CADMUS

Memorandum

To: Mitch Horrie; Public Service Commission of Wisconsin

From: Matthew Wisnefske, Yu Wu, and Marissa Lee; Cadmus

Subject: Wisconsin Focus on Energy Save to Give Rural Behavior Pilot Evaluation: Preliminary Results

Date: November 11, 2022

The Cadmus team evaluated the energy savings from Wisconsin Focus on Energy's Save to Give Rural Behavior pilot phase I, a community-based residential behavior energy efficiency program. In this memo, we describe our approach to estimating the treatment effect of the Save to Give pilot on residential customer energy use during Campaign One in Calendar Year (CY) 2021 and in April 2022, document the preliminary evaluation results, and propose recommendations.[1]

Executive Summary

As summarized in Table 1, there are two main takeaways from this evaluation:

- Save to Give participants achieved 2.2% electric savings and -2.9% gas savings in Lodi and 2.7% electricity savings and 1.8% gas savings in Bayfield County. However, due to the small number of participants, the savings are not statistically significant.
- The impact of the Save to Give Rural Behavior pilot on electricity consumption in Bayfield County is greater (0.6 kWh average daily savings per customer) than in Lodi (0.5 kWh average daily savings per customer). Again, these differences are not statistically significant.

Table 1. Savings Summary

Location	# of Treated Customers	# of Control Customers	Average Daily Savings per Customer	Total Annual Savings	% Savings
Lodi, Electricity	119	116	0.517 kWh	21,917 kWh	2.2%
Lodi, Gas	28	28	*-0.064 therm*	*-604 therm*	*-2.9%*
Bayfield, Electricity	74	73	0.64 kWh	17,421 kWh	2.7%
Bayfield, Gas	44	43	0.05 therm	787 therm	1.8%

[1] The dates of Campaign One for the two selected communities, Lodi and Bayfield County, in the first pilot year are January 25, 2021 and March 26, 2021, respectively.

Based on these findings, the Cadmus team has two main recommendations for Focus on Energy:

- Continue to expand the pilot in more communities and launch new campaigns in existing communities (Lodi and Bayfield County) to increase program participation
- Investigate the potential utility of household characteristics data (e.g., account age, bill payment methods, and customer-level demographic data) for both treatment and control group customers to improve the quality of the resulting matches

Introduction

In CY 2021, Focus on Energy launched the Save to Give Rural Behavior pilot to serve rural residential utility customers in Wisconsin with a unique energy efficiency offering. This two-year pilot uses a community-based behavior program design, where customers in select rural communities can sign up to take on energy efficiency challenges. In exchange for completing those challenges, participants earn points toward a monetary donation to a local nonprofit. Focus on Energy selected the city of Lodi and Bayfield County to partake in the first year of the pilot. Lodi is a small town of roughly 3,060 people located in Columbia County in the Driftless Region of Wisconsin. Bayfield County, the second largest county in Wisconsin in area, is home to roughly 14,990 people and is located in the Northwoods of Wisconsin on the southern shore of Lake Superior. Focus on Energy requested the Cadmus team assess the impact of the first year of the pilot (phase I) on energy consumption.

Data and Methodology

The Cadmus team collected billing data and participation data in Lodi and Bayfield County. Billing data spanned a year before the date of Campaign One in each treatment group through one year after the campaign date to allow for 12 months of pre-treatment data and 12 months of post-treatment data. The Cadmus team also collected billing data from a representative control group for each treatment community, Sauk City (near Lodi), and a group of towns near Bayfield County. Billing data contained customer name, address, meter read dates, and monthly usage by fuel type.

The Cadmus team obtained daily average temperature data for the pre- and post-treatment periods from National Oceanic and Atmospheric Administration (NOAA) weather stations representing all zip codes associated with the participants and control group. The team also used the Typical Meteorological Year, version 3 (TMY3) Normals series (1991-2005) to weather-normalize the billing data.

Data from Lodi and its control group (Sauk City) were cleaned separately from Bayfield County and its control group. Bayfield County data was also cleaned separately by fuel type. The Cadmus team followed the below steps to prepare the data for analysis:

1. Clean participant tracking information and identify eligible participant population (customers with active accounts during the analysis period).
2. Clean billing data to remove any data anomalies in the billing data (i.e., negative electric or gas reads, duplicated bills, and insufficient billing data with less than 25 days between meter reads or extended read dates across multiple months).

3. Map zip codes to nearest weather station, obtain daily average temperatures over pre- and post-treatment periods, and calculate total heating degree days (HDDs) and cooling degree days (CDDs) using base temperature 65°F occurring during each billing period.
4. Calendarize billing and weather data. The team allocated energy use, HDDs, and CDDs occurring during each billing cycle to calendar months based on the number of days in the billing cycle falling in each calendar month.

Propensity Score Matching

The Save to Give pilot functions as an opt-in program, meaning that customers enroll in the program at their own discretion rather than being enrolled in the program automatically. While the Save to Give pilot has selected the two control communities corresponding to the two treatment communities, the specific control groups had not been defined prior to program start. To develop the control groups, the Cadmus team leveraged the population of residential billing data in control communities and performed a propensity score matching.[2]

Using logistic regression models specified through forward stepwise model selection, the team estimated the probability—or propensity—of participating in the Save to Give pilot (in the treatment group) as a function of seasonal average daily energy consumption and/or monthly average daily energy consumption in the year preceding the Save to Give Campaign One launch in January 2021 (for Lodi) and March 2021 (for Bayfield County). The team matched each Save to Give participant to one nonparticipant in the control community whose propensity score was closest to that of the participant (i.e., using nearest-neighbor matching). Since the team expected that Lodi participants and Bayfield County participants would differ both in their typical energy consumption patterns and their eventual Save to Give savings, we separately conducted matching for the two communities' participants within each fuel type.

To ensure high-quality matching, the team conducted statistical equivalence tests to confirm that each matched control group had similar seasonal consumption levels to the those of Save to Give participants before their first campaign advertising date. Ideally, there should be no statistically significant differences in annual or within-season electricity consumption between the groups.

Billing Analysis

The Cadmus team used panel regression models to analyze the effect of Save of Give treatment on energy consumption. The analyses conformed to the approach described in the Uniform Methods

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[2] Given that the treatment is not randomly assigned, a quasi-experimental method must be employed to estimate the causal impact. A challenge to quasi-experimental studies is the occurrence of selection bias, which may lead to a loss of internal validity. Propensity score matching aims to reduce selection bias by matching on observable characteristics that could otherwise confound estimation of the treatment effect.

Abadie, Alberto, and Guido W. Imbens. 2016. "Matching on the Estimated Propensity Score." *Econometrica* (84, no. 2): 781–807.

Project.[3] The team used both post-only models and difference-in-differences models and tested different regression model specifications.[4] The models controlled for pre-Save to Give energy consumption patterns, customer-specific fixed effects (average consumption for each unique customer ID), time fixed effects (average consumption for each calendar month), and weather effects (heating and cooling degree days calculated at 65° F base temperature). The team clustered standard errors on each pair of participants and matched nonparticipants. Consistent with the matching, the team estimated separate models for Lodi and Bayfield County customers, and for electric customers and natural gas customers.

Savings Calculation

The Cadmus team estimated the percentage of unadjusted net savings,[5] which are the ratio of average daily savings per each Lodi or Bayfield County Save to Give participant to the control group's non-participant's average daily consumption in the post-participation period. These savings serve as an estimate of the baseline energy use absent the program.

The team also estimated annual unadjusted net savings as the product of average daily savings per participant and the total number of days all participants were treated, referred to as treatment days. If a customer was active for the whole year (a full year starting from the start date of Campaign One), the number of treatment days was 365. If a customer was inactive for part of the year, the number of treatment days was the number of days from the start date of Campaign One to the final active day in the dataset (less than or equal to 365 days).[6]

Preliminary Results

The Cadmus team conducted separate analyses for Lodi and Bayfield County. Those results are summarized below.

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[3] Stewart, Jim, and A. Todd. 2020. *The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures*. "Chapter 17: Residential Behavior Protocol." Prepared for National Renewable Energy Laboratory, Golden, Colorado. NREL/SR-7A40-77435. https://www.nrel.gov/docs/fy21osti/77435.pdf

[4] Post-only model regresses each customer's average daily energy consumption (in a given month) on a treatment indicator variable and other control variables. The control variables (regressors) include the customers' pre-treatment energy use by month, month-by-year fixed effects, and weather.

Allcott, Hunt, and Todd Rogers. 2014. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review* (104, no. 10): 3003–3037.

[5] The Cadmus team did not adjust net savings by uplift savings, which occur when treatment customers participate in other Focus on Energy residential energy efficiency programs at a higher rate than control group customers.

[6] If the number of days from the start date of Campaign One to the final active day in the dataset is greater than 365, the team uses 365 treatment days.

Lodi

The Cadmus team analyzed both electric and gas billing data for Lodi.

Matching for Electric Customers

In the propensity scores matching, the Cadmus team used a Logit model to estimate propensity scores that include pre-treatment period summer average daily energy consumption (ADC) as the covariate.[7] To assess the quality of the resulting matches, the team examined the covariate balance after matching (Table 2).[8] Standardized mean differences are close to zero and variance ratios are close to 1, indicating good balance. Based on a two-sample t-test, the mean of pre-treatment period summer ADC in the treatment group is not statistically different from the mean of pre-treatment period summer ADC in the control group.

Table 2. Summary of Balance after Matching for Lodi Electric Customers

	Means Treated	Means Control	Std. Mean Differences	Variance Ratio	Pair Distances
Distance	0.051	0.051	0.000	1.001	0.000
Pre-period Summer ADC	28.182	28.183	0.000	1.001	0.001

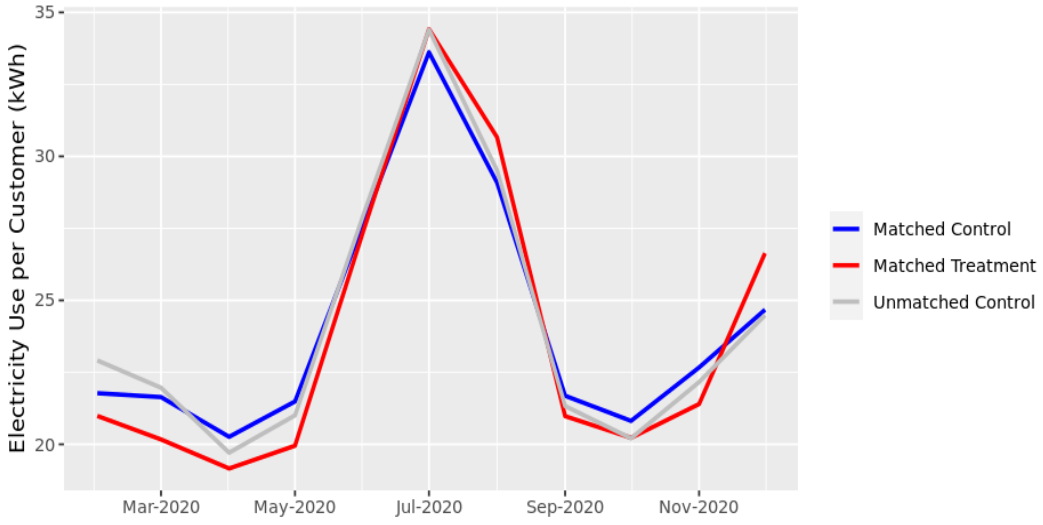
In addition, the team conducted visual diagnostics to look for differences between the groups. Figure 1 shows the monthly electric ADC in the pre-treatment period by matching groups. The treatment group's pre-treatment period ADC is better matched to the control group's pre-treatment period ADC during summer months.

[7] We also tested to include winter ADC, shoulder ADC, and total average ADC, and each of the 12 months ADC in the pre-treatment periods in the estimation of propensity scores. We chose the model which results in best fitness of model (lowest AIC) and matching balance.

[8] Assessing balance involves assessing whether the distributions of covariates are similar between the treated and control groups. Balance is typically assessed by examining univariate balance summary statistics for each covariate.

Greifer, N. 2021. *Assessing balance*. The R foundation. https://cran.r-project.org/web/packages/MatchIt/vignettes/assessing-balance.html

Figure 1. Pre-Treatment Period Average Daily Electricity Consumption in Lodi



Billing Analysis for Electric Customers

The Cadmus team found the treatment effect of the Save to Give pilot on electricity consumption is consistently negative across different model specifications, meaning participants' consumption was lower in the treatment group than in the control group. While the consistent results indicate electricity savings from the pilot, the treatment effects are not statistically significant. Table 3 shows the regression results of the post-only model, which typically have higher precision and are more robust. [9] The treatment effect is -0.517, that is average daily savings per customer is 0.517 kWh, or 517 Watt hours per day. Using the savings calculation formula referenced in the methodology section, this represents a net percentage savings of approximately 2.2% and total annual savings of 21,917 kWh across all Lodi participants.[10]

Table 3. Estimation of the Treatment Effects for Electric Customers in Lodi (standard errors in parentheses)

	Post-Only Model
Treatment Effect on Electricity Consumption	**-0.517**
(Standard Error)	(0.551)
Heating Days (HDD 65)	0.268*
(Standard Error)	(0.148)
Cooling Days (CDD 65)	1.490*
(Standard Error)	(0.814)
Month Fixed Effects × Monthly Pre-Period ADC	Yes
Month Fixed Effects	Yes
Observations	3,326
R^2	0.768

[9] Allcott, Hunt, and Todd Rogers. 2014. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review* (104, no. 10): 3003–3037.

[10] The post control group ADC is 23.58 kWh and the total number of treatment days are 42,393.

Adjusted R^2	0.766
Residual Std. Error	6.845 (df = 3301)

Note: This table reports estimates of the treatment effect of the Save to Give program and the effects of other covariables on energy consumption.
A "*" is placed next to estimate to indicate *p*-value (statistical significance level):
*p<0.1; **p<0.05; ***p<0.01.
Cluster-robust standard errors are in parentheses.

Matching for Gas Customers

In the propensity scores matching, the Cadmus team used a Logit model to estimate propensity scores that include pre-treatment period winter ADC as the covariate.[11] To assess the quality of the resulting matches, the team examined the covariate balance after matching (Table). Standardized mean differences are close to zero and variance ratios are close to 1, indicating good balance. Based on a two-sample t-test, the mean of pre-treatment period winter ADC in the treatment group is not statistically different from the mean of pre-treatment period winter ADC in the control group.

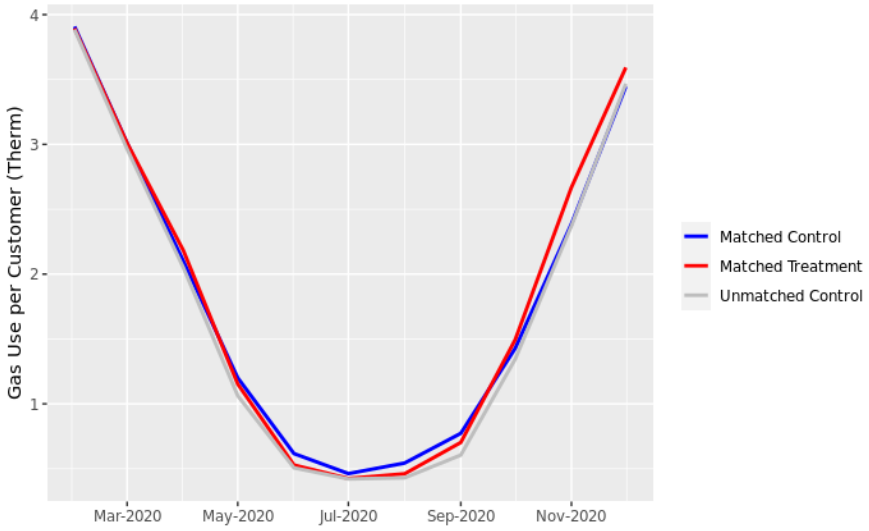
Table 4. Summary of Balance after Matching for Lodi Gas Customers

	Means Treated	Means Control	Std. Mean Differences	Variance Ratio	Pair Distances
Distance	0.015	0.015	0.000	0.998	0.001
Pre-period Winter ADC	3.435	3.435	0.000	0.998	0.001

In addition, the team conducted visual diagnostics to look for differences between the groups. Figure 2 shows the monthly gas ADC in the pre-treatment period by matching groups. The treatment group's pre-treatment period ADC is better matched to the control group's pre-treatment period ADC during winter months.

[11] We also tested to include summer ADC, shoulder ADC, and total average ADC, and each of the 12 months ADC in the pre-treatment periods in the estimation of propensity scores. We chose the model which results in best fitness of model (lowest AIC) and matching balance.

Figure 2. Pre-Treatment Period Average Daily Gas Consumption in Lodi



Billing Analysis for Gas Customers

The Cadmus team found the treatment effect of the Save to Give pilot on gas consumption is positive, meaning participants' consumption was higher in the treatment group than in the control group and no energy savings. Table 5 shows the regression results of the post-only model. The treatment effect is 0.064, that is average daily savings per customer is -0.064 therm. This represents a net percentage savings of approximately -2.9% and total annual savings of -604 therm across all Lodi participants.[12] However, the treatment effects and savings are not statistically significant, and the results are not consistent across models.

Table 5. Estimation of the Treatment Effects for Gas Customers in Lodi

	Post-Only Model
Treatment Effect on Gas Consumption	**0.064**
(Standard Error)	(0.041)
Heating Days (HDD 65)	0.075
(Standard Error)	(0.048)
Cooling Days (CDD 65)	0.051*
(Standard Error)	(0.029)
Month Fixed Effects × Monthly Pre-Period ADC	Yes
Month Fixed Effects	Yes
Observations	677
R^2	0.966
Adjusted R^2	0.964
Residual Std. Error	0.332

Note: This table reports estimates of the treatment effect of the Save to Give program and the effects of other covariables on energy consumption.

[12] The post control group ADC is 2.21 therm and the total number of treatment days are 9,441.

A "*" is placed next to estimate to indicate *p*-value (statistical significance level):
*p<0.1; **p<0.05; ***p<0.01.
Cluster-robust standard errors are in parentheses.

Bayfield County

The Cadmus team analyzed both electric and gas billing data for Bayfield County.

Matching for Electric Customers

In the propensity scores matching, the Cadmus team used a Logit model to estimate propensity scores that include monthly ADC in the pre-treatment period as the covariate.[13] Table 6 shows the covariates balance after matching. Most of standardized mean differences are close to zero (absolute values are less than 0.1) and variance ratios are close to 1, indicating good balance in general. Based on a two-sample t-test, the mean of pre-period monthly ADC in the treatment group is not statistically different from the mean of the corresponding pre-period monthly ADC in the control group.

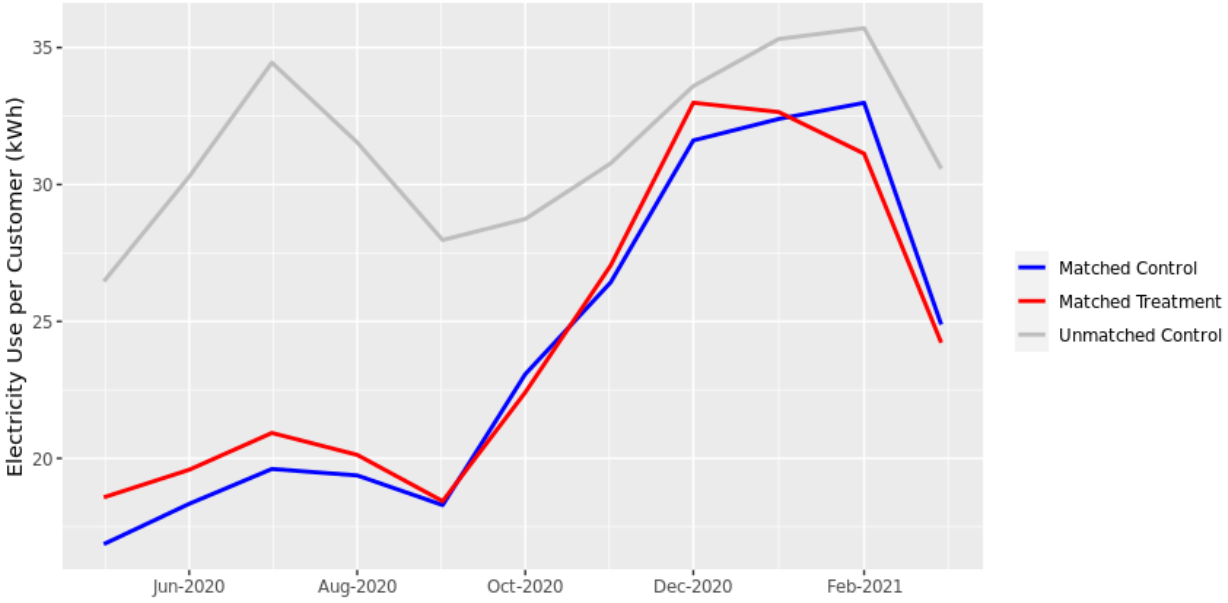
Table 6. Summary of Balance after Matching for Bayfield Electric Customers

	Means Treated	Means Control	Std. Mean Difference	Var. Ratio	Pair Distances
Distance	0.006	0.006	-0.001	0.995	0.001
Pre-period Jan. ADC	33.627	31.958	0.047	0.786	0.704
Pre-period Feb. ADC	32.171	32.538	-0.010	0.679	0.742
Pre-period Mar. ADC	25.105	24.550	0.022	0.680	0.770
Pre-period May. ADC	18.577	16.659	0.133	0.866	0.969
Pre-period Jun. ADC	19.584	18.261	0.091	1.455	0.819
Pre-period Jul. ADC	20.928	19.530	0.088	1.396	0.701
Pre-period Aug. ADC	20.186	19.272	0.062	1.232	0.769
Pre-period Sep. ADC	18.586	18.151	0.035	0.939	0.876
Pre-period Oct. ADC	22.354	22.777	-0.023	0.662	0.875
Pre-period Nov. ADC	27.009	26.069	0.037	0.776	0.768
Pre-period Dec. ADC	33.075	31.182	0.061	0.748	0.685

Visually, the treatment group's pre-treatment period ADC is better matched to control group's pre-treatment period ADC between September to November (Figure 3). Compared to the unmatched control group customers, the matched control group customers have more similar pre-treatment period energy consumption patterns to the treated customers.

[13] The Cadmus team also tested to include winter ADC, summer ADC, shoulder ADC, and total average ADC in the pre-treatment periods in the estimation of propensity scores. Additionally, the team conducted Mahalanobis distance matching. The final model is one that resulted in best fitness of model (lowest AIC) and matching balance.

Figure 3. Pre-Treatment Period Average Daily Electricity Consumption in Bayfield



Billing Analysis for Electric Customers

The Cadmus team found the treatment effect of the Save to Give pilot on electricity consumption is consistently negative across different model specifications, again suggesting lower consumption in the treatment group. While the consistent results indicate electricity savings from the pilot, the treatment effects are not statistically significant. Table 7 shows the regression results of the post-only model. The treatment effect is -0.645, or an average daily savings per customer of 0.645 kWh, or 645 Watt hours per day. Based on the savings calculation formula referenced in the methodology section, the net percentage savings is approximately 2.7% and total annual savings are 17,421 kWh across all Bayfield County participants.[14]

Table 7. Estimation of the Treatment Effects for Electric Customers in Bayfield

	Post-Only Model
Treatment Effect on Electricity Consumption	**-0.645**
(Standard Error)	(1.272)
Heating Days (HDD 65)	0.177
(Standard Error)	(0.222)
Cooling Days (CDD 65)	0.761
(Standard Error)	(0.556)
Month Fixed Effects × Monthly Pre-Period ADC	Yes
Month Fixed Effects	Yes
Observations	1,566
R^2	0.817
Adjusted R^2	0.814

[14] The post control group ADC is 23.51 kWh and the total number of treatment days are 27,010.

Residual Std. Error	11.306 (df = 1540)

Note: This table reports estimates of the treatment effect of the Save to Give program and the effects of other covariables on energy consumption.
A "*" is placed next to estimate to indicate *p*-value (statistical significance level):
*p<0.1; **p<0.05; ***p<0.01.
Cluster-robust standard errors are in parentheses.

Matching for Natural Gas Customers

Like propensity score matching for electric customers, the Cadmus team used a Logit model to estimate propensity scores for natural gas customers that include monthly ADC in the pre-treatment period as the covariate.[15] Table 8Table shows the covariates balance after matching. Most of standardized mean differences are close to zero (absolute values are around 0.1) and variance ratios are close to 1, indicating good balance in general. Based on a two-sample t-test, the mean of pre-period monthly ADC in the treatment group are not statistically differently from the mean of pre-period monthly ADC in the control group.

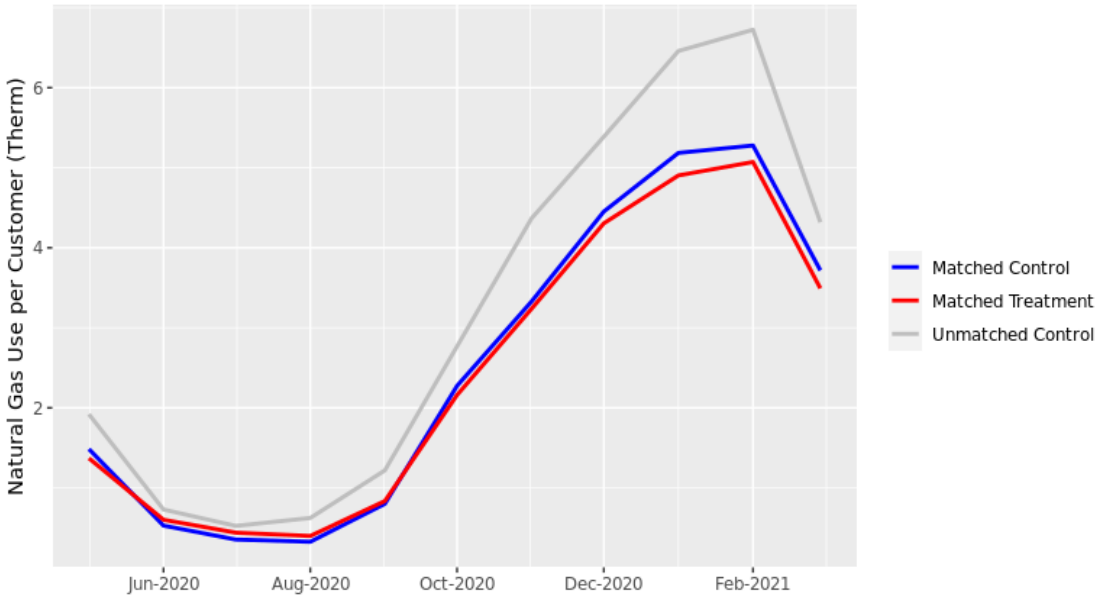
Table 8. Summary of Balance after Matching for Bayfield Natural Gas Customers

	Means Treated	Means Control	Std. Mean Difference	Var. Ratio	Pair Distances
Distance	0.033	0.020	0.096	7.276	0.096
Pre-period Jan. ADC	4.887	5.245	-0.161	0.302	1.261
Pre-period Feb. ADC	5.057	5.347	-0.122	0.402	1.127
Pre-period Mar. ADC	3.449	3.739	-0.170	0.236	1.443
Pre-period May. ADC	1.370	1.499	-0.192	0.262	1.491
Pre-period Jun. ADC	0.602	0.554	0.110	0.779	0.975
Pre-period Jul. ADC	0.441	0.363	0.125	1.284	0.664
Pre-period Aug. ADC	0.392	0.338	0.163	0.959	1.170
Pre-period Sep. ADC	0.836	0.815	0.040	0.525	1.271
Pre-period Oct. ADC	2.155	2.293	-0.137	0.227	1.548
Pre-period Nov. ADC	3.230	3.366	-0.091	0.328	1.266
Pre-period Dec. ADC	4.287	4.498	-0.108	0.270	1.328

Visually, the treatment group's average pre-treatment period ADC is better matched to control group's pre-treatment period ADC between May to December (Figure 4). Comparing to the unmatched control group customers, the matched control group customers have more similar pre-treatment period energy consumption patterns to the treated customers.

[15] We The Cadmus team also tested to include winter ADC, summer ADC, shoulder ADC, and total average ADC in the pre-treatment periods in the estimation of propensity scores. Additionally, the team conducted Mahalanobis distance matching. The final model is the one that resulted in best fitness of model (lowest AIC) and matching balance.

Figure 4. Pre-Treatment Period Average Daily Natural Gas Consumption in Bayfield



Billing Analysis for Natural Gas Customers

The Cadmus team found the treatment effect of the Save to Give pilot on gas consumption is consistently negative across different model specifications. While the consistent results indicate gas savings from the pilot, the treatment effects are not statistically significant. The treatment effect on gas consumption is smaller than for electricity in magnitude, -0.049 (Table 9). The net percentage savings are 1.8% and total annual savings are 787 therm across all Bayfield County participants.

Table 9. Estimation of the Treatment Effects for Natural Gas Customers in Bayfield

	Post-Only Model
Treatment Effect on Gas Consumption	**-0.049**
(Standard Error)	(0.062)
Heating Days (HDD 65)	0.022*
(Standard Error)	(0.013)
Cooling Days (CDD 65)	-0.030
(Standard Error)	(0.028)
Month Fixed Effects × Monthly Pre-Period ADC	Yes
Month Fixed Effects	Yes
Observations	942
R^2	0.969
Adjusted R^2	0.968
Residual Std. Error	0.558 (df = 916)

Note: This table reports estimates of the treatment effect of the Save to Give program and the effects of other covariables on energy consumption.
A "*" is placed next to estimate to indicate *p*-value (statistical significance level):
*p<0.1; **p<0.05; ***p<0.01.
Cluster-robust standard errors are in parentheses.

Conclusions and Recommendations

The evaluation team's analysis of Focus on Energy's Save to Give Rural Behavior pilot phase I indicated that the pilot produced electric and gas savings in 2021. However, due to the small number of participants, the savings are not statistically significant in both fuel types and selected communities. The Cadmus team recommends continuing to expand the pilot in more communities and to launch new campaigns in currently participating communities, including Lodi and Bayfield County, to increase program participation. This is largely due to the implementation teams existing connection to local officials and institutions, established customer relationships, and potential for further savings.

The magnitude of program effects varied between the two treated communities: Bayfield County observed greater treatment effects and a larger percentage of electric savings than Lodi. This discrepancy suggests that regional or pilot implementation variances led to different impacts. The Cadmus team recommends investigating the drivers of regional differences in savings through a process evaluation, which may help to improve program design in different geographic settings.

The Cadmus team used propensity score matchings to construct the control groups that have similar pre-treatment period energy consumption patterns as the treatment groups. However, due to limitations in data availability, matching did not control for household's specific characteristics. To improve the quality of the resulting matches, the Cadmus team recommends gathering and utilizing data on household characteristics (e.g., account age, bill payment methods, and customer-level demographic data), if available, for treatment and control group customers.

Cadmus anticipates that in future cycles this pilot may achieve greater total savings, due to the limitations with launching phase I of this pilot during the COVID-19 pandemic, which made face to face recruitment and education much more difficult than can be achieved currently.