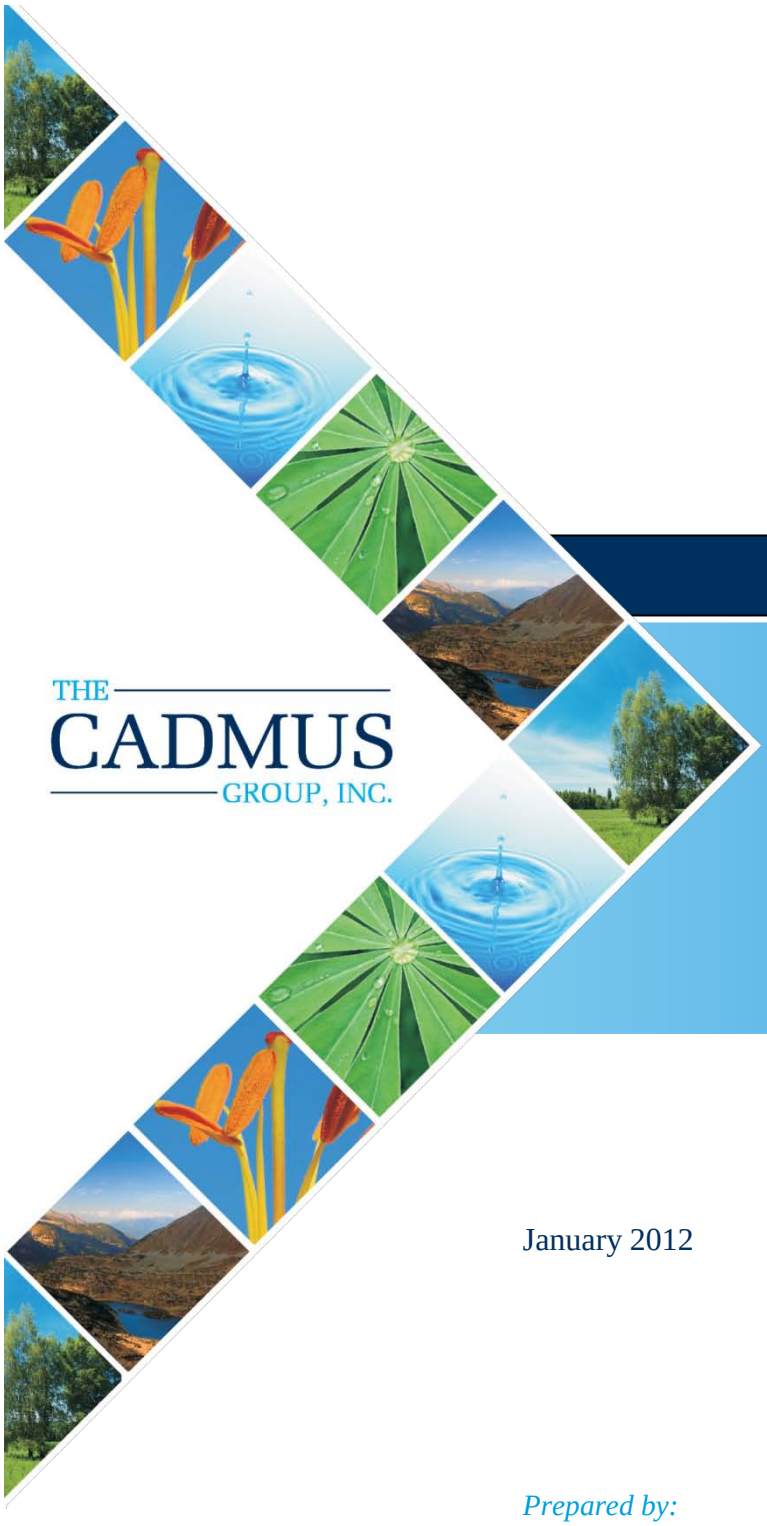

THE CADMUS GROUP, INC.

Home Energy Report Evaluation

– PY3 Evaluation

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1. Executive Summary

As part of its residential portfolio, Ameren Illinois began a two-year Home Energy Report pilot program in August 2010. The program was designed to reduce energy consumption by encouraging energy-efficient behaviors. The program was implemented by Opower, a privately held software-as-a-service company that partners with utility providers to promote energy efficiency through its Home Energy Reports program. Opower administers programs across the country with more than 60 utilities.

In the first year of this program, Ameren Illinois and Opower, targeted dual-fuel customers who live in high-population areas with higher-than-average energy use. Participants received a Home Energy Report in the mail that included the following information:

- Comparison of the customer's recent to past energy usage.
- A "neighbor comparison" of a customer's consumption to that of comparable customers in the same geographical area.
- Tips for reducing energy consumption, tailored to the customer's home energy profile (e.g., type of home, square footage, etc.).

In other studies, this set of information has been shown to stimulate customers to reduce their energy use, creating an average energy savings of 1% to 3%, depending on use patterns.

The Cadmus group performed the research activities listed in Table ES-1 to inform this evaluation.

Table ES-1. Summary of Evaluation Approach

Task	Impact	Process	Details
Stakeholder Interviews		♦	Interviews with key Ameren Illinois and Opower staff.
Billing Analysis	♦		Analysis of 100,000 treatment and control group customers
Database Cross Check	♦		Comparison of the rate of participation in PY3 Ameren Illinois incentive programs between Opower treatment and control groups.

Findings

The Home Energy Report pilot began in August 2010 when the first reports were sent to 50,000 customers. Cadmus estimated energy savings starting in September 2010, three months after the start of Ameren Illinois' Program Year 3 (June 2010). We estimated savings for two periods: Program Year 3, covering September 2010-May 2011; and for 12 months, covering September 2010-August 2011.

In Program Year 3, the Home Energy Report pilot saved 123.5 kWh and 5.6 therms per home. This represented 1.4 percent of electricity and 0.6 percent of gas consumption during the period. Over twelve months, the pilot saved 164.9 kWh (1.2 percent of annual electricity consumption) and 6.8 therms (0.7 percent of annual gas consumption). These results are presented in Table ES-2. The program saved approximately 5,400 MWh and 242,000 therms. Due to the attrition of some accounts becoming inactive, the total program impacts are less than the product

of per-home savings and the number of customers in the treatment group (50,000). These savings are in line with savings estimated for other Home Energy Report programs.

Table ES-2. PY3 and Annual Opower Program Savings

		kWh	Relative Precision	Therms	Relative Precision
Per Participant	PY3	123.5	14%	5.6	23%
	Annual	164.9	13%	6.8	19%
All Customers	PY3	5,399,393	14%	241,818	20%
	Annual	7,247,563	13%	298,333	20%

Some Home Energy Report pilot savings were achieved through the purchase and installation of energy saving equipment incented through other Ameren programs. We found that Home Energy Report customers were more likely to participate in the Ameren Illinois incentive programs than those in the control group. We refer to these savings as "savings overlap." Table ES-3 shows the amount of savings overlap, using evaluated net savings results based on program evaluations for Ameren Illinois' incentive programs.

Table ES-3. Home Energy Report Savings Overlap With Other Ameren Illinois Programs

Program	Net kWh Savings	Net Therms
ARCA Appliance Recycling	37,677	-
Home Energy Performance	23,427	12,665
HVAC New	103,256	9,796
Lighting & Appliances	(4,152)	-
Total	160,209	22,461

The savings estimates depend on the assumption that Opower randomly assigned homes eligible for the program to treatment and control groups. As a critical first step in our analysis we tested this assumption. We conducted t-tests of the statistical equivalence of average daily energy consumption for the control group and the treatment group in the pre-treatment period. We also conducted a chi-squared test of the equivalence of the geographic distribution of treatment and control group customers using information about a home's zip code location. Finally, we tested for differences between treatment and control groups in the responsiveness of energy use to heating and cooling degree days. In all cases, we could not reject the hypothesis of statistical equivalence, suggesting that customers were randomly assigned to the treatment and control groups.[1]

Overall, the Home Energy Report pilot rolled out smoothly and customers generally seem to be happy with the program. The program resulted in savings and encouraged customers to participate in Ameren Illinois' other incentive programs. The low call volume and low opt-out rates suggest that the 50,000 customers in the treatment group are satisfied with the program.

[1] Opower's contracts with vendors of home and demographic characteristic data prevent them from sharing the data with Cadmus and therefore we could not perform additional tests of statistical equivalence.

The relationship between Opower and Ameren Illinois has been productive and collaborative. The only negative comments we heard were that the Opower team can be a bit aggressive when it comes to sales, and improvements or changes to the program were rather costly. Additionally, Ameren Illinois would like to see more regular reports from Opower.

Recommendations

Below are a few recommendations for future programs.

- Opower should make the Ameren Illinois password for the Web portal easier to use. Stakeholders commented on the difficulty in accessing the site.
- Ameren Illinois should scrub the customer list for any who may not be appropriate for the treatment group. For example, exclude from the treatment groups customers who are on Ameren Illinois' list of those on life support.
- The complaints Ameren received about the program are typical for this type of program. Ameren should train its customer service staff to provide specific information about other residential programs for which a particular customer is eligible. This approach would offer immediate value to disgruntled customers.
- Opower should provide Ameren with more timely metric reports. The new program management team (Conservation Services Group) needs to report to Ameren Illinois monthly, but Opower currently issues its reports on a quarterly basis. Opower should consider allowing customer access to the reports any time for immediate download.
- Cadmus performed tests of the statistical equivalence of the treatment and control groups, and could not reject the hypothesis of equivalence. However, to meet best practices in future program implementation of randomized control experiments, Ameren Illinois and Opower should arrange for the treatment and control groups to be chosen by an independent evaluator or an independent third party.

2. Introduction

Program Description

As part of its residential portfolio, Ameren Illinois began a two-year Home Energy Report pilot program in August 2010.

Program Goals

The specific goals of the Home Energy Report pilot program were to:

- Reduce energy consumption by driving energy-efficient behaviors. This was to be accomplished by making customers more aware of how their behavior impacts their energy use through comparisons with others' energy use.
- Increase energy-efficiency program participation through a powerful, targeted marketing channel.
- Boost customer engagement and education by helping customers understand and save energy.
- Educate customers about no-cost and low-cost energy saving measures and behaviors.

In the first year of this program, Ameren Illinois and Opower targeted dual-fuel customers who live in high-population areas with higher-than-average energy use. Participants received a Home Energy Report in the mail that included the following information:

- Comparison of the customer's energy usage to past usage.
- A "neighbor comparison" of a customer's consumption to that of comparable customers in the same geographical area.
- Tips for reducing energy consumption, tailored to the customer's home energy profile (e.g., type of home, square footage, etc.).

In other studies, this set of information has been shown to stimulate customers to reduce their energy use, creating an average energy savings of 1% to 3%, depending on use patterns.

The program has an online component featuring a portal that allows customers 24-hour access to personalized reports and provides tips.

The program was implemented by Opower, a privately held software-as-a-service company that partners with utility providers to promote energy efficiency through its Home Energy Reports program. Opower administers programs across the country with more than 60 utilities.

Program Implementation

Ameren Illinois implemented its program using an experimental design with a random assignment of eligible customers to treatment and control groups. The pilot program focused on customers who lived in highly populated areas (e.g., Peoria, Champaign downtown metro, east St. Louis), were dual fuel, and had above-average annual energy use. From this customer population, Opower randomly selected 50,000 customers for inclusion in a treatment group and 50,000 customers for a control group. The treatment group received Home Energy Reports

beginning in April 2010. This protocol was chosen on Opower's recommendation based on its best practices, continual testing, and metrics from previous Opower pilots.

In the program's first year, Opower sent six Home Energy Reports to each treated home for a total of 300,000 reports. The first report contained a "welcome" insert that explained the program. Once a consumer received a report, they could update their home energy profile or establish a goal on the customer portal Website. On the Website, customers see their account page, the number of people in the household, the square footage, and energy saving tips. Opower purchases this information from a market research company to include in the reports. Customers can make a commitment to implement energy-efficient practices, such as changing their incandescent light bulbs to compact fluorescent lamps (CFLs) or lowering their thermostats.

For the first four months, the treatment group received Home Energy Reports once a month; after that, the frequency switched to bimonthly. The reports used "smiley face" symbols to positively motivate customers practicing energy efficiency. The reports contained easily achievable no-cost or low-cost energy saving suggestions.

Although the online customer portal was not the pilot's focus, Opower did increase traffic to the portal by 2.5 times in the January-February timeframe. Opower e-mailed 3,300 participating customers who had provided e-mail addresses to Ameren Illinois, then monitored Web analytics. The e-mail and hard-copy reports look very similar as they feed off the same system. A customer would stop receiving the reports only by opting out via phone or e-mail.

In the summer, Ameren Illinois supplemented the Home Energy Report with a door hanger and refrigerator magnet reminding customers to set their thermostats to save energy.

Evaluation Questions

The evaluation is intended to answer the following research questions:

- Do participants show greater enrollment in Ameren Illinois' other energy-efficiency offerings?
- What are the MWh and therm savings from this program?
- Does program response vary by customer demographic or season?
- What improvements can be made to the program from the perspective of the stakeholders?

Report Organization

The remainder of this report is organized as follows:

- Section 3. Evaluation Methods
- Section 4. Impact Results
- Section 5. Process Results
- Section 6. Conclusions and Recommendations
- Appendix A. Unconditional Model Specification

3. Evaluation Methods

Analytical Methods

The research activities that informed this evaluation are summarized in Table 1. This section describes each major task and data source.

Table 1. Summary of Evaluation Approach (PY2)

Task	Impact	Process	Details
Stakeholder Interviews		♦	Interviews with key Ameren Illinois and Opower staff.
Billing Analysis	♦		Analysis of100,000 treatment and control group customers
Database Cross Check	♦		Comparison of the rate of participation in PY 3 Ameren Illinois incentive programs between Opower treatment and control groups.

Stakeholder Interviews

We conducted simple one-on-one phone interviews, , with key program staff from Ameren Illinois as well as from Opower. The purpose of these interviews was to help uncover areas of early success and challenges to success. The interviews provided a rich source of key insights into the daily workings of the program from day one. We met with each stakeholder for an average of one hour to discuss the program vision, goals, services, educational processes, stakeholder participation, barriers, marketing, reporting and future outlook. Types of questions included stakeholder insights on the drivers and barriers to participation specifically for Ameren Illinois customers.

Billing Analysis

The objective of the billing analysis was to estimate the Home Energy Report program electricity and gas savings in Plan Year (PY) 3. Opower randomly selected 100,000 dual fuel customers who met program eligibility requirements. These were then randomly divided into treatment and control groups.

The savings were estimated using Difference-in-Differences (D-in-D) approach, which is a fixed effects regression analysis of the monthly gas and electric bills of treatment and control group customers.[2] The D-in-D refers to the model's implicit comparison of consumption before and after treatment of treatment and control group customers. The model includes customer specific intercepts (i.e., fixed effects) to capture differences between customers in their non-weather sensitive consumption. The estimation period covered September 2009 to August 2011 and included bills for 12 months in the pre and 12 months in the post-period.

The general model estimated had the following form:

$$ADC_{it} = \alpha_i + \beta_1 POST_{it} + \beta_2 PROGRAM_{it} \times POST_{it} + \mu_{my} + \varepsilon_{it} \qquad \text{(Equation 1)}$$

Where ADC is the average daily consumption (kWh or therms) for home i in month t. Other components of the model are:

[2] We also performed an unconditional analysis for comparison purposes and included the results in Appendix A.

α_i = home intercept corresponding to non-weather sensitive average daily consumption

POST = indicator variable for whether the period is pre- or post-treatment.[3] This variable is defined with a one month lag to allow for time for the home to implement energy savings measures. The first month in the post period was September 2010.

PROGRAM = an indicator variable for program participation (=1, if in treatment group; and =0, otherwise)

μ_{my} = month-by-year fixed effects intended to capture weather and other effects on consumption specific to the month[4]

ε_{it} = error term for customer *i* in month *t*

The coefficient β_1 represents the impact of factors affecting the consumption of all customers (i.e,, treatment and control) between the pre-treatment and treatment periods. The coefficient β_2 represents the average treatment effect of the program (the kWh or therm savings impact), controlling for changes in participant usage unrelated to the program.

Identification of the program savings derives from the random assignment of eligible customers to treatment and control groups and measurements for both groups on consumption before and after the treatment. (Below, we report results from tests of the statistical equivalence of the treatment and control groups suggesting assignment to the treatment was random.) Because the program design used random assignment to allocate customers to the treatment and control groups, the coefficient on $PROGRAM_{it}$ x $POST_{it}$ has a clear causal interpretation as the program effect. The large size of the treatment and control groups means that even small average treatment effects (< 1%) can be detected.[5]

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[4] This specification assumes that all control and treatment group customers are sampled from the same area and experience the same weather. If this assumption does not hold, the model would substitute location-specific monthly weather variables (e.g., HDDs, CDDs) for the month-by-year fixed effects. The program impacts were estimated using both specifications. Cadmus also estimated Equation 1 for each of the metro areas: Peoria, Champaign, and East St. Louis.

[5] Also, in this framework, it is possible to measure heterogeneous treatment effects by including interaction terms between POST x PROGRAM and observable customer characteristics. For example, the following specification would be used to estimate how savings evolve in the post-treatment period and the persistence of savings in homes in the second year of the program:

$$ADC_{it} = \alpha_i + \beta_0\, PROGRAM_{it} + \beta_1\, POST_{it} + \Sigma_{p=2}^{P}\beta_{2p}\, POST_{it} \times POSTMONTH_{ipt} + \beta_2\, PROGRAM_{it} \times POST_{it} + \Sigma_{p=2}^{P}\beta_{2p}\, PROGRAM_{it} \times POST_{it} \times POSTMONTH_{ipt} + \mu_{my} + \varepsilon_{ipt} \quad \text{(Equation 2)}$$

where p indexes the month number in the post-period for a building, p=1, 2, …, P and all of the other variables are defined as before. In this framework, the average program savings in a home in month p in the post period equals: Average monthly savings in post-period month 1 = β_2, Average monthly savings in post-period month p = $\beta_2 + \beta_{2p}$, for p=2 to P.

Database Cross Check

The Home Energy Report program savings reflect both behavioral changes, such as turning off lights in unoccupied rooms and adjusting thermostat settings, and investments in energy savings equipment, such as high-efficiency furnaces and CFLs. Savings from measures that were rebated through Ameren Illinois' energy-efficiency programs are counted in both the Home Energy Report program and the rebate programs, and thus are double-counted. In this section, we estimate the amount of Home Energy Report program gas and electric savings that were counted in other Ameren Illinois rebate programs using tracking data provided by Ameren.

Calculating the amount of savings overlap is relatively straightforward because of the Home Energy Report program's experimental design. To illustrate, suppose that there are an equal number of customers in the treatment and control groups and that information exists about the installation of Measure A, which is promoted by the utility, for both groups. Customers in the treatment and control groups are assumed to receive the same treatment from the utility for the program promoting Measure A (i.e., they face the same marketing and incentives). Because customers were randomly assigned to the treatment and control groups, any difference between the groups in the installation of Measure A can be attributed to the behavioral program.

Ameren's Program Year 3 began in June 2010 and ended in May 2011. As Home Energy Report customers received their first reports throughout the month of August 2010, only program data with recorded dates of September 2010 or later were included. Therefore, the period in which overlapping savings were calculated was from September 2010 through May 2011.

Data Sources

The following data sources were used in the impact and process evaluation:

- ***Data on customer assignments to treatment and control groups.*** Opower assigned 50,000 Ameren Illinois dual fuel customers eligible for the program to a treatment group and 50,000 program eligible customers to a control group. Treatment group customers received Home Energy Reports. Control group customers did not receive Home Energy Reports and were not told they belonged to the control group.
- ***Information about the date the first report was sent.*** Ameren Illinois customers received their first reports in August 2010. In the billing analysis, it was assumed that September was the first month that the program could have had an impact on electric and gas consumption.
- ***Monthly billing histories for all treatment and control group customers.*** We obtained gas and electric billing data between August 2009 and September 2011. The billing analysis used bills from between September 2009 and August 2011, which resulted in 12 months in the pre- and 12 months in the post-period. Because some customer accounts became inactive during the post-period, not all treatment and control group customers had 12 months of bills in the post-period. We excluded customers with fewer than 11

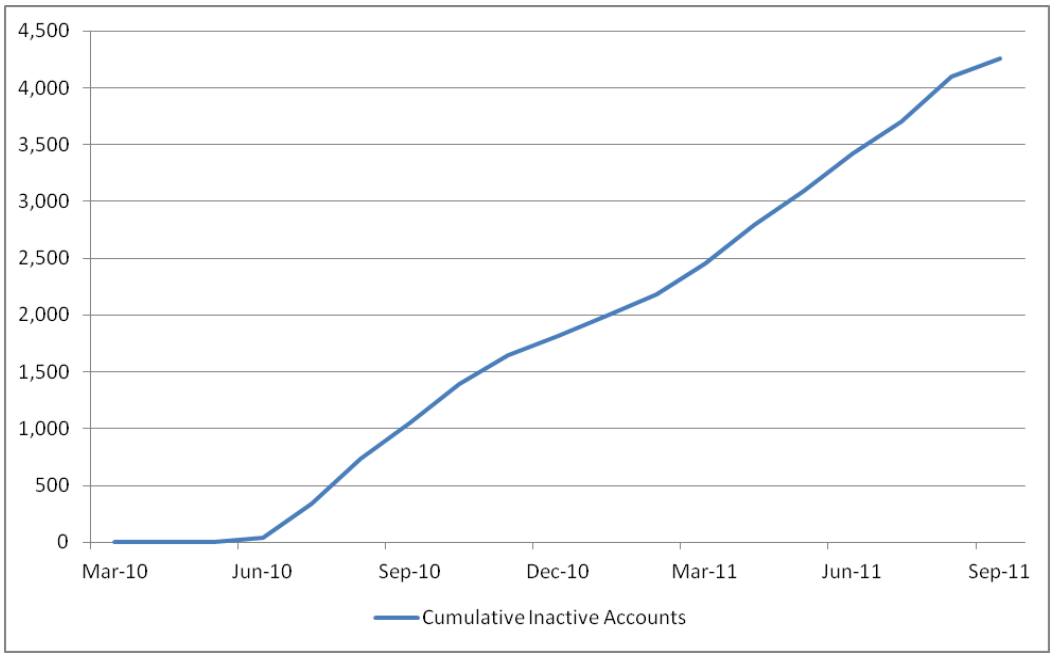
bills or 330 days of billing history from the estimation sample.[6] Table 2 below shows the sizes of the treatment and control group customer samples used in the billing analysis:

Table 2. Electric and Gas Estimation Samples

Fuel	Control Group	Treatment Group
Electric	45,776	45,254
Gas	45,779	45,261

Figure 1 shows the cumulative attrition from inactive accounts in the treatment group. Over 4,200 of the 50,000 Opower customer accounts became inactive and remained so during the first twelve months of the program period.

Figure 1. Cumulative Inactive Accounts in the Treatment Group



[6] We dropped inactive accounts because we estimated average monthly savings over the 12 months of the first program year. From other similar evaluations, we know the Home Energy Reports program results in seasonally varied savings (tending to be largest in the summer and winter months); so savings of inactive accounts depend on when the account became inactive. To control for influences of inactive accounts on average program savings, we dropped them from the analysis. We did compare active and inactive accounts, and found inactive accounts had marginally lower electricity consumption and higher gas consumption, but differences were very small. We hypothesize inactive accounts may be poorer households, with less-insulated homes.

We tested effects of omitting inactive accounts from the savings analysis by re-estimating the models and including both active and inactive accounts. The resulting model and savings estimates were the same (differences were not evident to 3 decimal places). Thus, gas and electricity savings estimates appear robust with the exclusion of inactive accounts from the analysis.

The regression-estimated monthly per-customer impact was multiplied by the total number of treatment group customers who received a report in that or a previous month and whose account was still active.

- ***Monthly weather data.*** We used daily temperature data from the nearest weather station to calculate the heating and cooling degree days during the days covered in each customer bill. These data were then merged with the monthly billing data.
- ***Savings from rebated energy efficiency measures in treatment and control group homes between September 2010 and June 2011.*** These data were used to estimate the amount of Home Energy Report program savings counted in other Ameren Illinois rebate programs in PY3.
- ***Interviews with Ameren Illinois and Opower Staff.***

4. Impact Results

Tests of Statistical Equivalence of Treatment and Control Groups

A key assumption of our analysis was that Opower randomly assigned homes eligible for the program to treatment and control groups. We tested this assumption as the first step in our analysis. We conducted t-tests of the statistical equivalence of average daily energy consumption for the control group and the treatment group in the pre-treatment period. We also conducted a chi-squared test of the equivalence of the geographic distribution of treatment and control group customers using information about a home's zip code location. In both cases, we could not reject the hypothesis of statistical equivalence, consistent with the random assignment of customers to treatment and control groups.

Table 3 shows the results of the analysis of average daily consumption in the pre-period. For both gas and electricity, we could not reject the hypothesis of statistical equivalence, suggesting Opower randomly assigned customers to the treatment and control groups. The difference in mean customer average daily consumption was 0.03 kWh and 0.0 therms. We found a chi-squared value of 249, with a p-value of 0.24,

Table 3. Results of T-Test on Equal Consumption

Fuel	Program Group	Mean ADC	t test	p-Value
Electric	Control (N=50,000)	36.43	-0.42	0.68
	Treatment (N=50,000)	36.46		
Gas	Control (N=50,000)	2.67	-0.94	0.35
	Treatment (N=50,000)	2.67		

In addition, Cadmus examined energy use for space cooling and heating in the pre-treatment period to see whether treatment and control group customers responded similarly to weather. We expected some program savings would derive from changes in weather-sensitive energy uses.

To compare weather-sensitive energy use of treatment and control group customers in the pre-treatment period, Cadmus estimated the following regression model:

$$ADC_{it} = \alpha_i + \mu_{my} + \beta_1 HDD_{it} + \beta_2 HDD_{it}^2 + \beta_3 HDD_{it}^3 + \beta_4 CDD_{it} + \beta_5 CDD_{it}^2 + \beta_6 CDD_{it}^3 + PROGRAM_{it}*(\theta_1 HDD_{it} + \theta_2 HDD_{it}^2 + \theta_3 HDD_{it}^3 + \theta_4 CDD_{it} + \theta_5 CDD_{it}^2 + \theta_6 CDD_{it}^3) + \varepsilon_{it}$$

where

α_i = customer fixed effect

μ_{my} = month-by-year fixed effects

HDD_{it} = average daily heating degree days in month t

CDD_{it} = average daily cooling degree days in month t

$PROGRAM_{it}$ = an indicator variable for program participation (=1, if in treatment group; and =0, otherwise)

The coefficients θ measure any difference between treatment and control groups in energy use related to heating and cooling. If assignment to treatment and control groups was random, these coefficients should be statistically indistinguishable from zero.

We estimated models for gas and electricity use (dropping the CDDs from the gas model), and with and without the month-by-year fixed effects.

In each model no θ coefficients on interaction terms between participation and HDDs or CDDs were statistically significant, suggesting no differences between treatment and control groups in their weather-sensitive energy use in the pre-period. We also could not reject the hypothesis of the joint insignificance of the coefficients on interaction terms.

Conditional Average Monthly Electric and Gas Savings

Table 4 reports our estimated program impacts on average daily electricity consumption using various regression model specifications.[7] After controlling for weather and customer-fixed effects, the program impacts are more precisely estimated. Because of the program's experimental design and the large numbers of customers in the treatment and control groups, the results are robust to changes in the model specification.

Table 4. Conditional Average Program Treatment Effects for Electricity

	Model 1	Model 2	Model 3	Model 4
Post	0.183	0.568	-0.501	-0.440
	(0.026)	(0.048)	(0.026)	(0.048)
Post x program	-0.454	-0.452	-0.454	-0.454
	(0.037)	(0.037)	(0.037)	(0.037)
Customer fixed effects	Yes	Yes	Yes	Yes
Month-by-year fixed effects	No	Yes	No	Yes
Weather polynomials	No	no	Yes	Yes
R^2	0.0001	0.484	0.524	0.529

Notes: Dependent variable is average daily consumption in a month. Standard errors in parentheses. Models estimated by OLS and standard errors adjusted for clustering at customer level. N is the number of customer bills used in the analysis.

Model 1 includes customer-fixed effects but does not control for weather. The conditional average treatment effect of the Program was -0.454 kWh per day with a relative statistical precision of 13%. This point estimate translates to 1.2% of average daily consumption and 13.8 kWh in monthly electricity savings. The second specification adds month-by-year fixed effects to capture the impacts of weather and other time-dependent variables on consumption. The third specification drops the month-by-year fixed effects and adds third degree polynomials in heating and cooling degree days. The fourth specification includes month-by-year fixed effects and the degree day variables. Inclusion of controls for weather significantly increases the R^2 of the

[7] We estimated all of the models by ordinary least squares (OLS), and we adjusted the standard errors for correlation over time in a customer's consumption using Huber-White robust standard errors. See Bertrand, Marianne, E. Duflo, and S. Mullainathan. *How Much Should We Trust Difference-in-Differences Estimates.* Quarterly Journal of Economics, 119 (1), pp. 249-275. 2004.

model, but the estimated savings are robust to the changes in specifications 1, 2, 3, and 5 and almost identical to that in model 1.[8]

Cadmus also estimated electricity (and gas) savings as a function of weather. As the Opower program targets weather-dependent space heating and cooling participant behaviors, it was expected program savings would be a function of weather. Our analysis, described in the Appendix, shows average daily savings in the weather-sensitive gas and electric models and those in Table 7 are identical to two or more decimal places, suggesting the model specifications in Table 7 capture any weather-sensitive savings.

Monthly Electricity Savings

Home Energy Report program savings change over time as the program ramps up, and also with changes in demand for lighting, heating, and cooling. How did savings evolve over PY3? In Equation 2 (see footnote above), we allow the conditional average treatment effect of the program to vary over months of the year. Figure 3 shows the results of estimating Equation 2. Opower sent the first reports in August 2010, and in September, there is evidence of modest program savings (0.13 kWh per day, 0.3%). Savings then increase steadily before leveling off around 0.5 kWh per day. The ramping of savings is consistent with gradual adoption of energy-savings behaviors after receiving the first reports, a pattern found in other Opower program evaluations.

[8] Cadmus also estimated specification 4 of Equation 1 for each metro area. The conditional average treatment effects in each metro area were as follows (standard errors in parentheses): Champaign -0.377 (0.072); Peoria -0.469 (0.060); and East St. Louis -0.486 (0.060). Metro area treatment effects were not statistically different.

Figure 2. Opower Program Electricity kWh and Percentage Savings

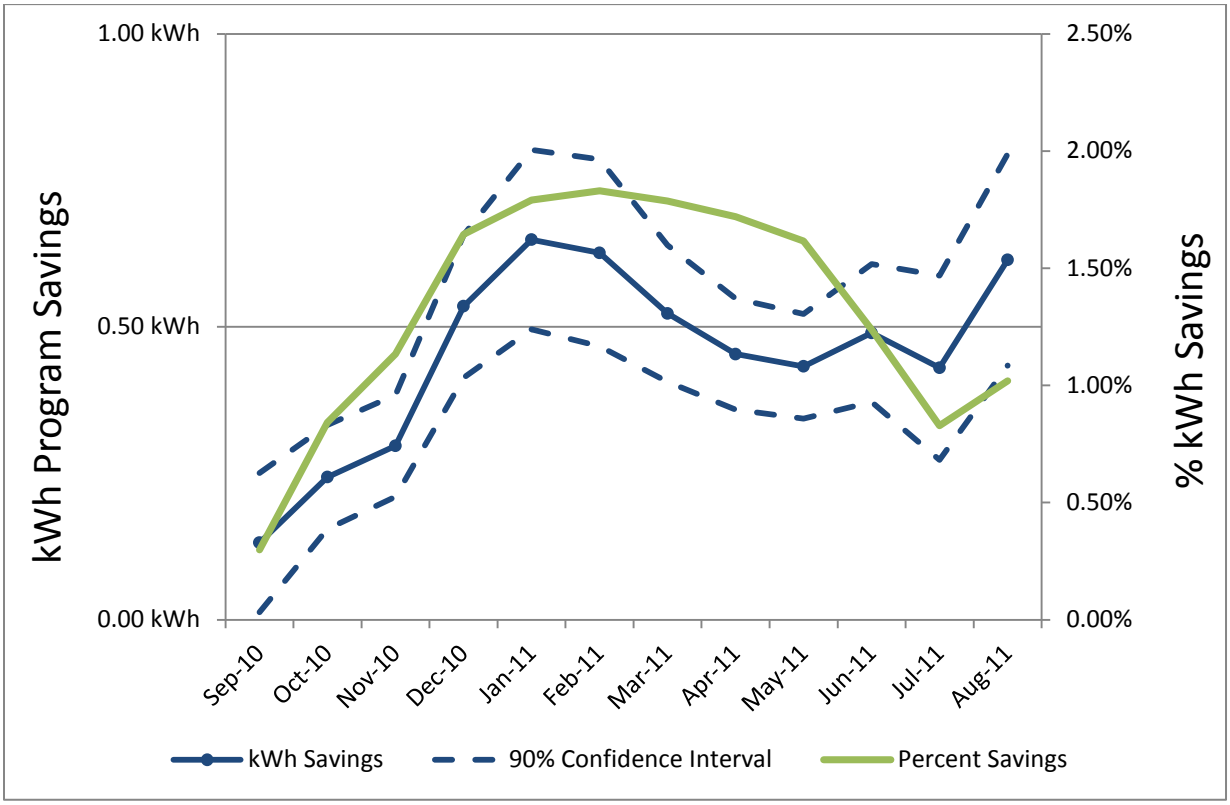


Figure 2 also shows that electricity savings follow a seasonal pattern. Absolute savings were greatest during the winter months, reaching a peak of 0.65 kWh per day (1.8%) in January. The next largest average daily savings were obtained in February (0.63 kWh, 1.8%). Savings decrease slightly in the spring and summer months before trending upward again in August (0.61 kWh, 1.0%). If a large percentage of savings derive from changes in lighting, absolute and percent savings would tend to be highest in winter.

PY3 Estimate of Home Energy Report Program Electricity Savings

The Home Energy Report program started in August and generated savings for nine months of PY3 (September 2010-May 2011). We used the estimates of monthly treatment effects shown above to estimate the PY3 savings. We also estimated and reported program savings for the 12 months between September 2010 and August 2011.

PY3 savings were estimated as the weighted sum of the average monthly treatment effects:

$$\text{PY3 Savings} = \sum_{p'=4}^{12} \beta_{2p'} * \text{Days}_{p'} * \text{TreatedHomes}_{p'}$$

Where:

p'	=	Indexes the months of PY3 starting with June 2010
$\beta_{2p'}$	=	The average kWh savings in month p' from Equation 2
$\text{Days}_{p'}$	=	The number of days in month p'

$TreatedHomes_{p'}$ = The number of homes receiving the treatment in that month or in a previous month and whose account was still active

Table 5 shows estimates of per participant and program savings for PY3 and the twelve months covering September 2010-August 2011 and relative precision estimated at the 90 percent level of confidence. Due to inactive accounts and lapses in billing data, total program savings are less than the product of the per-participant savings and the number of treated homes (N=50,000).

Table 5. Program Year 3 and Annual Savings

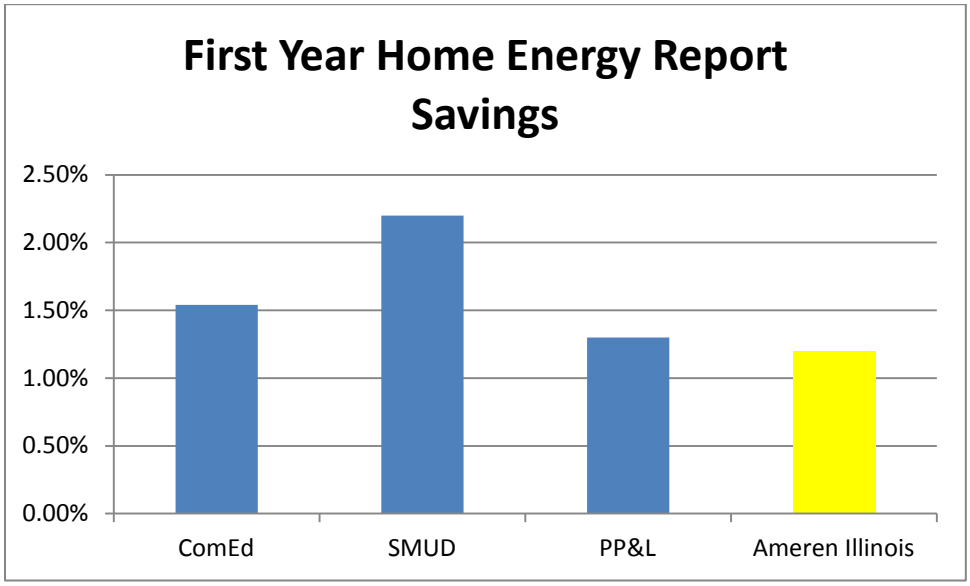
		kWh	SE	Relative Precision
Per Participant	PY3	123.5	10.5	14%
	Annual	164.9	13.3	13%
Program	PY3	5,399,393	458,126	14%
	Annual	7,247,563	586,032	13%

In PY3, per participant electricity savings were 123.5 kWh, which represent 1.4 percent of electricity consumption. Annual savings include the months of June, July, and August of 2011 and were 164.9kWh per participant, or 1.2 percent of electricity consumption.

In PY3, the program saved about 5,400 MWh of electricity. For the year, electricity savings were 7,248 MWh. We compared this result to Opower's own estimate of annual savings which was 7,443 MWh, a difference of less than 3 percent.

Cadmus also compared the results to several other programs in the first year of implementation. As shown in Figure 4, Ameren Illinois' results are close to others, although slightly lower. This could be due to the relatively lower energy rates in Ameren Illinois' area compared to Sacramento Municipal Utility District, ComEd, and Pennsylvania Power & Light.

Figure 4. Comparison of Home Energy Report Electricity Savings



Conditional Average Monthly Gas Savings

Table 6 reports estimates of the Home Energy Report program impacts on average daily gas consumption using the different model specifications. As in the electricity models, the gas results are fairly robust to changes in the model specification.

Table 6. Conditional Average Program Treatment Effects for Gas

	Model 1	Model 2	Model 3	Model 4
Post	-0.019	-0.011	-0.070	-0.007
	(0.002)	(0.002)	(0.002)	(0.002)
Post x program	-0.018	-0.019	-0.019	-0.019
	(0.002)	(0.002)	(0.002)	(0.002)
Customer fixed effects	Yes	Yes	Yes	Yes
Month-by-year fixed effects	No	Yes	No	Yes
Weather polynomials	No	No	Yes	Yes
R^2	0.00003	0.801	0.834	0.836

Notes: Dependent variable is average daily consumption in a month. Standard errors in parentheses. Models estimated by OLS and standard errors adjusted for clustering at customer level.

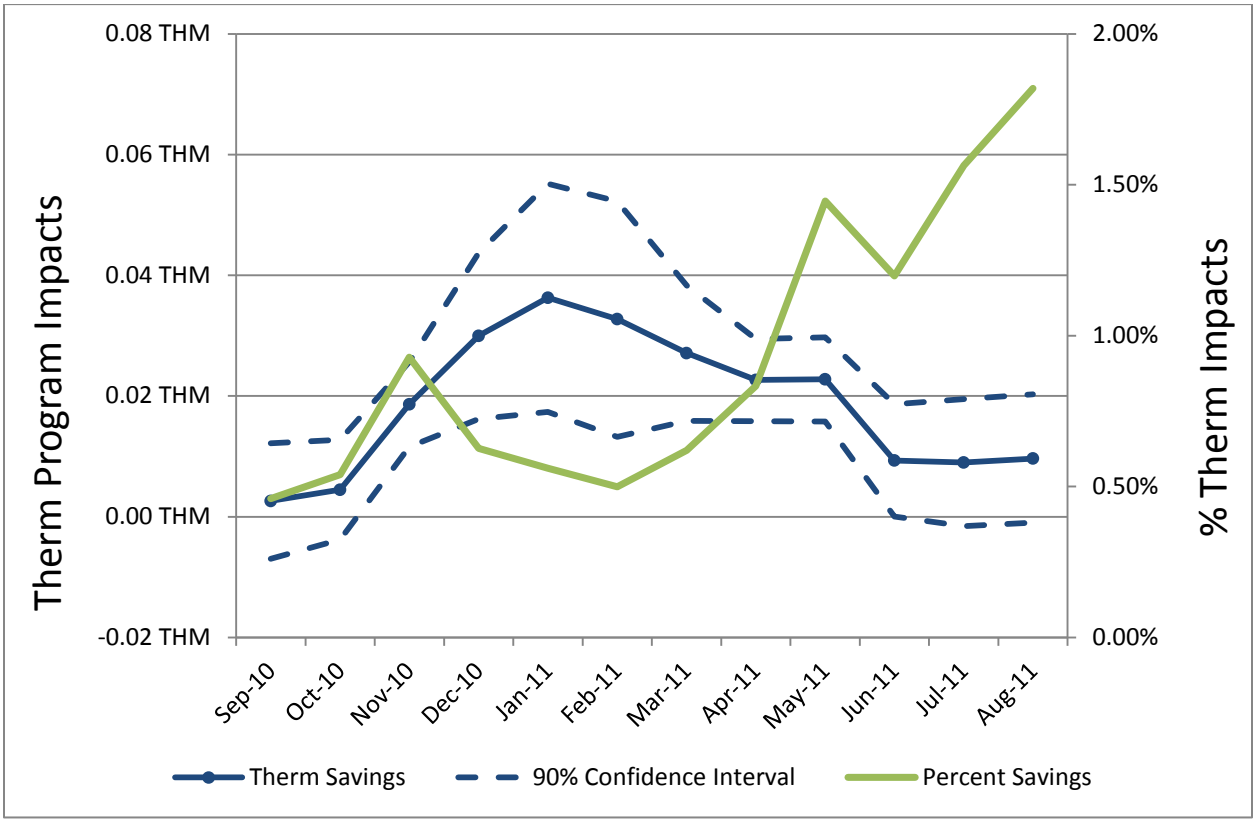
In Model 1, which does not control for weather, the conditional average treatment effect of the Program was -0.018 therms per day, with relative precision of 20% at the 90 percent level of confidence. The point estimate translates to 0.7% of average daily gas consumption between September 2010 and August 2011. The second and third specification includes either month-by-year fixed effects or third degree polynomials in heating and cooling degree days. The model R^2s increase significantly after controlling for weather, as gas is used for heating and thus very weather sensitive. Savings also increase slightly after controlling for weather to 0.019 therms per day. The savings are unchanged after controlling for month-by-year fixed effects and weather.[9]

Monthly Gas Savings

Figure 3 shows how program gas savings evolved between September 2010 and August 2011. In addition to the seasonality of electricity savings, gas savings showed strong seasonal patterns because gas demand in gas heat homes is very weather sensitive. Average daily gas savings during the summer and shoulder months were positive but statistically indistinguishable from zero in September, October, June, July and August. Savings ranged between 0.00 and 0.02 therms per day. Gas savings during the winter heating months were significantly larger, between 0.03 and 0.04 therms per day and statistically different than zero.

[9] Cadmus also estimated specification 4 of Equation 1 for each metro area. Conditional average treatment effects in each metro area were as follows (standard errors in parentheses): Champaign -0.024 (0.005); Peoria -0.020 (0.004); and East St. Louis -0.014 (0.003). Only the difference between Champaign and East St. Louis in gas savings was statistically significant. Homes in Champaign experienced a larger average reduction in gas consumption from the program than homes in East St. Louis.

Figure 3. Opower Program Gas Therm and Percentage Savings



PY3 Estimate of Home Energy Report Program Gas Savings

Cadmus estimated PY 3 and annual gas savings with the approach we used for electricity. PY 3 savings were estimated as the weighted sum of the conditional average monthly treatment effects between September 2010 and May 2011:

$$\text{PY3 Savings} = \sum_{p'=4}^{12} \beta_{2p'} * \text{Days}_{p'} * \text{TreatedHomes}_{p'}$$

where all of the variables are defined as before except $\beta_{2p'}$ now represents the average *therm* savings in month p' from Equation 2. Annual savings were the weighted sum of the treatment effects between September 2010 and May 2011.

Table 7 shows the program and per-participant PY3 and annual gas savings estimates. Due to inactive accounts and lapses in billing data, total program impacts are less than the product of per-participant impacts and the number of participating households.

Table 7. PY3 and Annual Gas Savings

		Therms	SE	Relative Precision
Per Participant	PY3	5.6	0.79	23%
	Annual	6.8	0.81	19%
All Customers	PY3	241,818	34,300	23%
	Annual	298,333	35,532	20%

In PY3, per home gas savings were 5.6 therms, which represented 0.6% of gas consumption. Annual savings include the months June, July, and August of 2011 and were 6.8 therms per participant, or 0.7% of gas consumption.

PY3 and annual program savings were, respectively, 241,818 and 298,333 therms. Opower's annual gas savings estimate was 299,868 therms, a difference of less than 1 percent from the evaluated savings.

Database Cross Check

The amount of savings overlap was estimated by matching program treatment and control group customers to PY3 energy efficiency participation data and calculating the difference in the groups' rebated savings. [10] This difference represents the impact of the program on savings in Ameren Illinois rebate programs. These savings are counted in both the Home Energy Report program and the other rebate programs.

The table below shows the amount of program gas and electric savings counted in each residential rebate program and in total using PY3 evaluated net savings estimates from each program. Treatment and control group customers participated in four rebate programs in PY3. The Heating and Cooling program accounted for most of the electricity savings overlap, and Heating and Cooling and Home Energy Performance accounted for most of the gas savings overlap. For example, 103,256 kWh of the program electricity savings equal were also counted in the HVAC program.

Table 8. Summary of Savings Overlap with Rebate Programs

Program	Treatment Group		Control Group		Difference in Group Savings (Double-counted Savings)	
	kWh	Therms	kWh	Therms	kWh	Therms
ARCA Appliance Recycling	466,349	-	428,671	-	37,677	-
Home Energy Performance	55,170	24,645	31,743	11,980	23,427	12,665
HVAC	527,560	62,084	424,304	52,289	103,256	9,796
Lighting & Appliances	77,083	-	81,235	-	(4,152)	-
Total	1,126,161	86,729	965,953	64,269	160,209	22,461

The total electricity savings overlap was approximately 160 MWh. This represented 3.0% of the PY3 Home Energy Report pilot electricity savings and 1.2% of the total savings of the Ameren Illinois incentive programs.

The total gas savings overlap was 22,461 therms. This represented 9.3% of the PY 3 Home Energy Report pilot savings and 3.0% of the total savings of the Ameren Illinois incentive programs.

[10] As the program could have generated savings between September 2010 and May 2011, we only used records with installation dates in these months.

It is also possible that overlap savings occur between the Home Energy Report pilot and Ameren Illinois's upstream lighting programs. We did not estimate the double-counting of these program savings because information is not available to identify customers who purchase CFLs through the upstream program.

5. Process Evaluation

Stakeholder Interview Findings

The stakeholder interviews revealed detailed information about program processes and progress. This section reports the findings from all stakeholder interviews to identify early successes and challenges. It also assesses the effectiveness of administration and implementation.

Roles and Responsibilities

The Ameren Illinois program team consisted of a program manager and a customer representative team. The program manager worked closely with Opower to oversee the program. The customer service representatives took care of communication with customers through phone calls, handling customer opt-outs, and updating customer profiles.

Opower had a large program team. Its roles and responsibilities from an engagement and management standpoint were to design the right offering to achieve stated goals and to monitor delivery so it can be optimized during the life of the program. The team consisted of an engagement and management team, a technical project manager, a consumer-marketing team, an energy efficiency content team, a design team, and an analytics team. The energy-efficiency content team created the tips and handled messaging. The analytics team was involved initially as part of the design. The analytics team constantly monitored the energy savings and engagement with the reports and Website; they delivered reports quarterly. The management team spent time before the program was launched on planning activities; they remained in touch during the maintenance phase.

Program Services and Educational Process

Completion of the pilot program roll-out process took seven weeks. During this phase, the Ameren Illinois and Opower managers spoke daily. Once the program was rolled out, they held weekly phone calls, which transitioned into biweekly phone calls. During the program's maintenance phase, they talked only as needed, but maintained constant communication through e-mail. They also met in person quarterly to discuss results.

The launch went very smoothly according to both stakeholder teams.

Internal education helped program implementation succeed. The program started with an in-person meeting between the full Ameren Illinois' and Opower teams. The Opower team presented an overview of the program and explained the implementation plan. Ameren Illinois set the task assignments and milestones. Opower next provided program design training directly to the Ameren program manager. Finally, Opower trained Ameren Illinois' customer service representative team. Sixteen customer service representatives received two days of training, which included three training modules. The first module presented the Home Energy Reports. The second presented the Web portal; specifically, representatives were taught how to help customers update their energy profile and how to opt a customer out of the program. The third module was called the "complaint department module" and involved learning how to respond to e-mails and phone calls. Opower made sure that representatives had the necessary tools and resources to answer customers- frequently asked questions.

Opower also engaged Ameren Illinois' IT team. They were able to obtain a security clearance for the new group and set up secure file transfer protocol sites to get the data up and running in two

weeks. According to stakeholders, it went smoothly. The reports come three to four days after customers receive their bills. To date, in 21 billing cycles, they have had no problems. They also have not hit any snags on the program side and have not had to make any adjustments to the program. The program team reports that the IT team did a great job.

Challenges and Opportunities

One challenge the program encountered, which other, similar programs have encountered as well, was a negative perception by some customers when they received their report. Ameren Illinois' customer service representatives logged customer complaints in the system. Some of the complaints received were:

- Customers do not think their house is as big as the one next door
- Customers' profile is not up to date
- Customers do not like that "big brother is watching"
- Customers believe they should be able to use as much electricity as they want because they are buying it.
- Customers do not like being compared to their neighbors.

Some customers called to explain why they used more energy. Examples were customers who are on life support, customers having multiple generations living in one house, and senior citizens who said that they were trying to reduce but they do not know what other steps to take because they have limited income. (A positive aspect of calls from senior citizens was that they could be referred as good candidates for an energy audit. In fact, the customer service representatives flag those customers and send them to a manager. The manager then calls them personally and offers an energy audit.) Another group of customers called to object to the use of paper for reports. Ameren Illinois has a list of customers on life support and felt they should take them off the list in the future as they tend to be sensitive to being singled out for high their high energy use.

Most of these complaints were received via e-mail or phone. Some recipients also talked to Ameren Illinois in person at lighting clinics. At first, the customers mention that they received the reports and had a negative response. But after talking, they report energy-efficient behaviors and the conversation turns positive. Customers are speaking with Ameren Illinois, providing testimonials and details around how they are saving.

The Website was also effective for interaction. During the pilot program, 77 customers out of the 50,000 treatment group set people set energy goals on the Website. Opower has found that the customers who set goals online were more engaged and eager to complete the goals. The program team plans to send more e-mails to drive traffic to the Website, which they believe will help achieve greater program savings.

Marketing

Because the Home Energy Report program is not an opt-in program, Ameren Illinois did not market it to customers. No information about the program is present on the Ameren Illinois Website.

Reporting

This program was very closely tracked and reported to compare treatment group vs. control group as well as 12-month usage pre-treatment vs. post-treatment. Opower tracks overall energy efficiency savings as well as the levels of various treatments. They report these results quarterly and then again annually with greater detail. As discussed earlier, Opower savings estimates are very close to our evaluated results. Opower reported very little variation among customers based on income and ownership status, but greater savings in those with greater consumption.

Ameren Illinois provides Opower with a breakdown of the calls received. They also track customer opt-outs, which have been relatively low (0.93%). This indicates that a majority of customers are satisfied with the reports and are finding them useful. According to Opower, call center volume has been lower than expected based on similar programs for other utilities.

Opower uses online analytics software to track the customer portals and sends reports on a quarterly basis. The Web metrics include page views, how many people open accounts, and the number of e-mail reports that drive customers to the Website. They do not analyze particular customers compared to others, but rather the total number of people who visit the site.

Future Plans

The program scaled up by an additional 125,000 customers in Ameren Illinois' PY4 . The original 50,000 customers remain in the program. Opower will focus messaging this year on customer testimonials rather than energy saving tips. Opower will continue to send bimonthly reports to customers with high energy consumption.

In the future, Opower plans to test an envelope design to see whether readership increases. Opower also will test different e-mail messaging to drive customers to the Website. They have proposed engagement phone calls to a portion of the test group to keep reports top of mind and to propose simple energy-efficient actions.

6. Conclusions and Recommendations

The following conclusions and recommendations are offered based on findings presented in the previous sections.

Conclusions

Table 9 presents total net energy and gas savings for the PY3 period as well as the year ending August, 2010.

Table 9. PY3 and Annual Opower Program Savings

		kWh	Therms
Per Participant	PY3	123.5	5.6
	Annual	164.9	6.8
All Customers	PY3	5,399,393	241,818
	Annual	7,247,563	298,333

Program Year3 savings were approximately 5,400 kWhs (1.4% of electricity consumption) and 298,000 therms (0.6% of gas consumption). Also, Home Energy Report customers were more likely to participate in the other incentive programs more than non-participants. In PY3, electricity savings overlap was 160 MWh and gas savings overlap was about 22,000 therms.

Overall, the Home Energy Report pilot rolled out smoothly and customers generally seemed to be happy with the program. The program resulted in savings and encouraged customers to participate in Ameren Illinois' other incentive programs. The low call volume and low opt-out rates are indicators that the 50,000 treatment group is satisfied with the program. The relationship between Opower and Ameren Illinois was productive and collaborative. The only negative comments we found were that the Opower team can be a bit aggressive when it comes to sales, and improvements or changes to the program were rather costly. Additionally, Ameren Illinois would like to see more regular reports from Opower.

Recommendations

Below are a few recommendations for future programs.

- Opower should make the Ameren Illinois password for the Web portal easier to use. Stakeholders commented on the difficulty in accessing the site.
- Ameren Illinois should scrub the customer list for any who may not be appropriate for the treatment group. For example, exclude from the treatment groups customers who are on Ameren Illinois' list of those on life support.
- The complaints Ameren received about the program are typical for this type of program. Ameren should train its customer service staff to provide specific information about other residential programs for which a particular customer is eligible. This approach would offer immediate value to disgruntled customers.
- Opower should provide Ameren with more timely metric reports. The new program management team (Conservation Services Group) needs to report to Ameren Illinois

monthly, but Opower currently issues its reports on a quarterly basis. Opower should consider allowing customer access to the reports any time for immediate download.

- Ameren Illinois and Opower should arrange for the treatment and control groups to be chosen by an independent evaluator, which would eliminate any potential concern about "gaming" the sample.

Appendix A. Unconditional Savings Analysis

Cadmus planned to evaluate program savings using both a conditional savings analysis and an unconditional savings analysis. After reviewing both approaches, we find the conditional analysis to be the most useful, but include the unconditional analysis in this appendix for documentation.

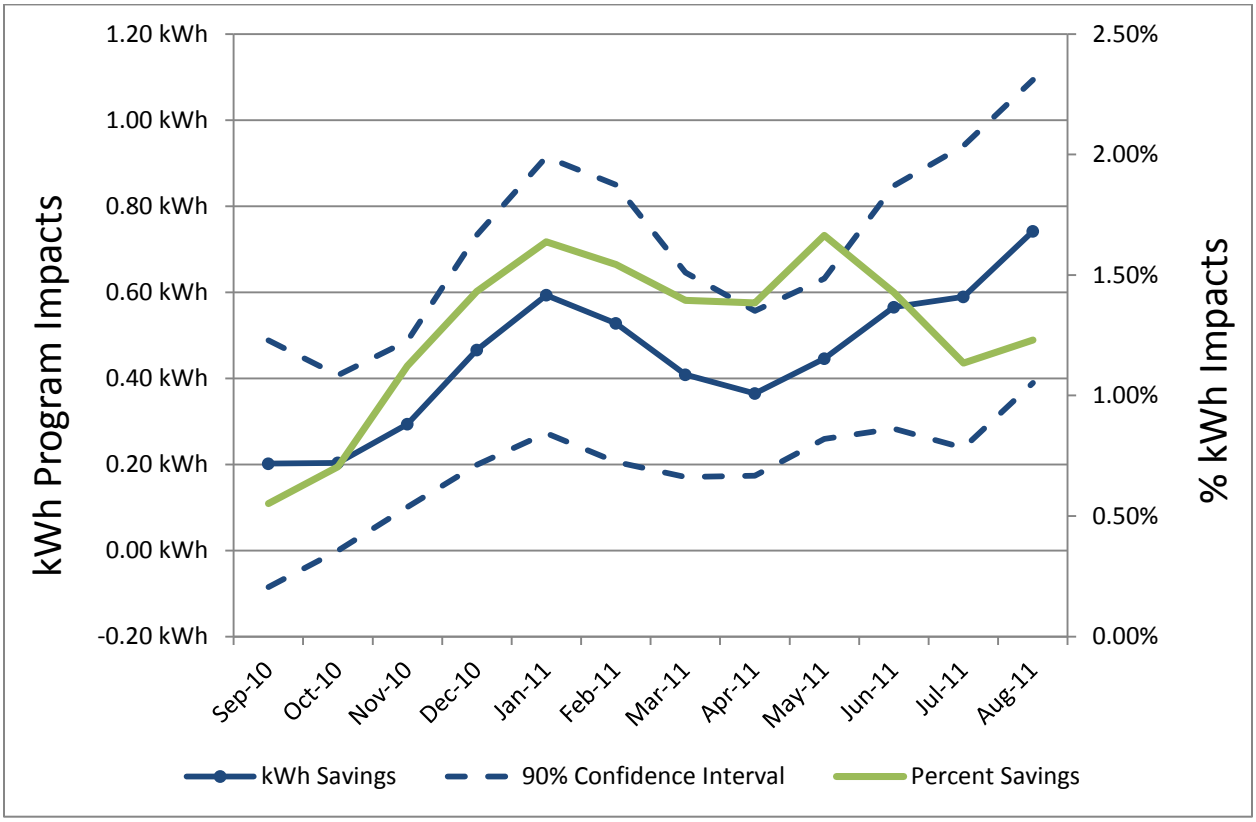
We report unconditional mean D-in-D savings estimates in each month after the program began. These savings estimates are calculated as:

$$\Delta kwh^{T}_{m} - \Delta kwh^{C}_{m}$$

where $\Delta kwh^{T}_{m} = kwh^{T}_{m} - kwh^{T}_{m-12}$, or the difference in mean consumption between month m in the post-period and 12 months earlier (in the pre period) for treatment group customers. Δkwh^{C}_{m} is defined analogously. Percentage savings can be obtained by expressing this difference relative to mean control group customer consumption in the post-period. The difference-in-differences should be negative if the Home Energy Report pOpower Program saved energy.

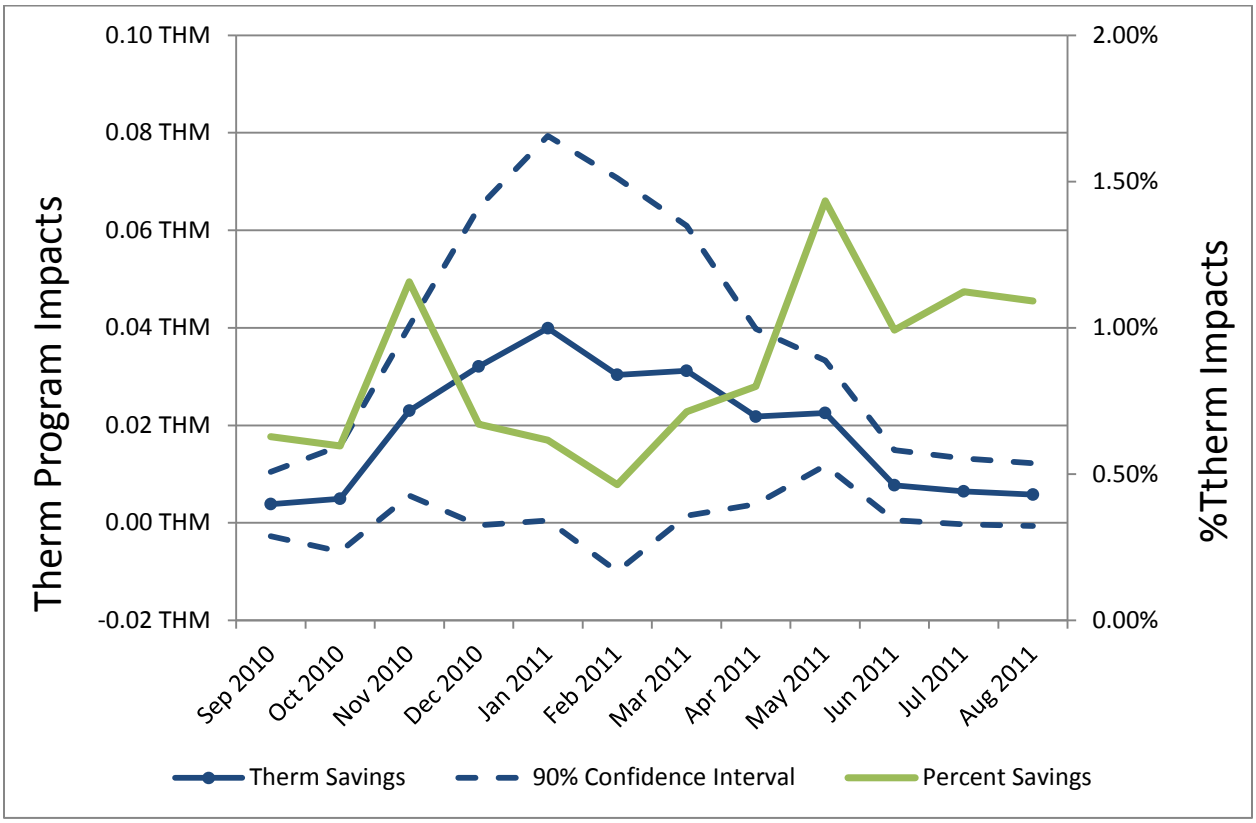
Figure A-1 and Figure A-2 show the gas and electric unconditional mean difference-in-difference savings estimates, 95% confidence intervals, and percentage savings. Note that unlike the regression-based estimates, the unconditional mean estimates are not weather-normalized and do not control for time-invariant differences between customers in consumption. As a consequence, they are not precisely estimated.

Figure A-1. Unconditional Mean Difference-in-Difference Electricity Savings



Monthly electricity savings are positive and statistically significant after October 2010. Average daily savings ranged between 0.4 kWh and 0.6 kWh or 1.2% and 1.6% of consumption. The maximum was reached in January 2011.

Figure A-2. Unconditional Mean Difference-in-Difference Gas Savings



The unconditional mean gas savings estimates are positive in all months but not statistically different from zero except for May 2011. This suggests the importance of using regression analysis to estimate savings.

Appendix B. Analysis of Savings as a Function of Weather

To see how electricity and gas savings depended on weather, Cadmus re-estimated specifications 3 and 4 in Table 7 and Table 9, allowing savings to depend on HDDs and CDDs. Specifically, we estimated the following models of average daily gas and electricity consumption:

$$ADC_{it} = \alpha_i + \mu_{my} + \beta_1 POST_{it} + \beta_2 PROGRAM_{it} \times POST_{it} + \gamma_1 HDD_{it} + \gamma_2 HDD_{it}^2 + \gamma_3 HDD_{it}^3 + \gamma_4 CDD_{it} + \gamma_5 CDD_{it}^2 + \gamma_6 CDD_{it}^3 + \beta_3 PROGRAM_{it} \times POST_{it} \times HDD_{it} + \beta_4 PROGRAM_{it} \times POST_{it} \times CDD_{it} + \varepsilon_{it}$$

In this specification, the treatment indicator variable $PROGRAM_{it} \times POST_{it}$ is interacted with monthly HDD and CDD. β_2 represents average program savings from consumption that is not weather sensitive; β_3 and β_4 represent program savings from weather-sensitive consumption.

We estimated the model separately for gas and electricity use (dropping CDDs from the gas model), and with and without the month-by-year fixed effects. We then estimated gas and electricity savings using the average HDDs and CDDs in the treatment period for treatment group customers.

The coefficients on the treatment indicator variables are reported in Appendix B Table 1.

Appendix B Table 1. Weather-Sensitive Savings Model Coefficients

	Electricity	Gas
$PROGRAM_{it} \times POST_{it}$	-0.322	-0.009
	(0.066)	(0.006)
$PROGRAM_{it} \times POST_{it} \times HDD_{it}$	-0.007	-0.001
	(0.003)	(0.0004)
$PROGRAM_{it} \times POST_{it} \times CDD_{it}$	-0.007	n/a
	(0.009)	n/a
Customer fixed effects	Yes	Yes
Month-by-year fixed effects	Yes	Yes
Weather polynomials	Yes	Yes

Notes: The dependent variable is average daily consumption in a month. Standard errors shown in parentheses. Models estimated by OLS and standard errors are adjusted for clustering at customer level. N is the number of customer bills used in the analysis. Models include: customer fixed effects, month-by-year fixed effects, and weather polynomials.

In the electricity models, the coefficient on $PROGRAM_{it} \times POST_{it}$ increases (becomes less negative) in comparison to the otherwise identical model, which does not allow savings to depend on weather (Model 4, Table 7). The model suggests non-weather sensitive average monthly savings are about 11 kWh. The coefficient on Program x Post x HDD is negative and statistically significant, suggesting savings depend positively on HDD. An increase of 10 in average daily HDDs would result in monthly electricity savings of 2.1 kWh (-0.07 x 30). The coefficient on Program x Post x CDD is not statistically different from zero, suggesting savings are not sensitive to summer weather. Results in the electricity model without month-by-year fixed effects are not reported, but are very similar.

In the gas model, the coefficient on $PROGRAM_{it}$ x $POST_{it}$ increases (becomes less negative) and become statistically insignificant after allowing savings to depend on HDDs (compared to the otherwise identical model in Model 4, Table 9). The coefficient on Program x Post x HDD is negative and statistically significant. An increase of 10 in average daily HDD would result in monthly gas savings of approximately 0.3 therms (-0.001 x 10 x 30).

Using historical weather data and estimated coefficients from these models, we estimated average savings in the first program year, and compared estimates to those from the models that do not allow savings to depend on weather. Results are presented in Appendix B Table 2.

Appendix B Table 2. Gas and Electricity Savings as a Function of Weather

	Electricity		Gas	
	Average Monthly Savings	Annual Savings	Average Monthly Savings	Annual Savings
Savings depend on weather	-13.81	-165.68	-0.57	-6.82
	(1.11)	(13.38)	(0.07)	(0.81)
Savings do not depend on weather	-13.81	-165.67	-0.57	-6.82
	(1.11)	(13.38)	(0.07)	(0.81)

Standard errors in parentheses.

Average daily savings in the gas and electric models are identical to two or more decimal places, suggesting model specifications in the draft report capture any weather-sensitive savings.