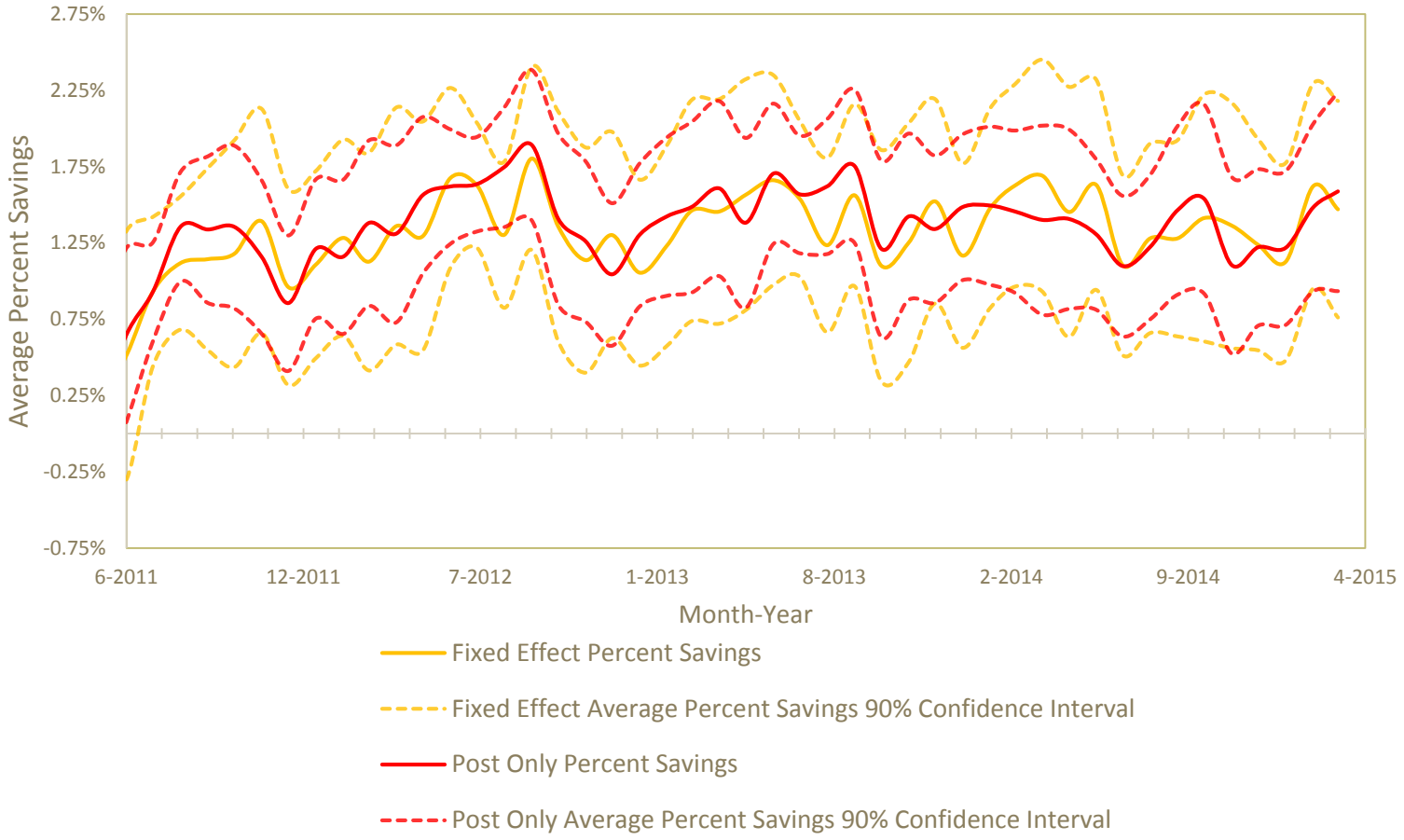
For the DTE Electric cohort, Opower's PO model generally produces larger estimates of percent savings compared with FE. PO confidence intervals are tighter, reflecting smaller standard errors.

Figure B-4. FE and PO Percent Savings and Confidence Interval Comparison, DTE Electric Cohort



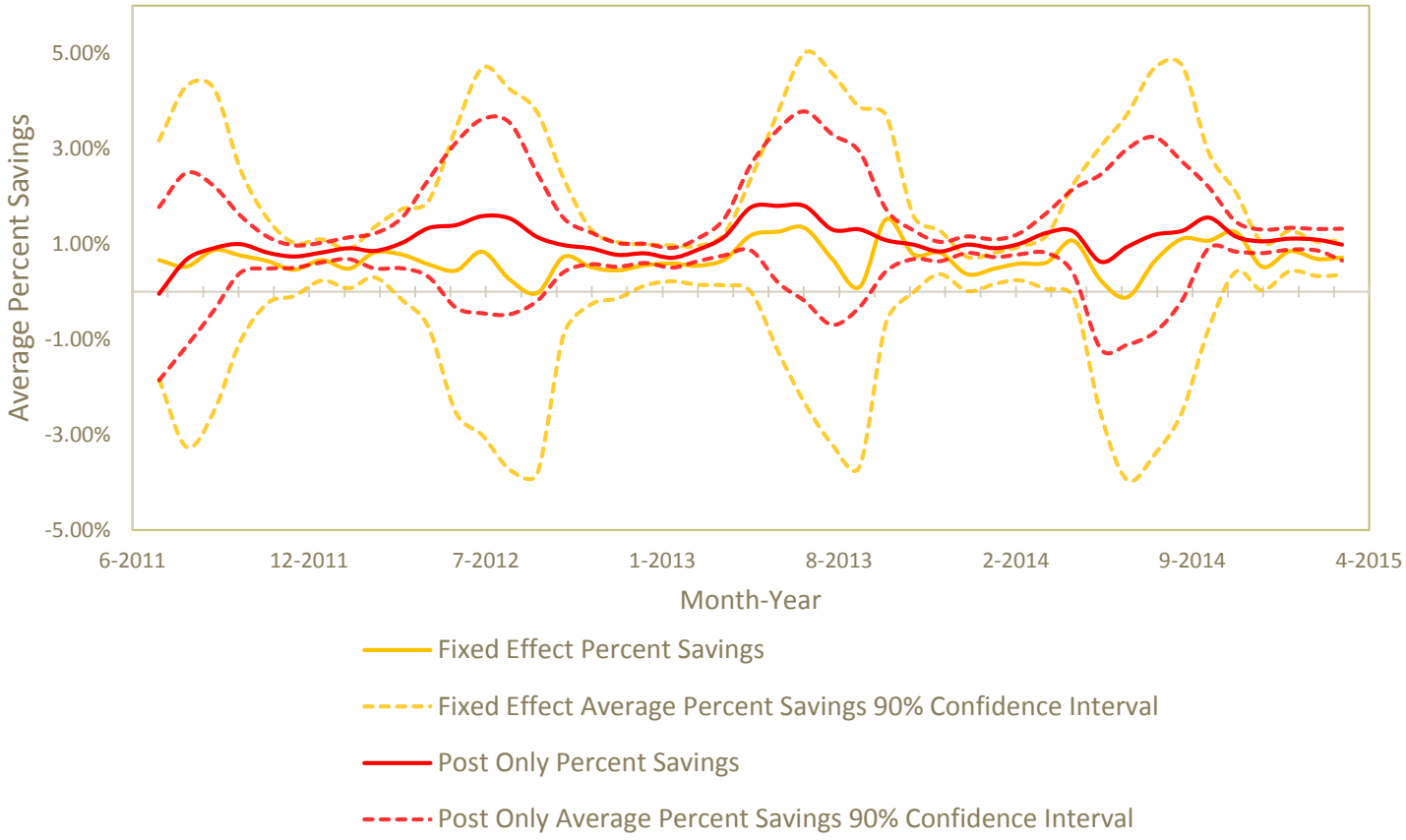
For Consumers Energy electric cohort, Opower's PO and FE percent savings estimates are very similar, but the PO confidence intervals are tighter, reflecting smaller standard errors.

Figure B-5. FE and PO Percent Savings and Confidence Interval Comparison, Consumers Electric Cohort



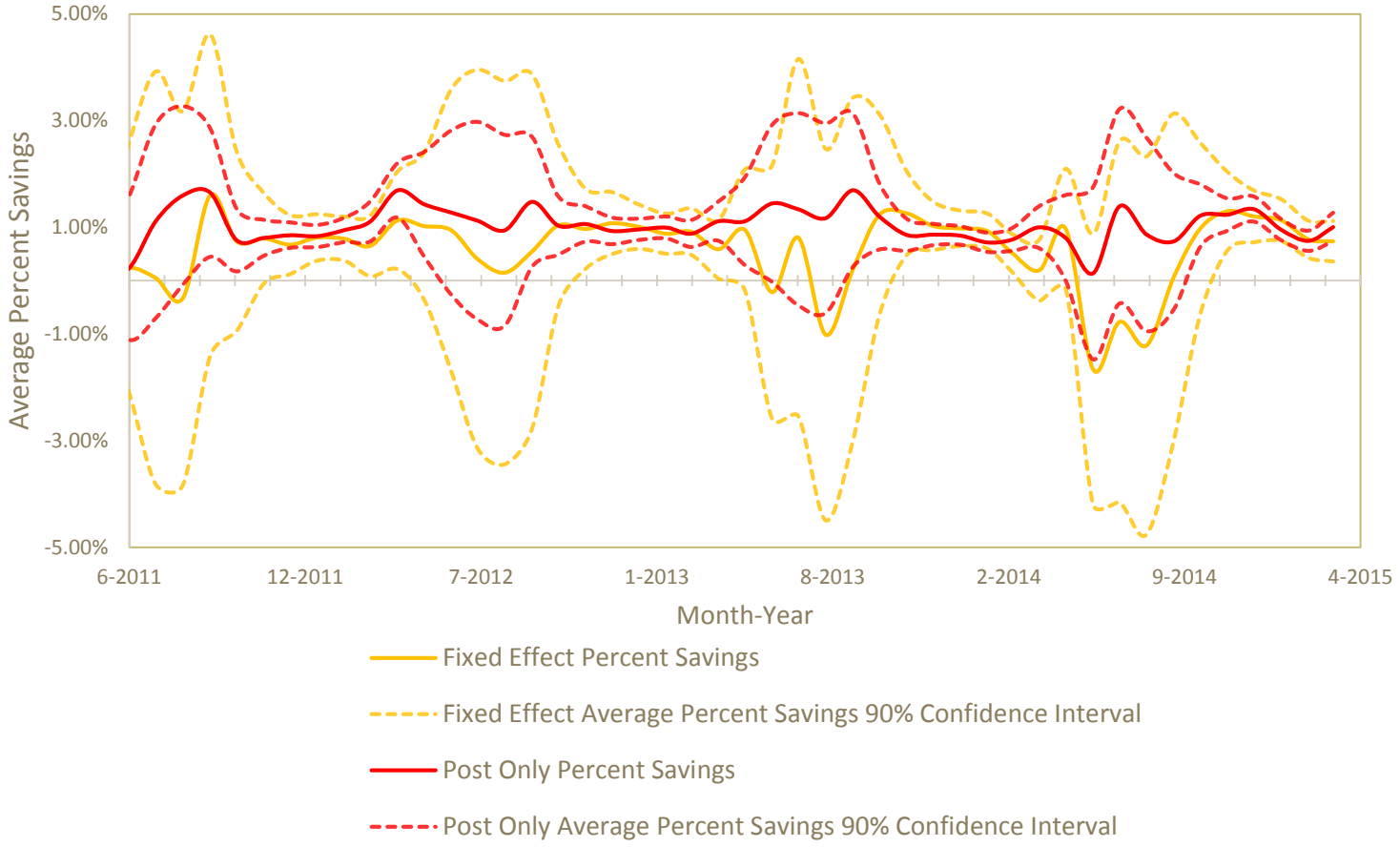
For the DTE gas cohort, Opower's PO model generally produces larger estimates of percent savings compared with FE, and PO confidence intervals are tighter, reflecting smaller standard errors.

Figure B-6. FE and PO Savings and Confidence Interval Comparison, DTE Gas Cohort



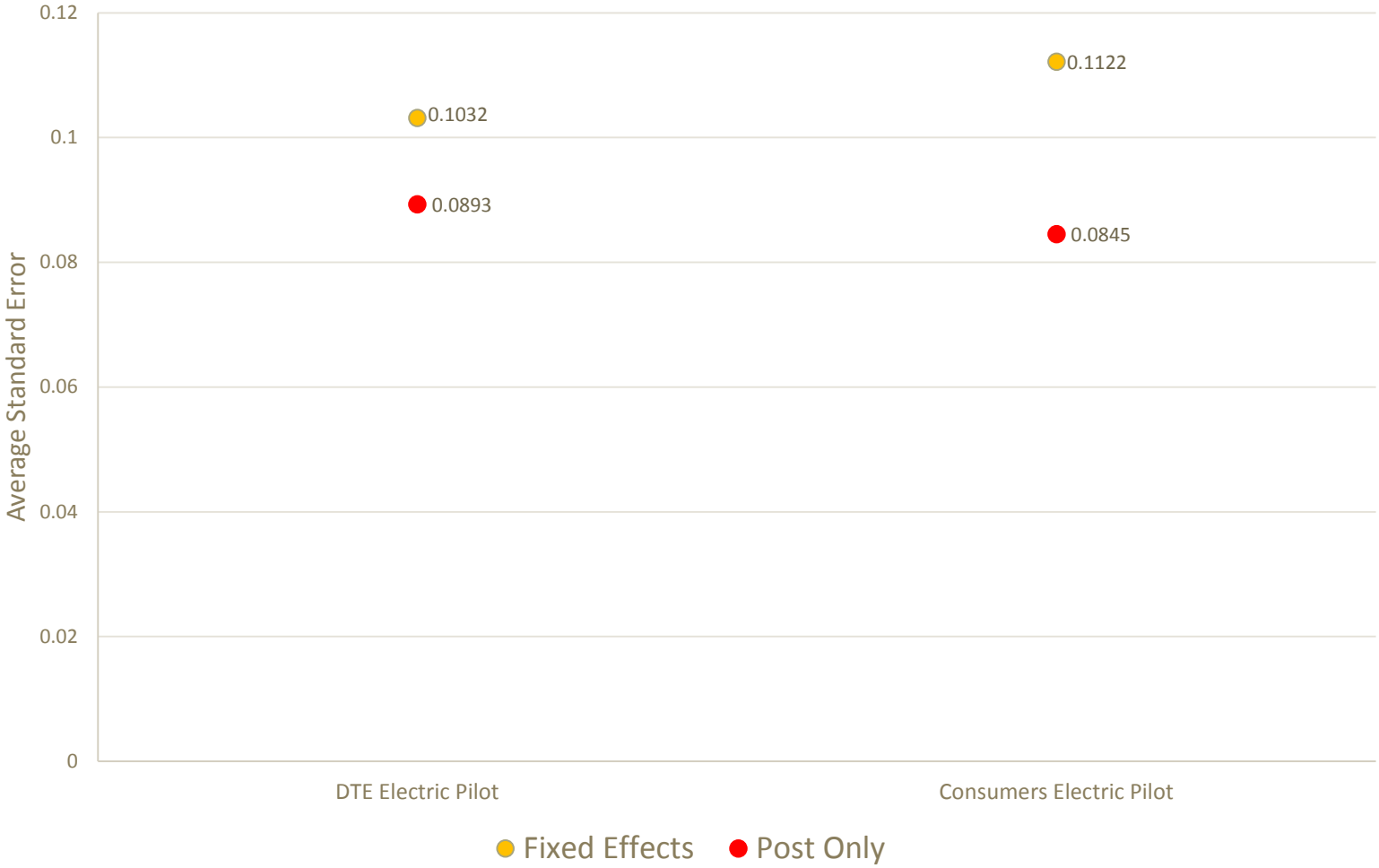
For the Consumers Energy gas cohort, Opower's PO model generally produces larger estimates of percent savings compared with FE, and PO confidence intervals are tighter, reflecting smaller standard errors.

Figure B-7. FE and PO Savings and Confidence Interval Comparison, Consumers Gas Cohort



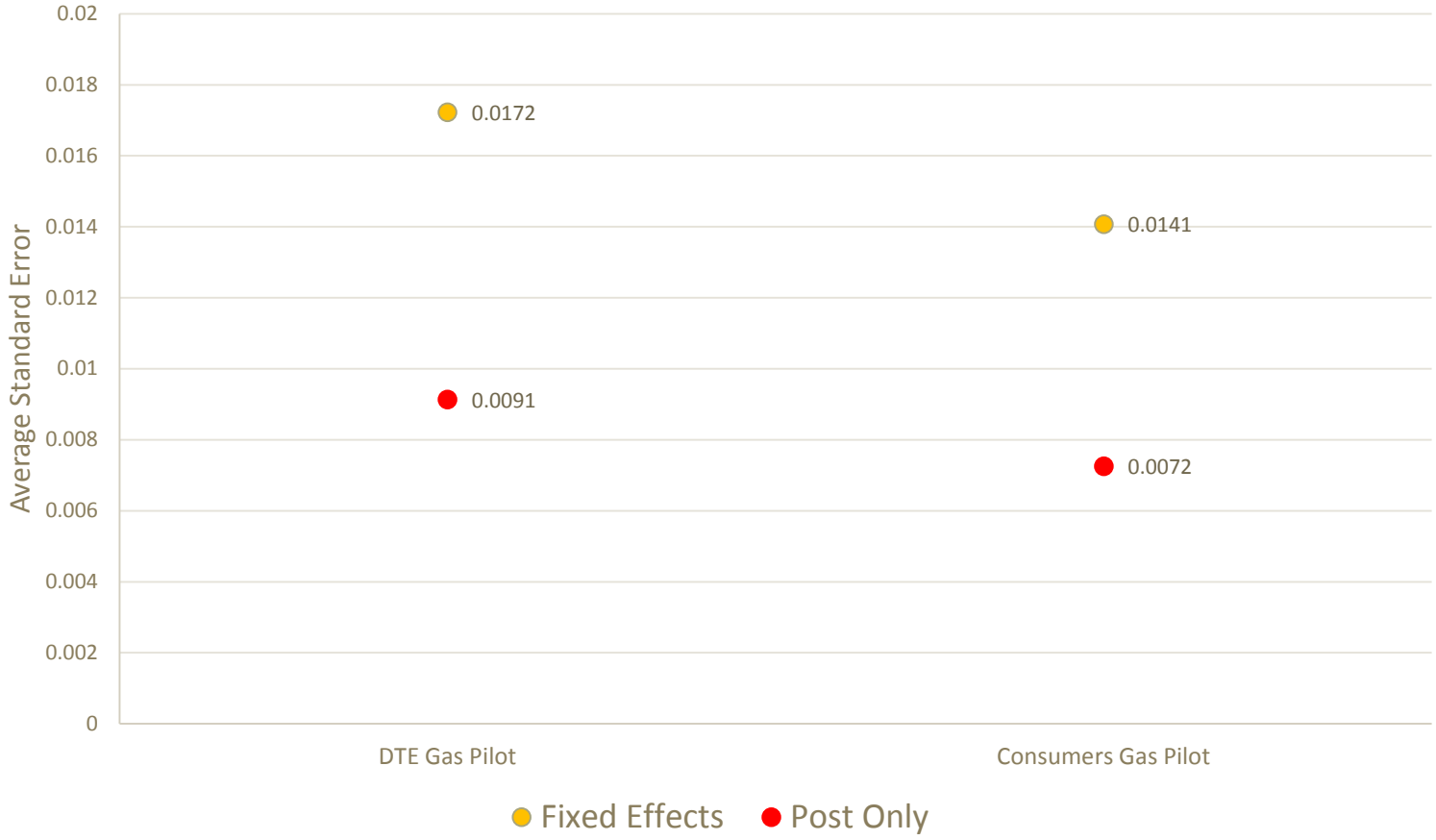
Opower's Post Only regression results exhibit smaller standard errors associated with the savings coefficient estimate, both for Consumers and DTE electric cohorts, when averaged across all months and years.

Figure B-8. Electric Cohorts FE and PO Average Standard Error Comparison, Across all Years



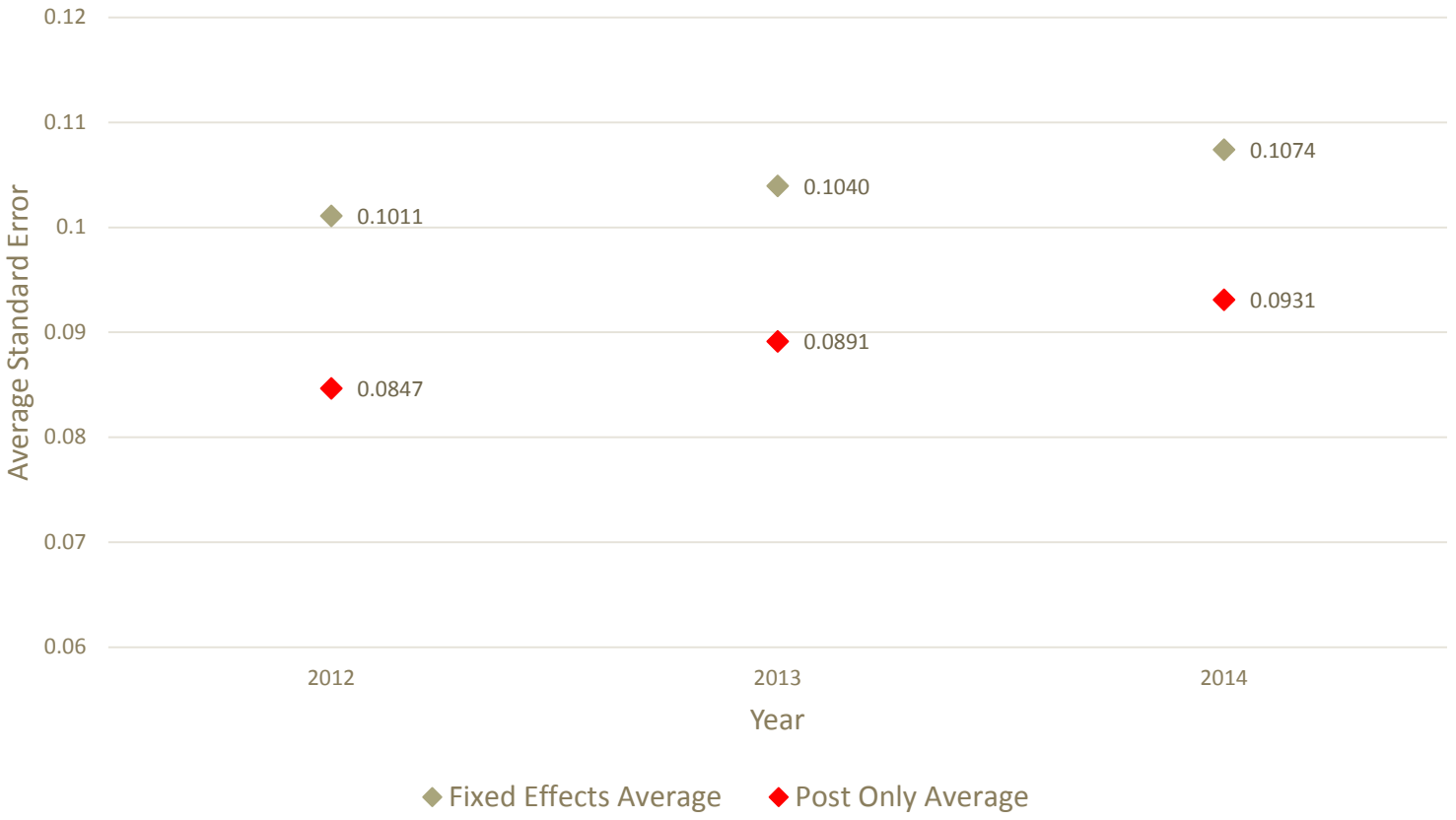
Opower's Post Only regression results exhibit smaller standard errors associated with the savings coefficient estimate, both for Consumers Energy and DTE gas cohorts, when averaged across all months and years.

Figure B-9. Opower Model Calibration: Gas Cohorts FE and PO Average Standard Error Comparison across all Periods



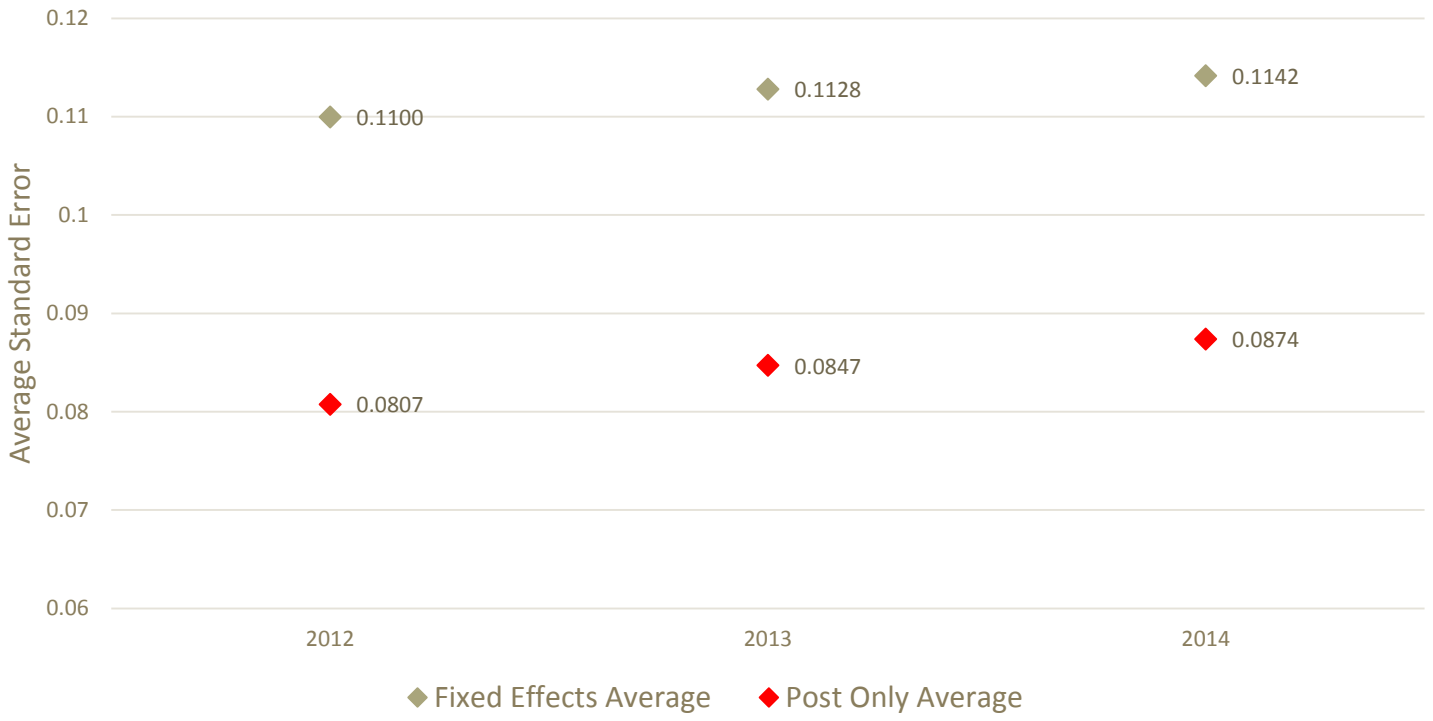
Opower's PO regression results exhibit smaller standard errors associated with the savings coefficient estimate for DTE's electric cohort compared with FE, when averaged by year.

Figure B-10. FE and PO Average Standard Error Comparison across Years, DTE Electric Cohort



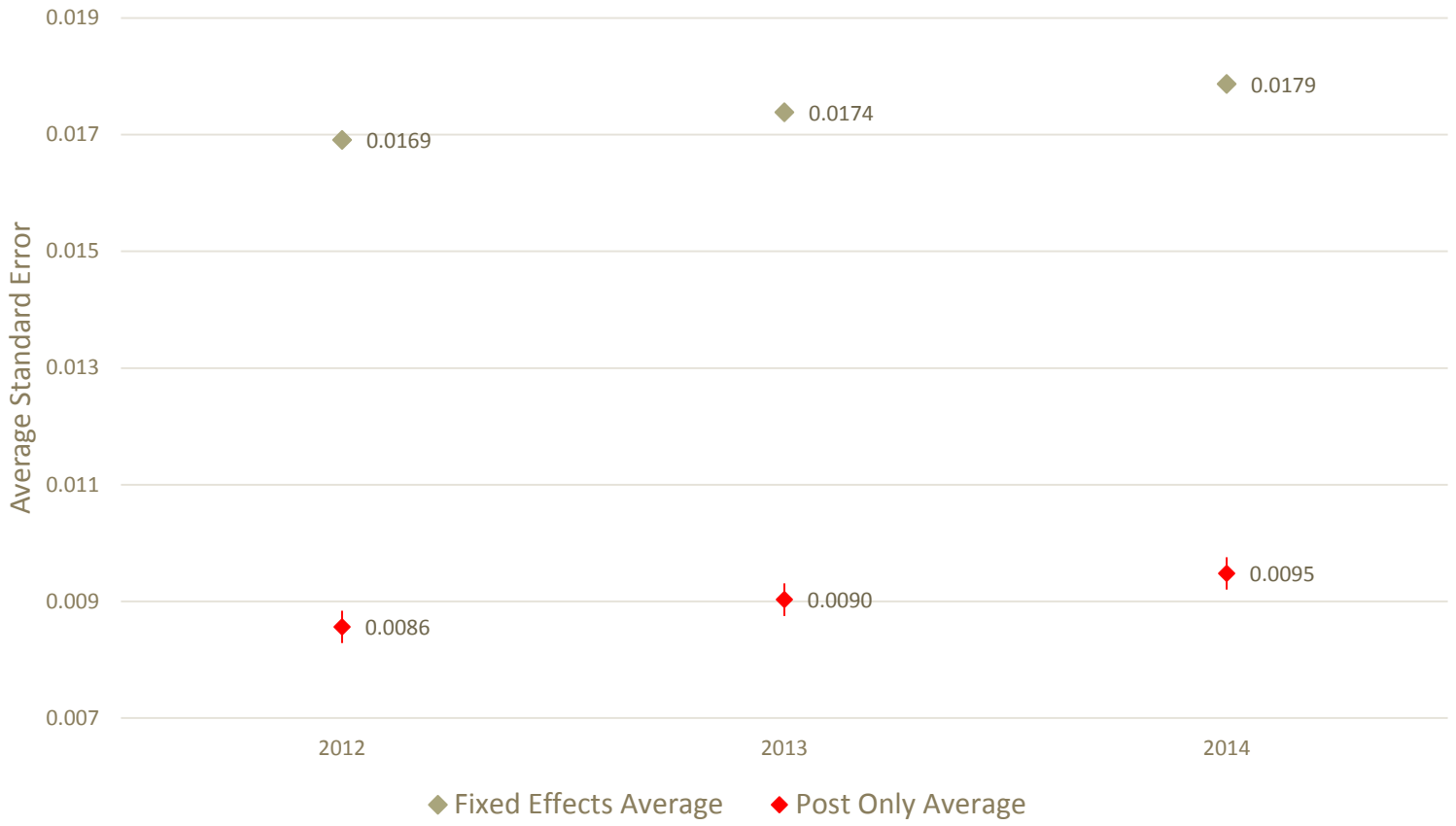
Opower's PO regression results exhibit smaller standard errors associated with the savings coefficient estimate for Consumers Energy's electric cohort compared with FE, when averaged by year.

Figure B-11. FE and PO Average Standard Error Comparison across Years, Consumers Electric Cohort



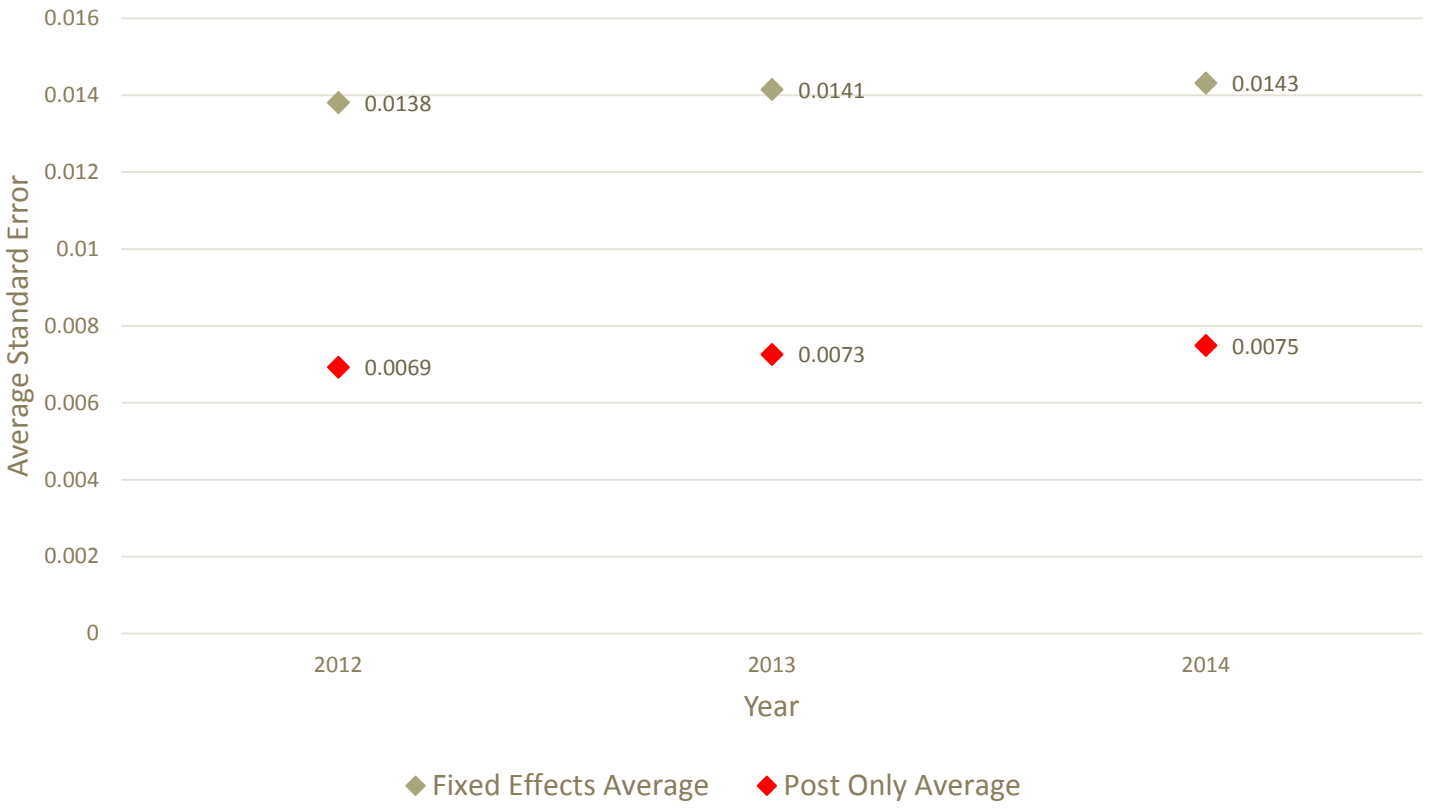
Opower's PO regression results exhibit smaller standard errors associated with the savings coefficient estimate for DTE's gas cohort, compared with FE, when averaged by year.

Figure B-12. FE and PO Average Standard Error Comparison across Years, DTE Gas Cohort



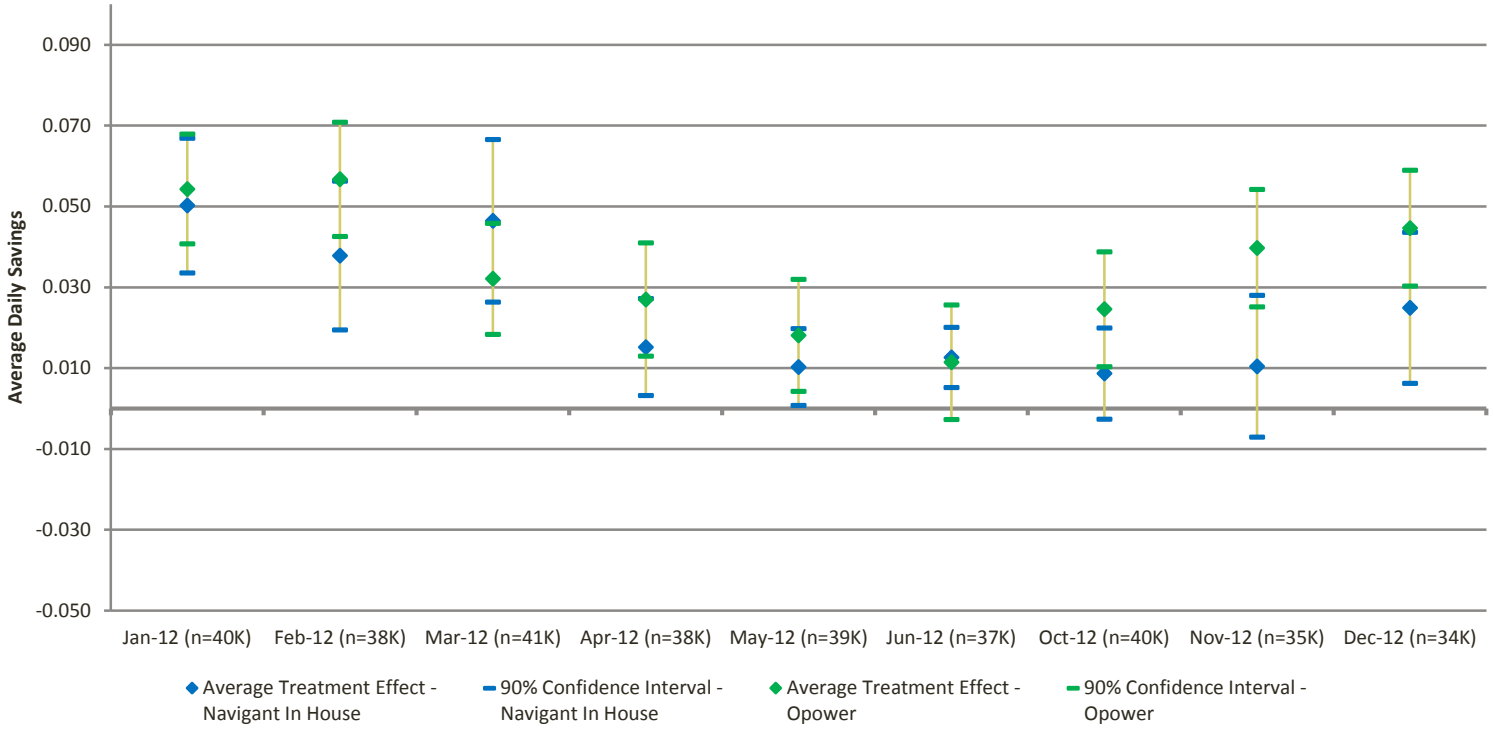
Opower's PO regression results exhibit smaller standard errors associated with the savings coefficient estimate for Consumers' gas cohort, compared with FE, when averaged by year.

Figure B-13. FE and PO Average Standard Error Comparison across Years, Consumers Gas Cohort



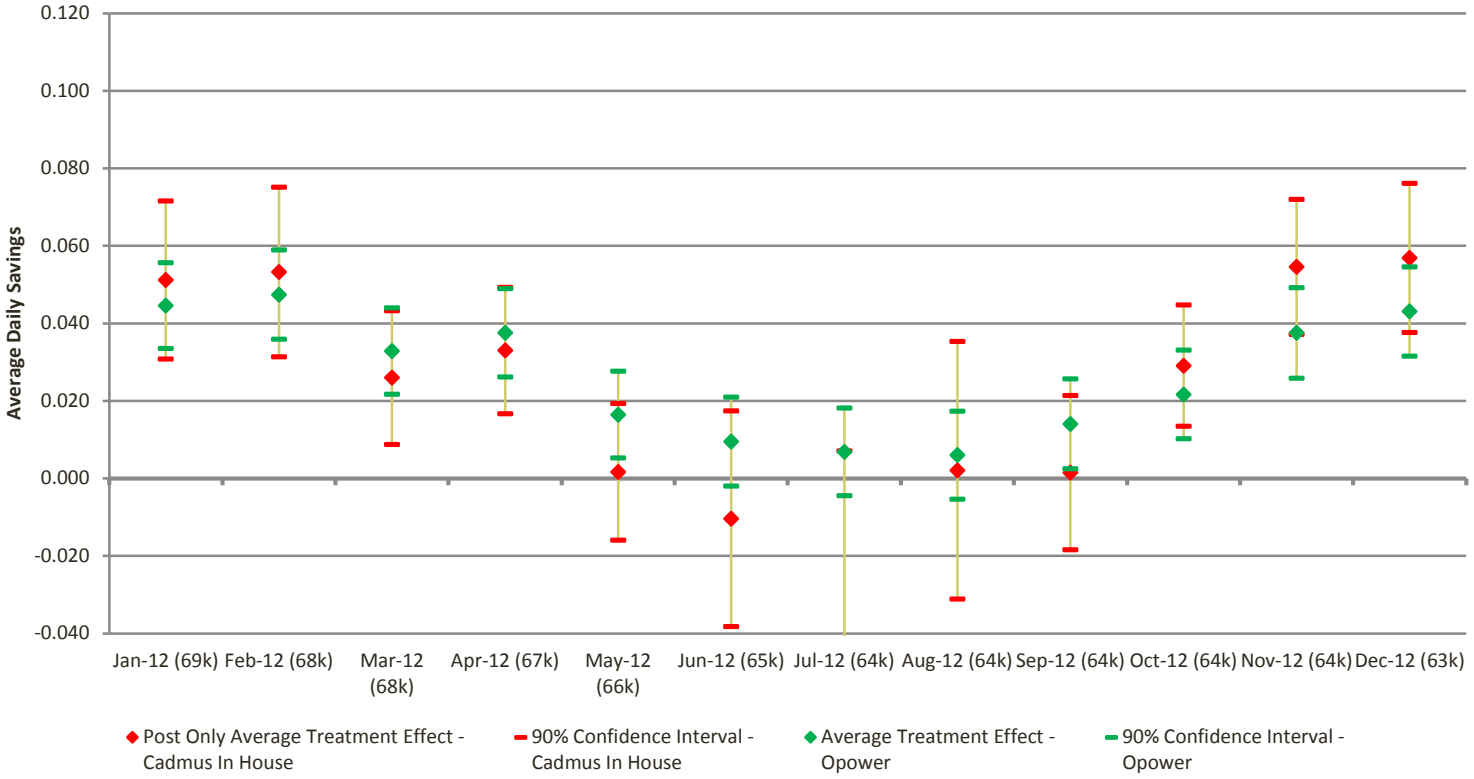
Navigant's in-house Post Only model generally produces results similar to Opower's Post Only results, though Navigant's in-house PO gas results are less similar to Opower's results than for electric.

## Figure C-1. Navigant In-House Model vs Opower Model Results Comparison, DTE Gas, 2012



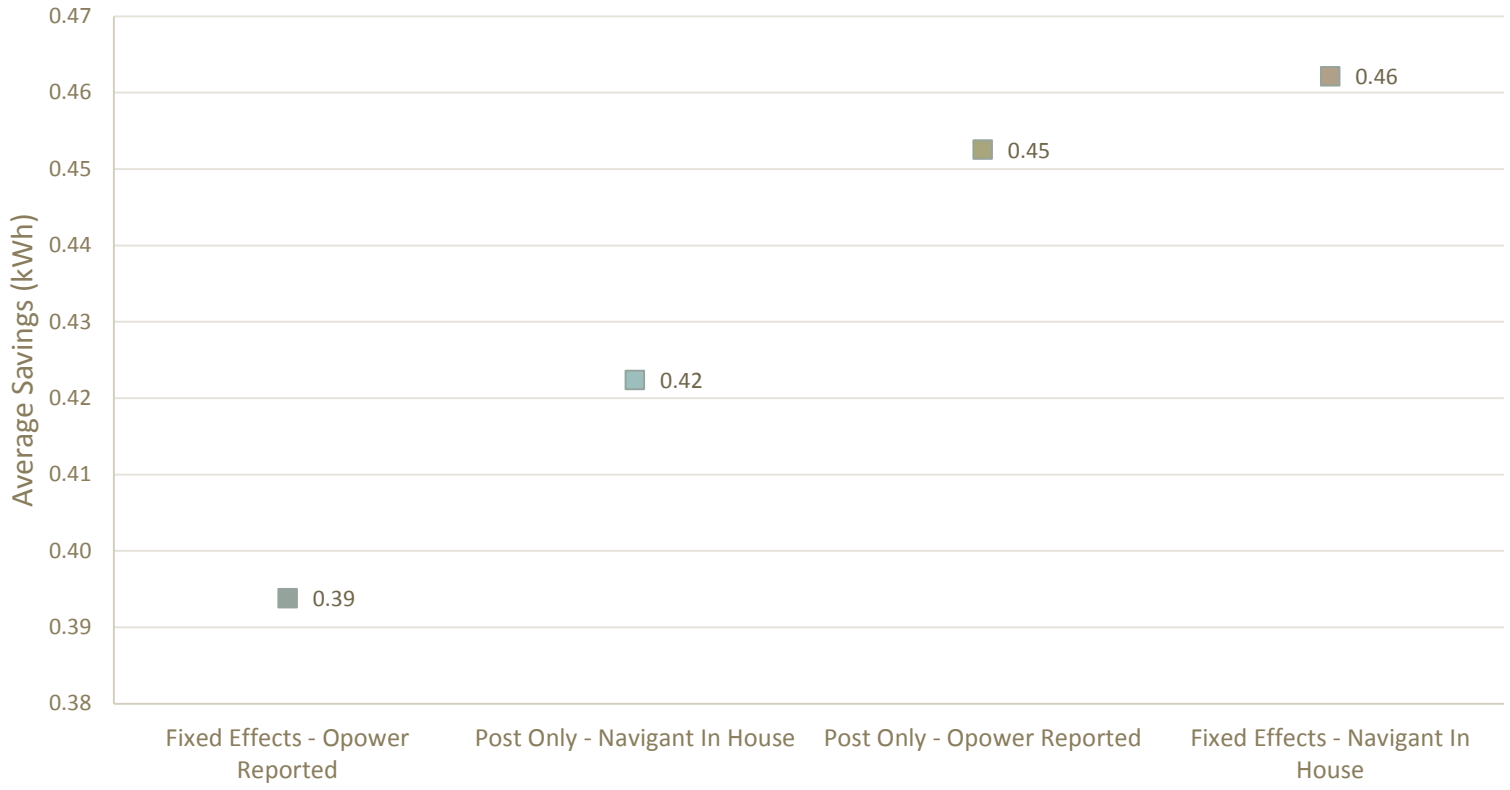
Cadmus' in-house Post Only model generally produces results similar to Opower's Post Only results, though Cadmus' in-house PO gas results are less similar to Opower's results than for electric.

## Figure C-2. Cadmus In-House Model vs Opower Model Results Comparison, Consumers Energy Gas, 2012



Taking the average across all years, Opower's FE model produces the smallest average daily electric savings estimates, while Navigant's FE model produces the largest. All methods result in average estimates ranging within a 0.07 kWh/day.

Figure C-3. DTE, Average Daily Electric Savings, Average Across all Years




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

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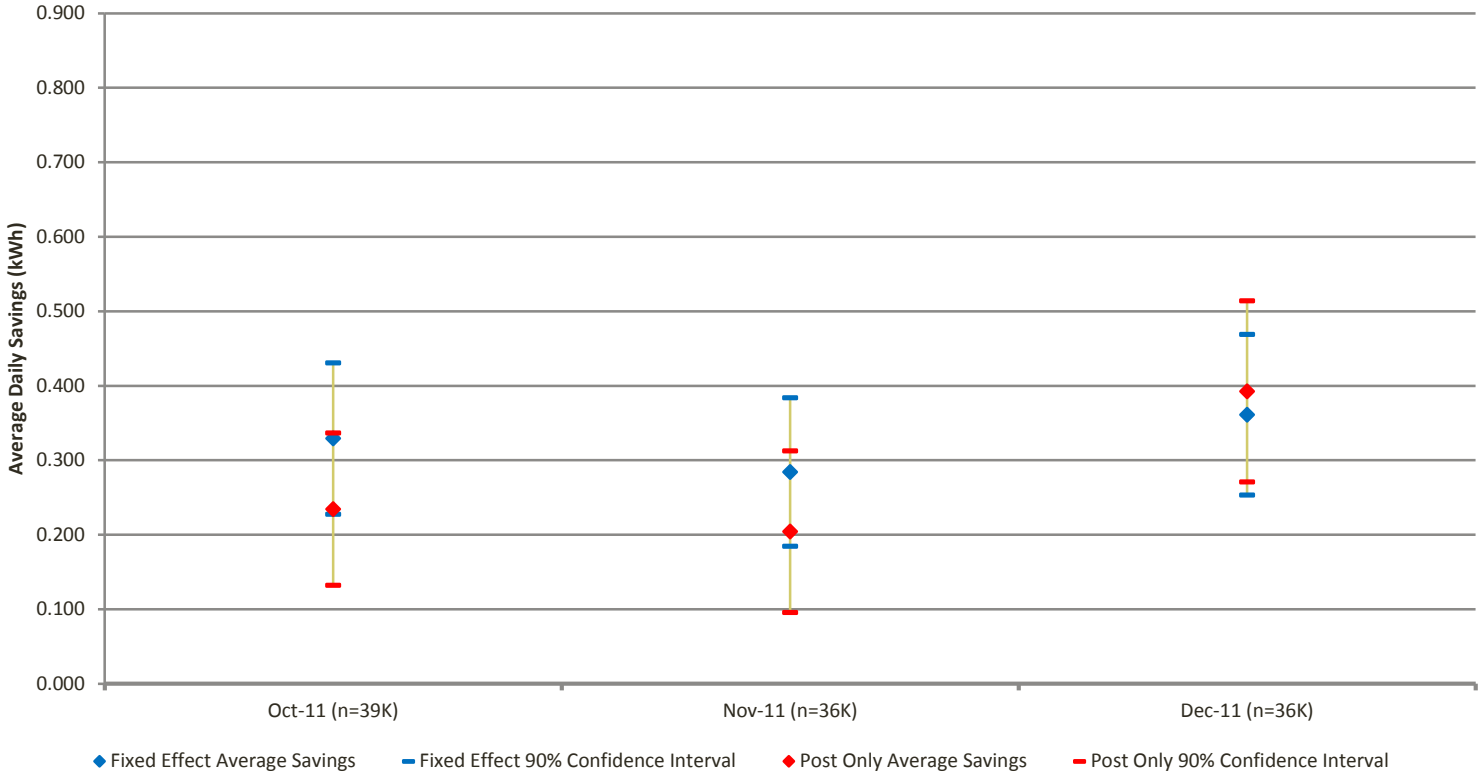
With DTE electric Opower raw data, using Navigant's typical data cleaning process, Navigant's PO and FE models produce similar savings estimates which are rarely statistically different. PO standard errors are not consistently smaller than FE.

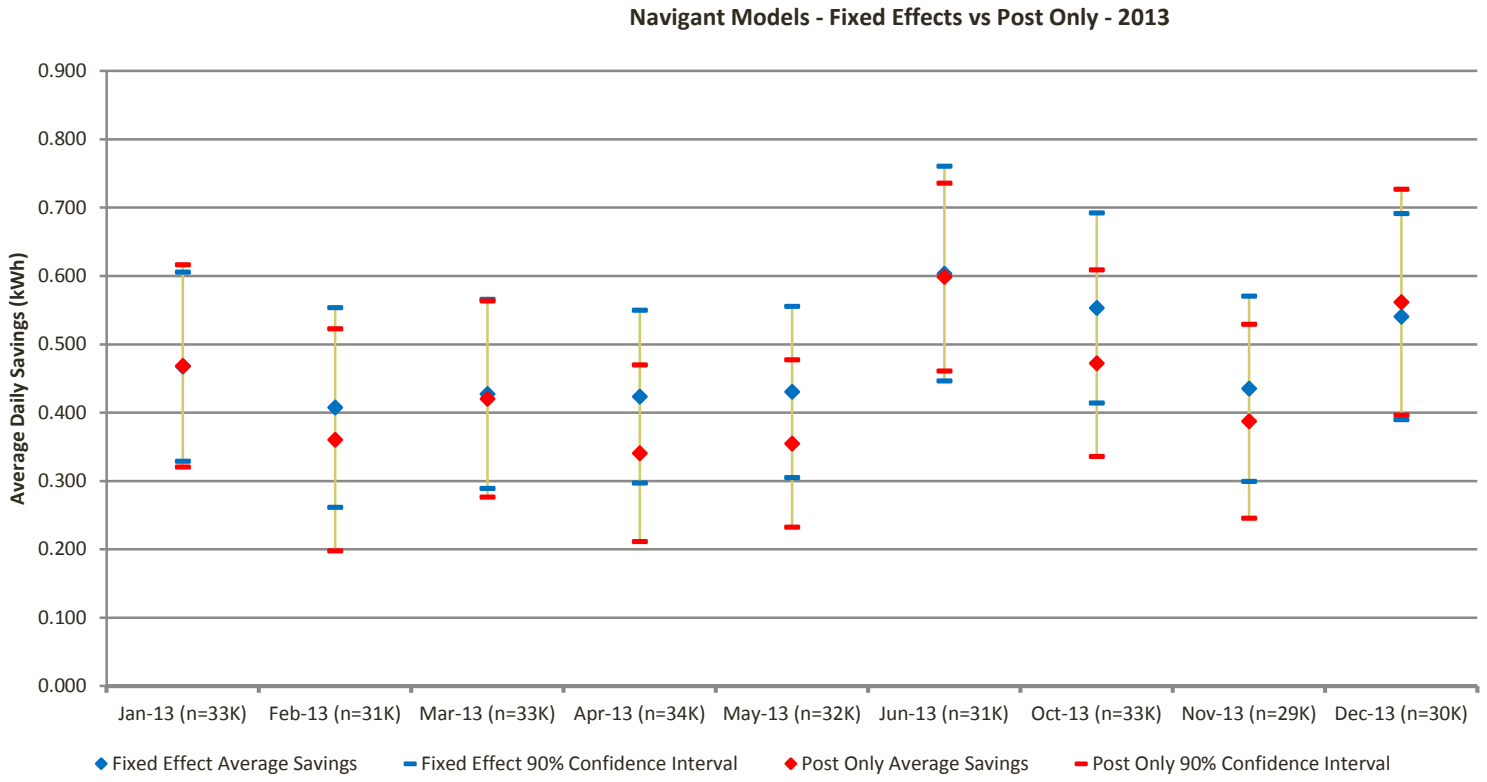
## Figure C-4. Navigant In-House Models, DTE Electric, 2011, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With DTE electric Opower raw data, using Navigant's typical data cleaning process, Navigant's PO and FE models produce similar savings estimates which are rarely statistically different. PO standard errors are not consistently smaller than FE.

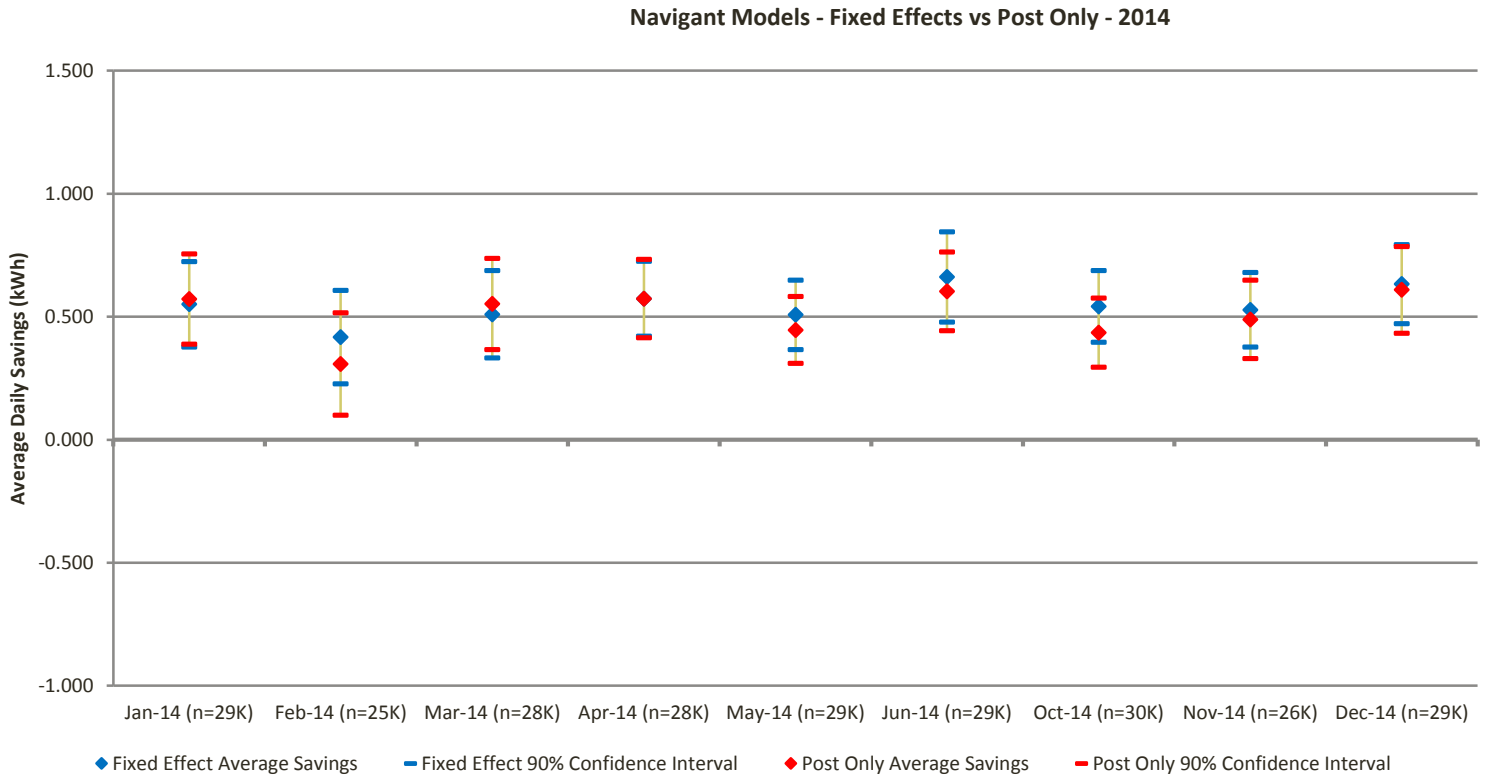
## Figure C-5. Navigant In-House Model, DTE Electric, 2013, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With DTE electric Opower raw data, using Navigant's typical data cleaning process, Navigant's PO and FE models produce similar savings estimates which are rarely statistically different. PO standard errors are not consistently smaller than FE.

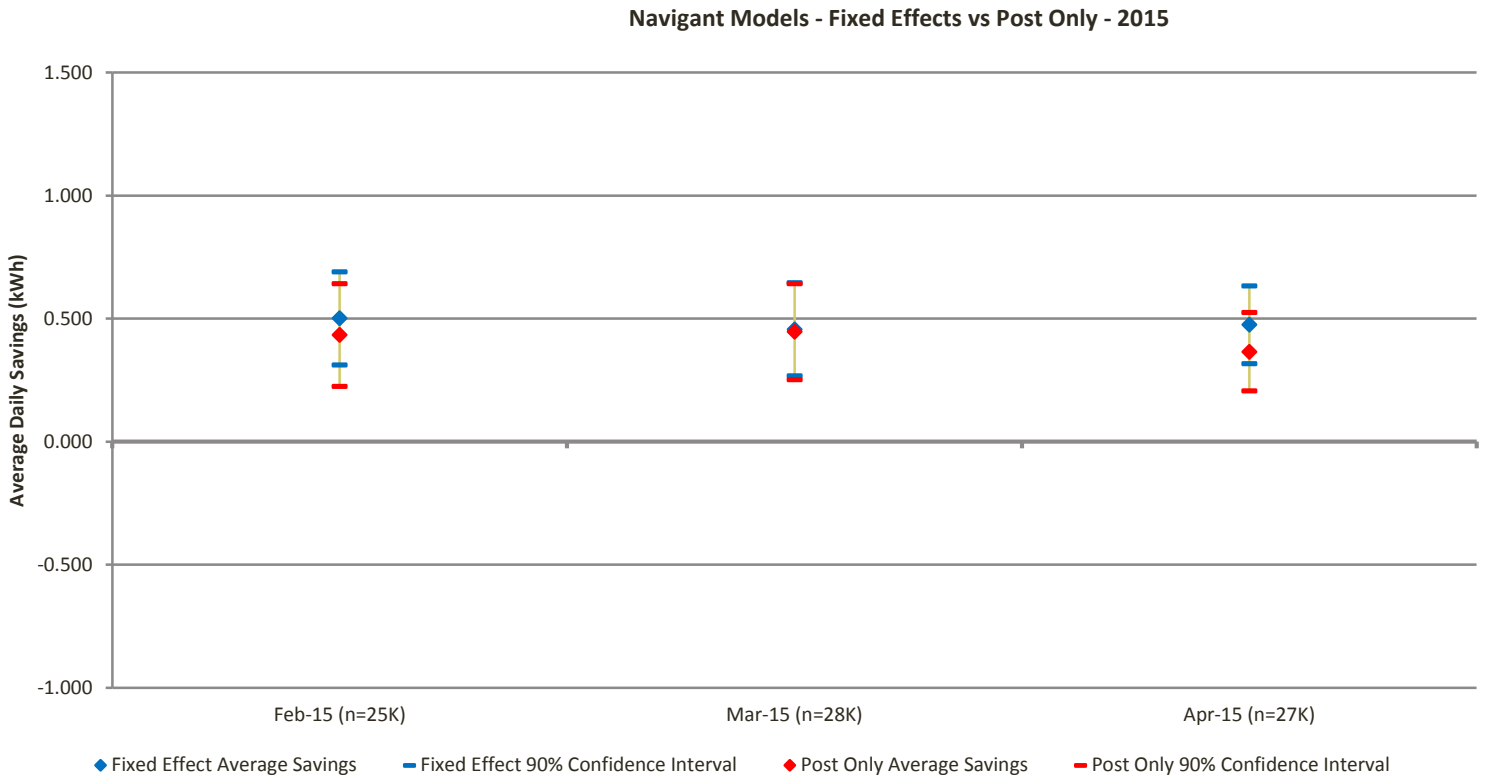
Figure C-6. Navigant In-House Model, DTE Electric, 2014, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With DTE electric Opower raw data, using Navigant's typical data cleaning process, Navigant's PO and FE models produce similar savings estimates which are rarely statistically different. PO standard errors are not consistently smaller than FE.

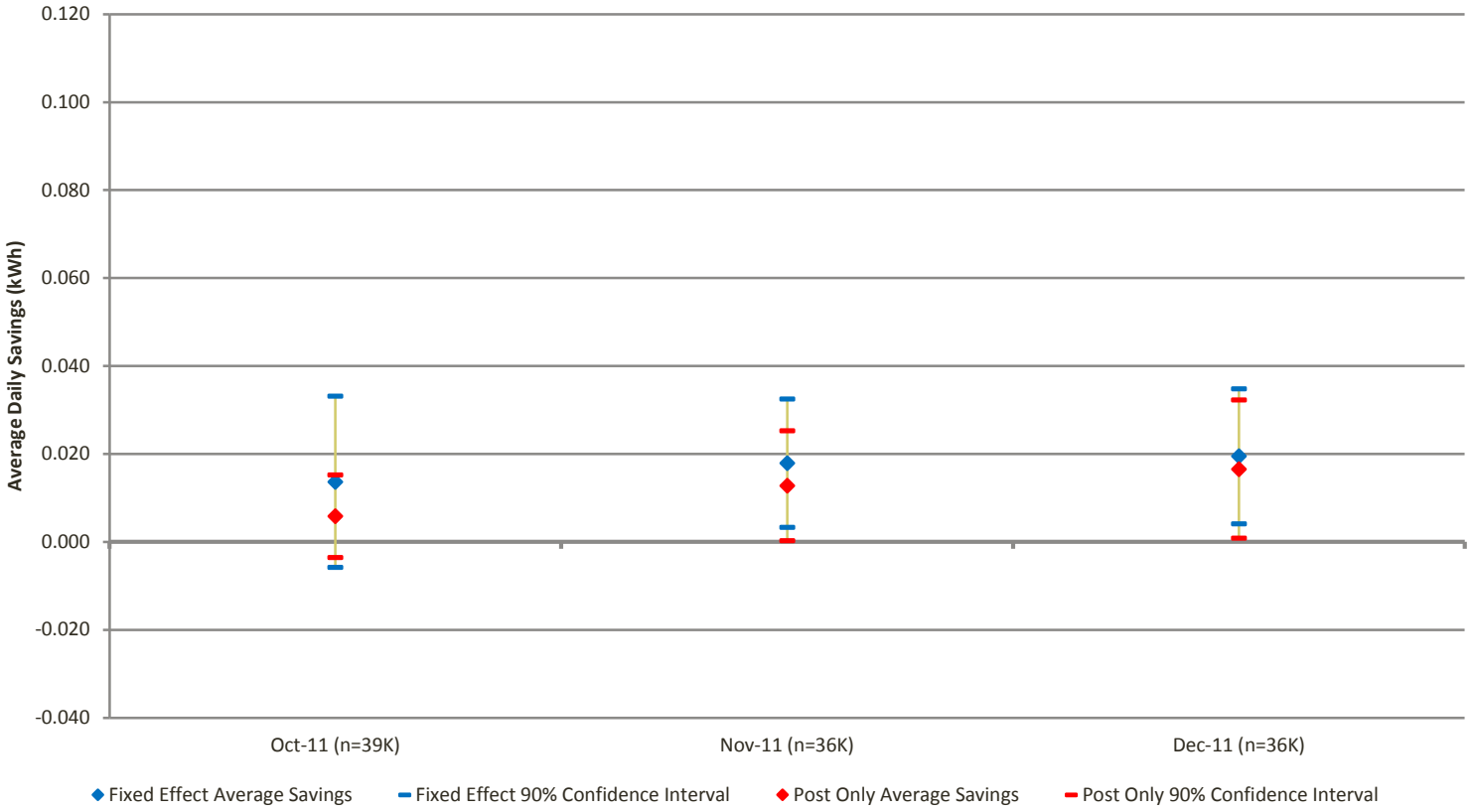
Figure C-7. Navigant In-House Model, DTE Electric, 2015, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With DTE gas Opower raw data, using Navigant's typical data cleaning process, Navigant's FE models generally produce larger savings estimates than PO, differences are rarely statistically different. PO standard errors are smaller than FE.

Figure C-8. Navigant In-House Model, DTE Gas, 2011, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

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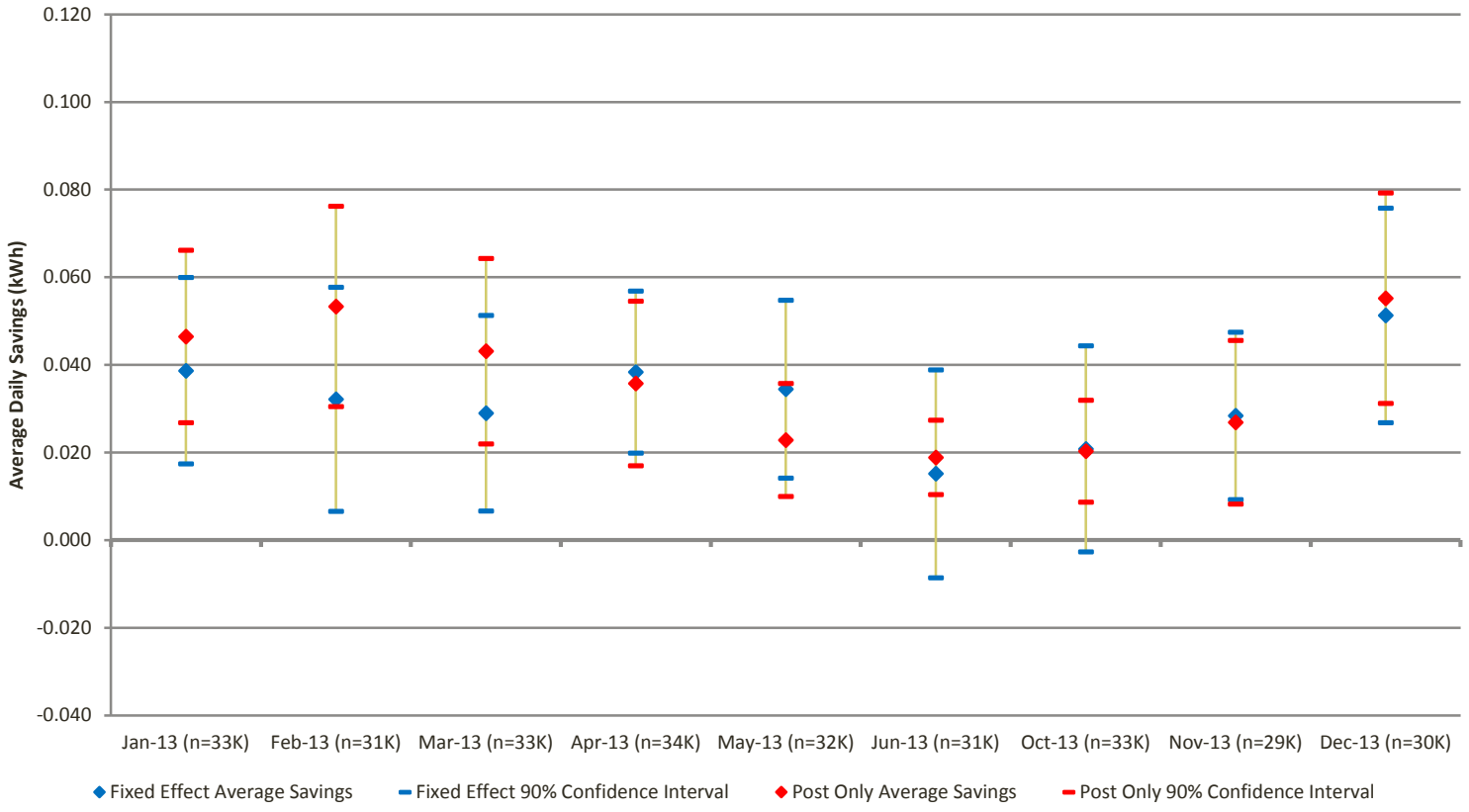
With DTE gas Opower raw data, using Navigant's typical data cleaning process, Navigant's FE models generally produce larger savings estimates than PO, differences are rarely statistically different. PO standard errors are smaller than FE.

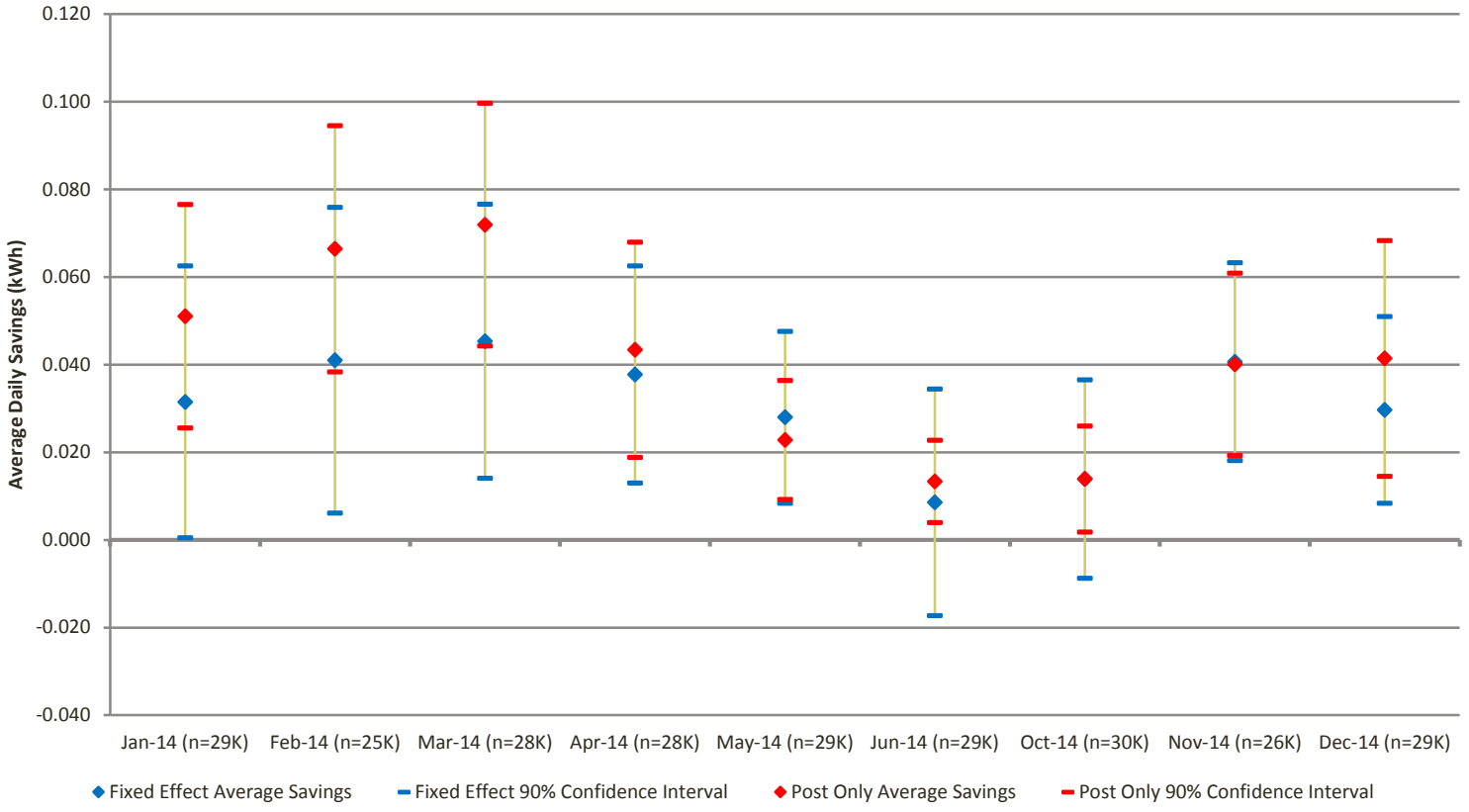
Figure C-9. Navigant In-House Model, DTE Gas, 2013, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With DTE gas Opower raw data, using Navigant's typical data cleaning process, Navigant's FE models generally produce larger savings estimates than PO, differences are rarely statistically different. PO standard errors are smaller than FE.

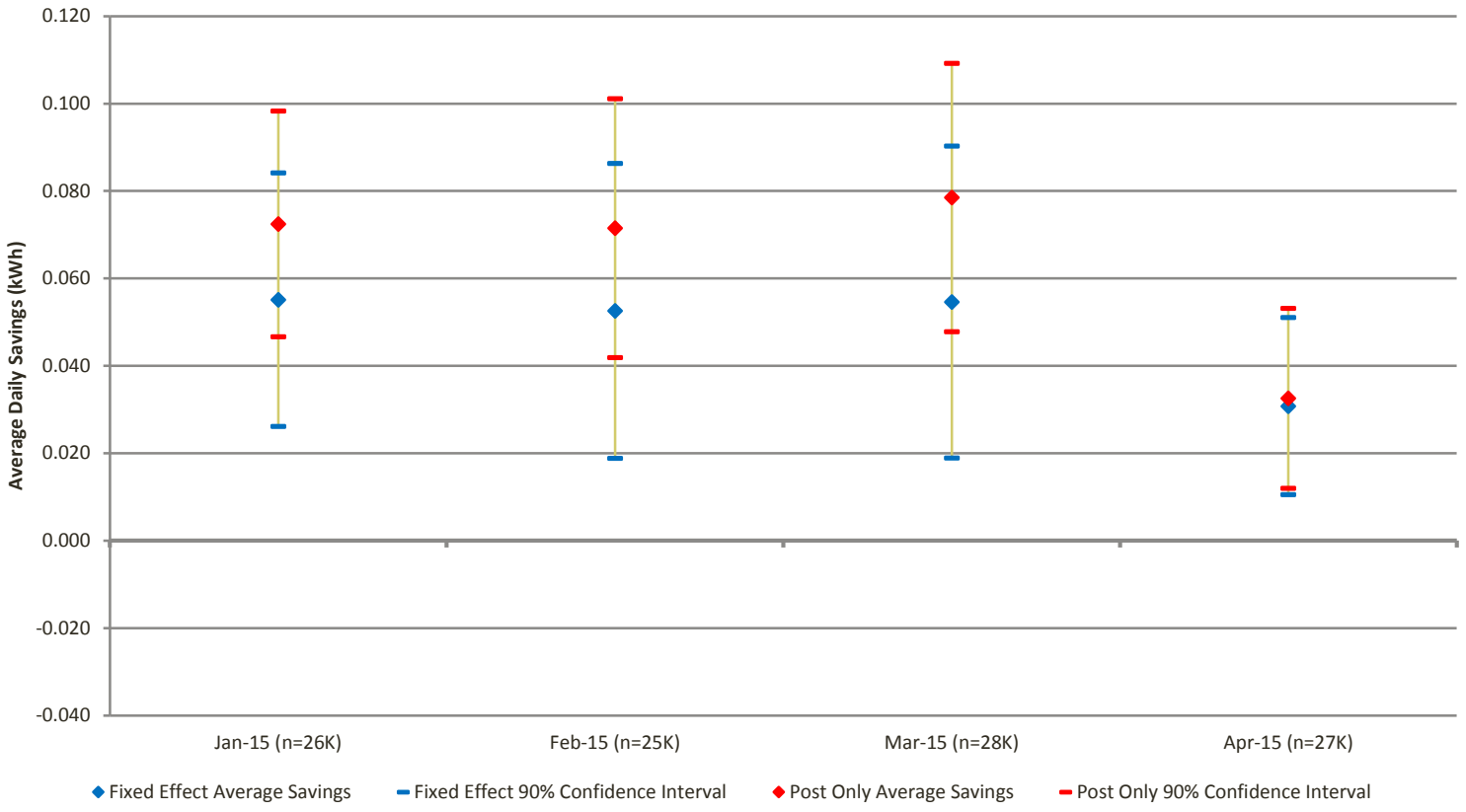
## Figure C-10. Navigant In-House Model, DTE Gas, 2014, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September

With DTE gas Opower raw data, using Navigant's typical data cleaning process, Navigant's FE models generally produce larger savings estimates than PO, differences are rarely statistically different. PO standard errors are smaller than FE.

Figure C-11. Navigant In-House Model, DTE Gas, 2015, PO versus FE Results, using Opower Raw Data




Note: Due to Opower's lack of data for the first three months of pre-year usage for the DTE pilot waves, Navigant was unable to use these months in its Post Only regressions. For this reason, all charts and results in this section are reported based on nine months of the year, excluding July, August and September