July 2, 2015

REPORT #E15-314

Northwest Food Processors Association Energy Savings Model Review

Prepared by:
Energy 350

Northwest Energy Efficiency Alliance
PHONE
503-688-5400
FAX
503-688-5447
EMAIL
info@neea.org

Table of Contents

1 Executive Summary

Founded in 1914, the Northwest Food Processors Association (NWFPA) represents over 80 food processors with 180 production plants in Oregon, Idaho and Washington. In January 2009, working in conjunction with NEEA and its efforts to transform how energy is managed in the Northwest industrial sector, the NWFPA board of directors set a goal to reduce energy intensity in their facilities by 25 percent in ten years and 50 percent in twenty years (Barrow, Thornton 2013). This reduction in energy intensity will be achieved by implementing capital improvements or implementing low/no cost measures such as optimizing schedules, set points, and turning equipment off when it is not needed.

The goal of this effort by Energy 350 is to validate the savings estimates provided by NWFPA on a subset of member sites participating in the Energy Roadmap program by performing a top-down analysis that quantifies savings at sites modeled by NWFPA during the 2013 calendar year. To this end, Energy 350 analyzed utility, production and weather data for ten sites from 2012 and 2013. Based on the results of our review, we found the NWFPA's energy reduction campaign resulted in little electric energy savings during our 2013 performance period. However, this represents only a small portion of NWFPA's members. Table 1 shows the 2013 top-down energy savings for each of the ten sites.

Table 1: 2013 Top-down energy savings for sites submitted by NWFPA

Site	Able to Model?		Electric Savings (aMW)	Gas Savings (MMBtu)
	Electric	Gas		
A014	Y	Y	-0.051	-4,428
A028	Y	Y	0.115	-1,691
A030	N	N	0.000	0
A034	Y	Y	-0.015	-2,256
A039	N	Y	0.000	-38
A040	Y	Y	0.117	-10,535
A041	N	Y	0.000	29,358
A042	Y	Y	-0.029	2,239
A047	N	N	0.000	0
A052	Y	Y	-0.135	-2,042
Total			**0.001**	**10,607**

While data was provided for ten sites, Energy 350 was able to develop statistically strong models describing electric energy use for just six of those sites. Of those six sites with robust electric models, two sites yielded positive electric energy savings and four sites yielded negative electric energy savings. The result of this is very small electric savings, totaling only 0.001 aMW.

While it appears that natural gas savings are more substantial, we note that the majority of the natural gas savings are from a single site, A041. There were some sites where we were unable to develop a model with a good enough fit. We listed those sites as "not able to model" and they are shown as having zero savings in Table 1.

Through performing this analysis we were able to make a number of observations on the impact of NWFPA's energy reduction campaign and how savings are quantified.

- Sites that participated directly in NEEA's initiative to transform industrial energy management (initially called Continuous Energy Improvement - CEI and later changed to Strategic Energy Management - SEM) yielded much higher electric savings even though their performance period was shorter. The performance period was shorter because NEEA has already claimed savings for these facilities through September 30, 2013. CEI facilities saved 0.031 aMW during their three month performance period, whereas non-CEI sites used 0.029 aMW more energy during their year-long performance period. This supports the case for the continuous engagement model of the CEI program and the benefits that come along with embedding strategic energy management into business and manufacturing operations. Additionally, it indicates that merely setting a goal may not be a strong enough intervention to precipitate energy savings. Additional incentives or support are likely required in order to impart meaningful improvements on energy performance.
- Utility, production, and weather data is sufficient to develop models for the majority of sites. However, about 30 percent of the sites we analyzed would require additional detail in order to develop usable models. Data such as when major changes in facility operation occurred, processing schedules and details of other fuel sources used on site could be used to improve the fit of the models and enable us to report energy savings for more sites. We recommend NWFPA work with sites where we were unable to develop a suitable model to get more data that might help refine the models and allow saving to be claimed for more sites in subsequent years.

While energy use at the modeled sites for the 2013 performance period is nearly flat, a look at a longer period of time shows 2013 to be anomalous. The longer term trend of these sites shows quite positive performance. Section 2.3.7 of this report further explores the longer term performance of the modeled sites.

2 Overview of Modeling Approach & Observations

2.1 NWFPA Modeling Method

NWFPA developed models for ten sites throughout the Northwest based on monthly electric, natural gas, production and weather data. They used JMP, a statistical analysis tool, to develop the regression models and to complete their energy accounting. Their model development can be split into two efforts; models for sites A014, A040, A042, and A052 were developed before meeting with Energy 350, and the remainder of the models were developed after meeting with Energy 350. The meeting with Energy 350 consisted of a brief conversation about modelling methods including the use of indicator variables, ambient variable selection, and baseline period selection. After the conversations between NWFPA and Energy 350, NWFPA modified their approach based on early feedback from Energy 350. The NWFPA approach before speaking with Energy 350 was:

- Post process weather data to determine average monthly wet bulb and average monthly dry bulb temperature.
- Review production data and create a production indicator variable based on when the facility appeared to be in a production mode. This was loosely defined as when production was greater than ten percent of annual peak production.
- Use JMP to individually evaluate electric and natural gas models for each site using either average monthly dry bulb or average monthly wet bulb as the ambient variable. The baseline period began when data was first available for the site (typically January 2006). Ambient variable selection and baseline period length were determined based on which combination resulted in a model with the highest coefficient of determination (R^2).
- Evaluate energy savings for each year dating back to 2007 using an offset calendar year of October through September. Energy savings were defined as the difference between the modeled data and the metered data, without making adjustments for savings reported in previous years.
- Plot the NWFPA models, metered data, and cumulative energy savings.

As previously mentioned, NWFPA's modelling approach changed slightly for the sites A028, A030, A034, A039, A041, and A047. Their modelling method after meeting with Energy 350 was:

- Post process weather data to determine average monthly wet bulb temperature, average monthly dry bulb temperature, heating degree days (HDD) with reference temperatures between 30 degrees Fahrenheit and 90 degrees Fahrenheit, and cooling degree days (CDD) with reference temperatures between 30 degrees Fahrenheit and 90 degrees Fahrenheit.
- Use the stepwise regression feature of JMP to individually evaluate electric and natural gas models for each site. Multiple baseline periods were evaluated between 2006 and 2010 with a variety of lengths. Additionally, a variety of ambient variables were investigated including: average monthly dry bulb temperature, average monthly wet bulb temperature, and CDD/HDD with reference temperatures ranging from 30 degrees Fahrenheit to 90 degrees Fahrenheit. The stepwise regression feature was used to run a multitude of models with different combinations of independent variables and baseline periods and then rank the models based on adjusted coefficients of determination (R^2). NWFPA then manually

reviewed the high ranking models to identify models with significant independent variables at the 95 percent confidence limit. As part of this analysis NWFPA also used JMP to look for outliers in the data. If outliers were identified, NWFPA would not include them in their models.

- Evaluate energy savings for each year dating back to 2007 using an offset calendar year of October through September. Energy savings were defined as the difference between the modeled data and the metered data, without making adjustments for savings reported in previous years.
- Plot the NWFPA models, metered data, and cumulative energy savings.

2.2 Energy 350 Modeling Method

NWFPA provided Energy 350 with their models and monthly electric, natural gas, production and weather data for ten sites throughout the Northwest. This monthly data was provided in two formats; a Microsoft Excel Worksheet and JMP database. Upon receipt of this data we performed the following:

- Post process weather data to determine heating degree days (HDD) and cooling degree days (CDD) ranging from a 55 degree Fahrenheit to 65 degree Fahrenheit reference temperature. This was only completed for sites where NWFPA had not already calculated HDD/CDD. If NWFPA had already calculated HDD/CDD, we reviewed their calculations to ensure HDD/CDD were calculated correctly.
- Identify when NEEA last claimed savings for each site. We then set that timeframe as our baseline period for all regression analyses.
- Individually evaluate natural gas and electric models for each site using a variety of ambient variables including: CDD/HDD 55F, CDD/HDD 60F, CDD/HDD 65F, average monthly dry bulb temperature, average monthly wet bulb temperature, and no ambient variable. Ambient variables were only included if they were significant at the 95 percent confidence limit. Professional organizations such as the American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) typically do not recommend confidence limits because acceptable confidence limits vary based on application. However, the 95 percent confidence limit is the most frequently used by researchers (Rumsey 2011). While ASHRAE does not recommend confidence limits, they do recommend that the coefficient of determination (R^2) for energy estimating models should be greater than 0.75 (ASHRAE 2013).[1] Therefore, we only included models with coefficients of determination greater than 0.75. Our complete analysis including independent variable selection and regression statistics are documented in Appendix A.
- Plot the Energy 350 model, NWFPA model, and metered data. This allows us to visually verify that our model has a good fit with the metered data during the baseline period, compare the Energy 350 model to the NWFPA model, and identify anomalies in the model that might not be evident in the regression statistics.
- Compare our model's and NWFPA's model's estimated energy use to the metered data. The reported savings during the performance period is then computed as the difference between

[1] If multiple models met these criteria, we used the model with the highest adjusted coefficient of determination.

the energy use estimated by our model and the actual energy use as indicated by the metered data.

2.3 Observed Themes in Analysis

Many of the changes we made to each model were fairly repetitive across many or all of the models. This section discusses changes that we made across many or all models and the rationale behind them.

2.3.1 Weather Data

The initial NWFPA models used average monthly temperatures for the weather adjustment. This is a reasonable approach, but for some sites we were able to improve the significance of our independent variables by using Heating Degree Days (HDDs) and Cooling Degree Days (CDDs) for our ambient variables. HDDs and CDDs account for the variability in weather throughout the month that is masked by an average temperature. Additionally, we found that some sites were not weather dependent and for those sites a bivariate model based only production rate yielded the best fit.

2.3.2 Indicator Variables

NWFPA used a number of indicator variables in their models. Based on conversations with NWFPA, we discovered that the indicator variables were only based on the production rate. They did not indicate any step changes in processes on the site. We found this application of indicator variables redundant to real production data and the removal of the indicator variables improved the explanatory power of the models (adjusted R^2) and significance of the independent variables (p-values). Indicator variables are valuable tools to note step changes or anomalies at a facility. An example may be to mark a change in the product that they produce or a change in the method by which they produce it. However, without intimate knowledge of each facility, we don't have the information needed to determine what changes, if any, warrant the use of an indicator variable.

2.3.3 Energy Accounting

Given a multi-year engagement like this, special care must be taken in energy accounting. Year over year savings at a given site should be tracked as incremental, not cumulative. For example, let's say a site saves 1 kWh in year one and an additional 1 kWh in year two. In year two the site is still achieving the 1 kWh of savings from year one. In a cumulative accounting approach, this could be characterized as a savings of 2 kWh in year two. Alternatively, incremental accounting claims only new savings in each year, so in this example, the year two savings should be 1 kWh.

2.3.4 Baseline and Performance Periods

NEEA must report savings that are incremental to those that have been reported previously. One way to ensure that savings claims are incremental, not cumulative is in determining the baseline period. If in the current analysis year, the baseline timeframe is the previous performance period, all savings measured by the model will be incremental. We would call this approach a rolling baseline. If however, the baseline period for each year's model is fixed at a period prior to the engagement, special care must be taken to net out early year savings from later year performance. From NEEA's perspective, the fixed baseline approach can be valid as long as proper accounting is performed to net out previous years' savings claimed from the current year to ensure savings aren't tracked cumulatively. The rolling baseline approach has the advantage of always using more recent data as the baseline, which captures ever evolving facility operations. For example, if a facility adds or changes equipment, changes their product mix, or manufacturing process, this can be reflected in the rolling baseline approach, whereas the fixed baseline approach is prone to inaccuracy in later years as facility operations change.

In our analysis, we chose a baseline period consistent with last year's performance period. Table 2 shows the baseline and analysis periods for each site. Prior to this evaluation, the CEI sites used different performance periods than non-CEI sites. To align timeframes for cleaner evaluations going forward, we only used a 3 month performance period for CEI sites. While this results in a short performance period this year, all performance periods can now be aligned for future evaluations.

Table 2: Baseline and performance period for all sites in this analysis

	2012											
Site	January	February	March	April	May	June	July	August	September	October	November	December
A014												
A028												
A030	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
A034												
A039	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
A040												
A041	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
A042	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
A047	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline
A052												

	2013											
Site	January	February	March	April	May	June	July	August	September	October	November	December
A014	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Performance	Performance	Performance
A028	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Performance	Performance	Performance
A030	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance
A034	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Performance	Performance	Performance
A039	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance
A040	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Performance	Performance	Performance
A041	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance
A042	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance
A047	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance	Performance
A052	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Baseline	Performance	Performance	Performance

(orange)	Baseline Period
(green)	Performance Period

Sites A014, A028, A034, A040, and A052 are participants in NEEA's CEI program and have already had savings claimed through September 30, 2013. Therefore, we were only able to claim the last quarter of 2013 as saving. Our baseline period for those projects was limited to January 1, 2013 until September 30, 2013. Our performance periods for this validation were selected to all end at the same time so that the next year's validation can use the same performance periods for all sites.

2.3.5 Model Fit

Developing regression evaluation criteria is a critical step in developing energy models. We used the following criteria.

- Only include independent variables that are significant at the 95 percent confidence limit.

- Only include models where the regression has a coefficient of determination greater than 0.75.[2]
- Exclude any models where the baseline does not capture the entire range of independent variable conditions experienced during the performance period.[3]

By sticking to these criteria we were able to develop good fitting models with significant independent variables. The adjusted coefficient of determination and ambient variable for each of our models is shown in Table 3.

Table 3: Adjusted coefficients of determination (R^2) and ambient variables for each site[4]

Site	Electric R^2	Natural Gas R^2	Electric Regression Ambient Variable	Natural Gas Regression Ambient Variable
A014	0.996	0.838	None	None
A028	0.976	0.883	None	HDD 55F
A030	0.289[5]	0.667[5]	None	HDD 55F
A034	0.960	0.996	CDD 65F	None
A039	0.163[5]	0.977	Average Monthly Wet Bulb	HDD 65F
A040	0.993	0.994	CDD 60F	HDD 55F
A041	0.578[5]	0.783	Average Monthly Dry Bulb	Average Monthly Wet Bulb
A042	0.946	0.985	None	None
A047	0.830[5]	0.884[5]	None	None
A052	0.993	0.988	None	None

The average adjusted coefficients of determination for electric and natural gas models where we are reporting savings are 0.977 and 0.931 respectively. This indicates that in general the models have a good fit and are capable of describing the majority of variation in the baseline data. Additionally, we found that half of the sites' energy use was not strongly weather dependent, as indicated by insignificant ambient variables in their models. While this would be a very odd occurrence in commercial buildings, it is a reasonable finding for industrial sites where energy use is much more strongly coupled with production rates than ambient conditions.

2.3.6 Impact of Model Differences

While we saw a very large discrepancy between the NWFPA calculated savings and Energy 350 calculated savings, the differences in modeling approach represent only a small portion of the discrepancy. The difference is largely because the NWFPA approach calculates savings cumulatively, not incrementally. In other words, the savings reported by NWFPA for the most recent evaluation period are actually the total savings throughout the entire engagement.

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[2] If multiple models have adjusted coefficients of determination greater than 0.75, we selected the regression with highest adjusted coefficient of determination.
[3] This arose for one site A047. We did not count savings for this site because one month in the performance period had production that was 140 percent higher than any month in the baseline period. We recommend excluding savings for this site because data driven models are often very poor at extrapolating beyond the bounds of the data they are based on.
[4] Coefficient of determination (not adjusted) is used when the regression has only one independent variable
[5] Savings are not reported for these models. See site specific sections for more details.

Additionally, NWFPA reported energy savings for multiple sites where we were unable to develop regressions with a good enough fit because we did not throw out unexplained outlier data points in our baseline models. It is our position that outlier data points should only be thrown out when known to be erroneous. For example, if we see a month of unusually high production and we confirm with the facility that it is inaccurate data and that production was not actually that high, this is a valid reason to eliminate that data point. However, unless outlier data points can be confirmed to be erroneous, it is our practice to include outlier data points.

Table 4 shows the savings reported by NWFPA and Energy 350 for each site.

Table 4: Energy 350 and NWFPA energy savings comparison for all sites

	Electric Savings (aMW)		Gas Savings (MMBtu)	
Site	Energy 350	NWFPA	Energy 350	NWFPA
A014	-0.051	-0.025	-4,428	2,369
A028	0.115	0.307	-1,691	-2,495
A030	0.000	0.175	0	0
A034	-0.015	0.010	-2,256	-1,787
A039	0.000	0.054	-38	0
A040	0.117	0.262	-10,535	6,875
A041	0.000	0.494	29,358	152,481
A042	-0.029	0.005	2,239	353
A047	0.000	0.180	0	50,556
A052	-0.135	-0.012	-2,042	-288
Total	**0.001**	**1.450**	**10,607**	**208,064**

There is a very large difference between the energy savings determined by Energy 350 and NWFPA. While different independent variables may be the source of some of the difference in energy savings, baseline period selection and energy accounting practices likely account for much more of the discrepancy. These large differences in savings can likely be attributed primarily to NWFPA accounting for savings cumulatively whereas we accounted for savings incrementally.

2.3.7 Trend of Site Energy Performance

As shown previously, electric energy savings for the 2013 performance period are very small. However, we wanted to evaluate the long-term trend of energy savings to see if the small savings in the 2013 performance period are representative of the long term energy performance for these sites. The percent savings for electric and natural gas energy dating back to 2009 is shown in Figure 1 and Figure 2.

Figure 1: Cumulative electric energy savings dating back to the beginning of NWFPA's energy reduction campaign in 2009

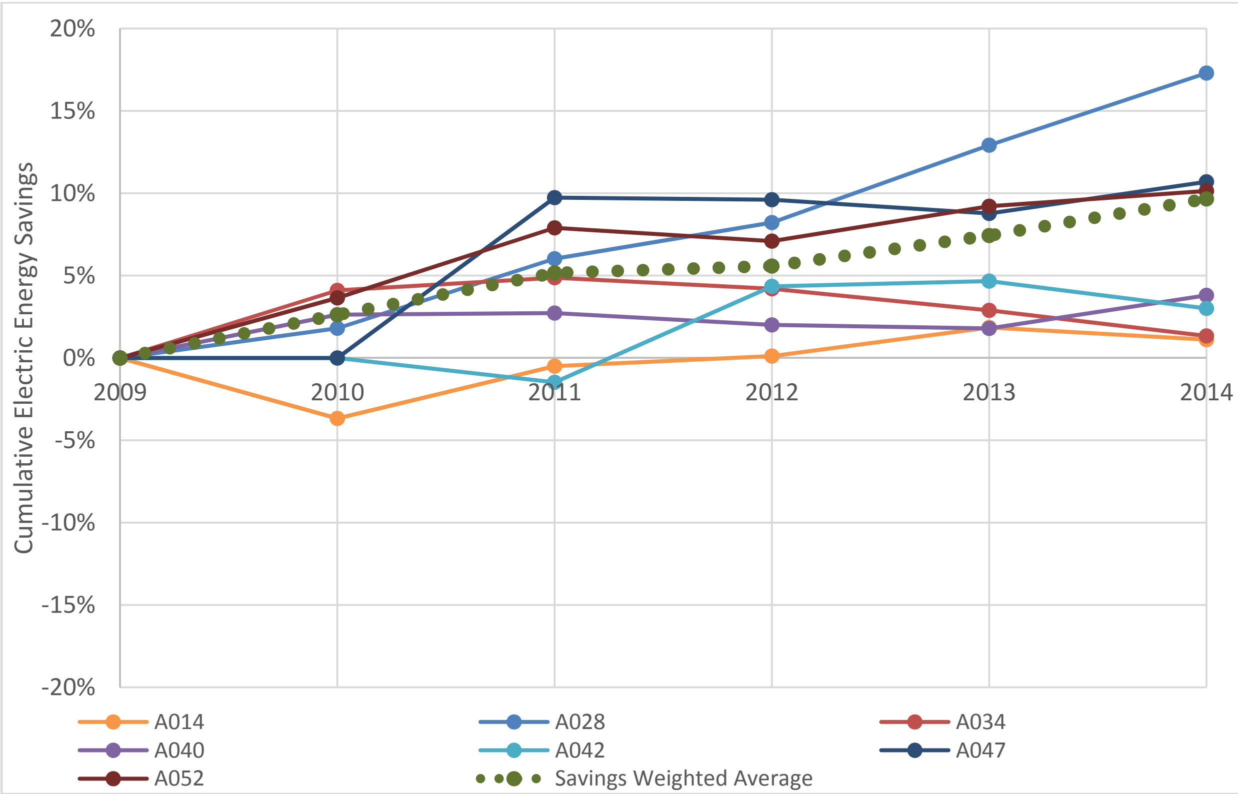


Figure 2: Cumulative natural gas energy savings dating back to the beginning of NWFPA's energy reduction campaign in 2009

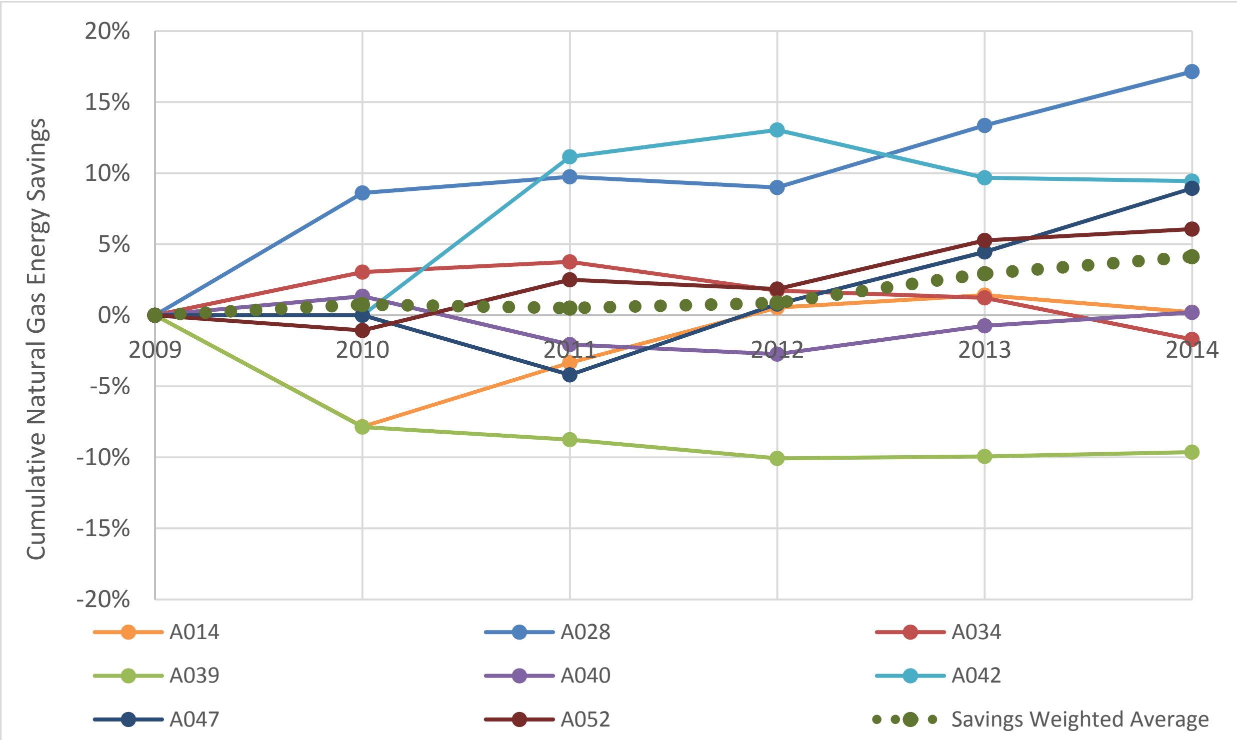


Figure 1 shows that cumulative electric energy savings have been steadily increasing since the beginning of NWFPA's energy reduction campaign. Cumulative savings at the end of 2013 reached nearly ten percent, which translates to average annualized electric savings of 1.8 percent. The reason Figure 1 shows a sizeable increase in savings during 2013, whereas the detailed 2013 performance period analysis shows very little electric savings is because the performance periods for many of the sites in the detailed analysis was only the last quarter of 2013. The two sites showing positive savings in the detailed analysis both participate in NEEA's CEI program and therefore we were only able to claim savings for those sites for the last quarter of 2013. Whereas, the sites that did not participate in NEEA's CEI program, and thus we were able to claim savings for all of 2013, tended to show negative or very small energy savings.

As can be seen in Figure 2, cumulative natural gas savings since 2009 are not as large as electric savings during the same period. Cumulative natural gas savings at the end of 2013 reached nearly five percent, which translates to average annualized natural gas savings of 0.8 percent.

As indicated in Figure 1 and Figure 2, long-term improvements to energy performance are being achieved by sites that participate in NWFPA's energy reduction campaign. These long-term savings trends suggest that NWFPA's energy reduction campaign is having an impact on energy use at their facilities even though the reported electric savings for the 2013 performance period are very small.

3 Site Level Review

3.1 Site A042 Summary

Participant in NEEA's Continuous Energy Improvement Program: No

The regressions created by NWFPA resulted in a model with a good fit, however Energy 350 identified several improvements to the model. The most significant improvement was related to the baseline period. This site provided energy and production data dating back to 2009, which coincides with the beginning of NWFPA's energy reduction campaign. As noted in Table 5, NWFPA's model utilized a three year baseline beginning in 2009 and ending in 2011. The NWFPA model used this three year baseline and did not account for savings that NEEA has previously claimed at the site. Therefore, energy savings were being recounted from previous years.

Our approach was to identify the last period of time when NEEA claimed savings at the site and use that period of time as our baseline period. This site does not participate in NEEA's CEI program so NEEA most recently claimed savings for this site from January 1st, 2012 until December 31st 2012 based on findings in Market Progress Evaluation Report #8 (MPER 8) (DNV KEMA Energy and Sustainability, Research Into Action Inc. 2014). For all sites, we attempted to align our baseline period with the previous performance period. Therefore, as shown in Table 5 our baseline uses 2012 calendar year data. In addition to the baseline period duration, other changes we made to the model include:

- Removal of the production indicator variable – We removed this because the production indicator variable used by NWFPA did not signify a step change in production such as switching production technique or switching what was being produced. The production indicator variable used by NWFPA only related to the presence of production at the site. The production rate variable already captures the impact that production has on energy use, so the production indicator variable used by NWFPA was statistically insignificant at the 95 percent confidence limit. Indicator variables are valuable for capturing step changes or anomalies in operation, but when used to indicate periods of high or low production, are redundant to the production rate variable. Removing the indicator variable improved the significance (p-values) of the independent variables.
- Removal of the weather variable – We investigated replacing the average monthly dry bulb temperature variables used by NWFPA with heating degree day (HDD) and cooling degree day (CDD) variables. However, we found that the HDD and CDD variables were still insignificant. Therefore, we used a bivariate regression with production rate as the only independent variable.

Table 5: Key model characteristics for site A042

	Energy 350	NWFPA
Baseline Period	01/01/2012 – 12/31/2012	01/01/2009 – 12/31/2011
Performance Period	01/01/2013 – 12/31/2013	01/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.946/0.985	0.970/0.994

Key regression statistics including the adjusted coefficients of determination (R^2) and independent variable p-values were used to determine the goodness of fit of the regressions. Adjusted coefficients of determination and p-values for each independent variable investigated can be found in Appendix A. As indicated in Table 6, these model changes had a significant impact on estimated energy savings.

Table 6: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	-0.029	0.005
Natural Gas Savings (MMBtu)	2,239	353

The difference in electric savings estimated using the two different models during this period is significant. However, without detailed knowledge of changes implemented at the site, it is difficult to attribute the savings to specific changes in plant operation. Therefore, energy use is plotted in Figure 3 and Figure 4 in order to better visualize the two models and understand differences between them.

Figure 3: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model

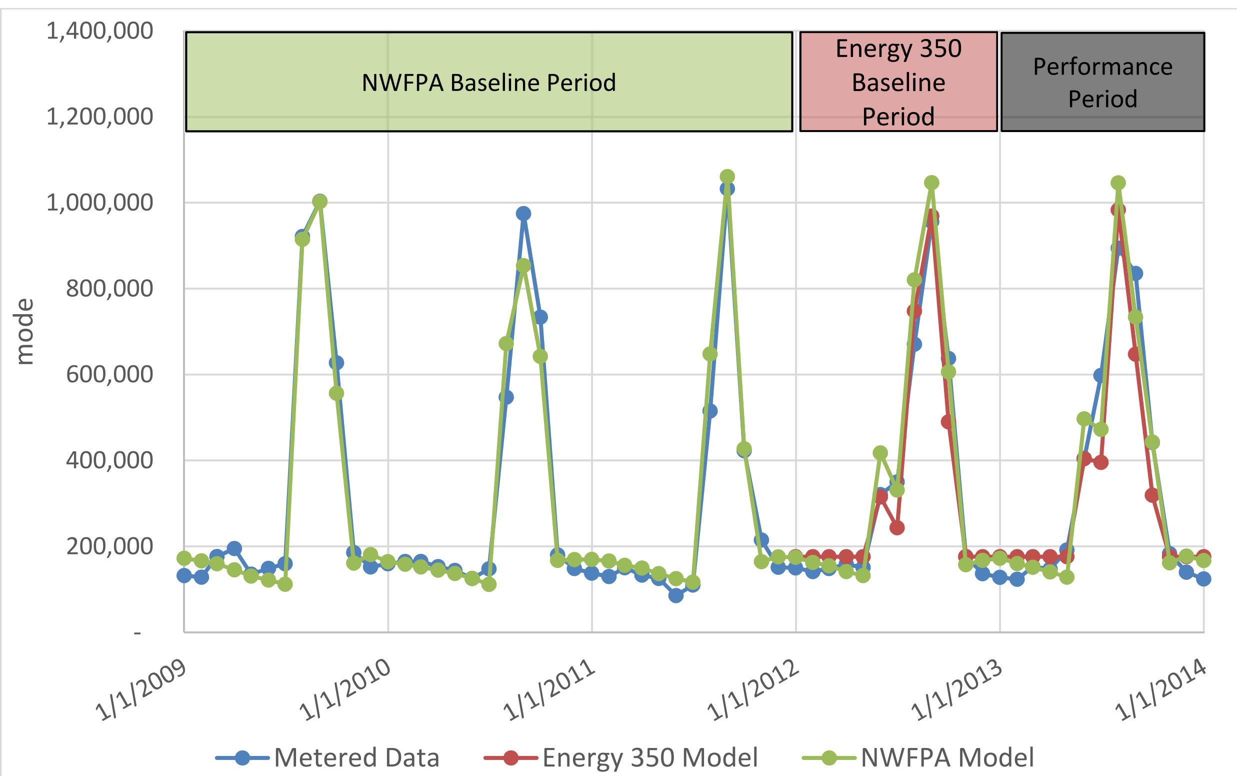
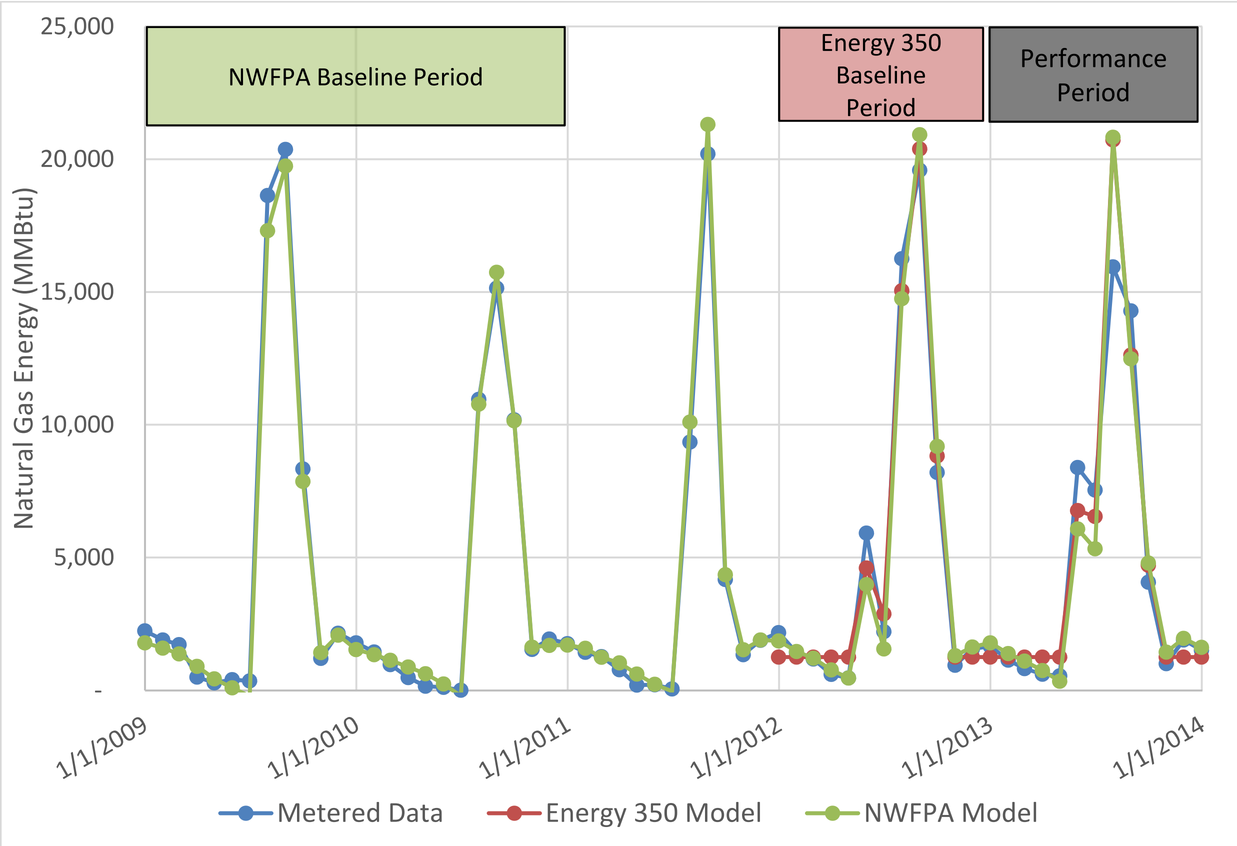


Figure 4: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model



Both electric models show savings during non-production periods (November through May) and peak production periods (September). However, the Energy 350 electric model tends to show slightly more savings during non-production periods and the NWFPA electric model shows more savings during peak production. While both models show savings during non-production and peak production, the overall savings over the analysis period is negative because both models yield negative savings during moderate production periods (June, July, August and October).

Both natural gas models show similar savings during non-production times. Similarly to the electric regressions, both natural gas models also show large negative savings during moderate production periods.

3.2 Site A052 Summary

Participant in NEEA's Continuous Energy Improvement Program: Yes

The NWFPA models for this site showed significant energy savings and the regressions had high adjusted coefficients of determination (R^2). Key regression characteristics for the NWFPA and Energy 350 models are shown in Table 7.

Table 7: Key model characteristics for site A052

	Energy 350	NWFPA
Baseline Period	01/01/2013 – 09/30/2013	01/01/2006 – 12/31/2009[6] 01/01/2006 – 12/31/2007
Performance Period	10/01/2013 – 12/31/2013	10/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.993/0.988	0.974/0.983

The adjusted coefficients of determination (R^2) for both models are very high. However, the baseline periods are different between the NWFPA and Energy 350 models. NEEA has claimed savings for this site since NWFPA's energy reduction campaign began in 2009. Therefore care must be taken in energy accounting practices to ensure savings are not double counted. We account for savings that have already been claimed by training our baseline during the last performance period when NEEA claimed savings. This approach ensures that energy savings are not double counted. NWFPA used a baseline based on data from before the last time NEEA claimed savings. Additionally, NWFPA did not make any adjustments to account for improved facility performance based on savings that NEEA has already claimed, which results in an accounting of savings cumulatively. In addition to using a different baseline period, we elected to make several other changes to the models, including:

- Removal of the production indicator variable – As previously mentioned, NWFPA used the production indicator variable to signify periods when the facility was in production. The production indicator variable did not signify step changes in production such as switching production technique or switching what was being produced. Therefore, we removed the production indicator variable because the production rate variable already captures the impact that production has on energy use. The insignificance of the production indicator variable was made evident by its high p-values. The production indicator variables' p-values for the electric and natural gas regressions were 0.313 and 0.440, respectively.
- Removal of the ambient variable – We investigated replacing the average monthly dry bulb ambient variable used by NWFPA with HDD and CDD variables. However, we found that the ambient variables were still insignificant. Therefore, we utilized a bivariate regression using production rate as the only independent variable.
- Inclusion of all months in the energy model – NWFPA did not include April or May in their models. These months were excluded from the models due to a data entry oversight by NWFPA. They entered the production data for April and May as blanks instead of zeros into their statistical modelling tool, JMP. This resulted in JMP interpreting the production for April and May as missing data points, even though the data for those months was provided by the site. We identified and corrected the issue in JMP, therefore our models include all months.

As indicated by Table 8, the result of the changes to the models is an increase in negative electric and natural gas savings.

[6] NWFPA used different baseline periods for the electric and natural gas models. The electric baseline period is shown on the first line and the natural gas baseline period is shown on the second line.

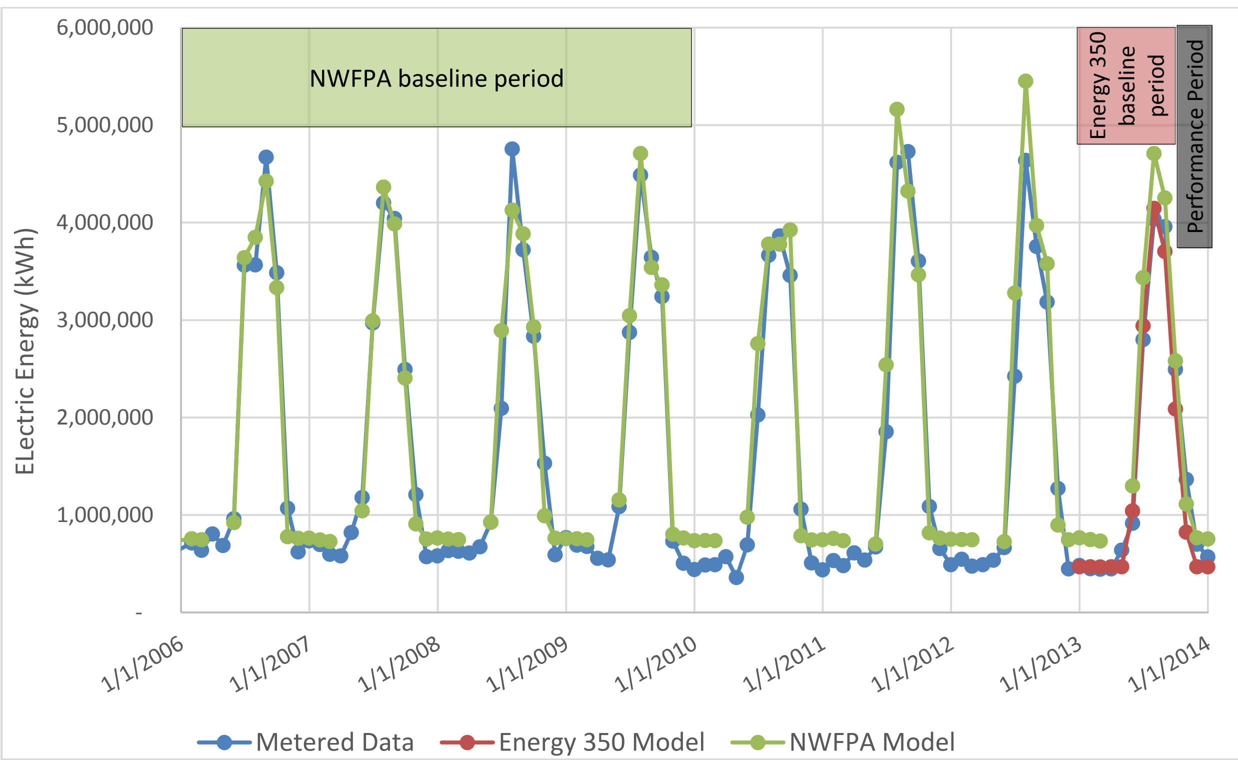
Table 8: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	-0.135	-0.012
Natural Gas Savings (MMBtu)	-2,042	-288

All models show negative savings at this site, however the Energy 350 model shows more negative savings. The difference is largely driven by the baseline selection. The NWFPA model uses a baseline dating back to 2006 and does not net out previously claimed savings. This method of accounting tracks annual savings cumulatively, whereas our savings are tracked incrementally.

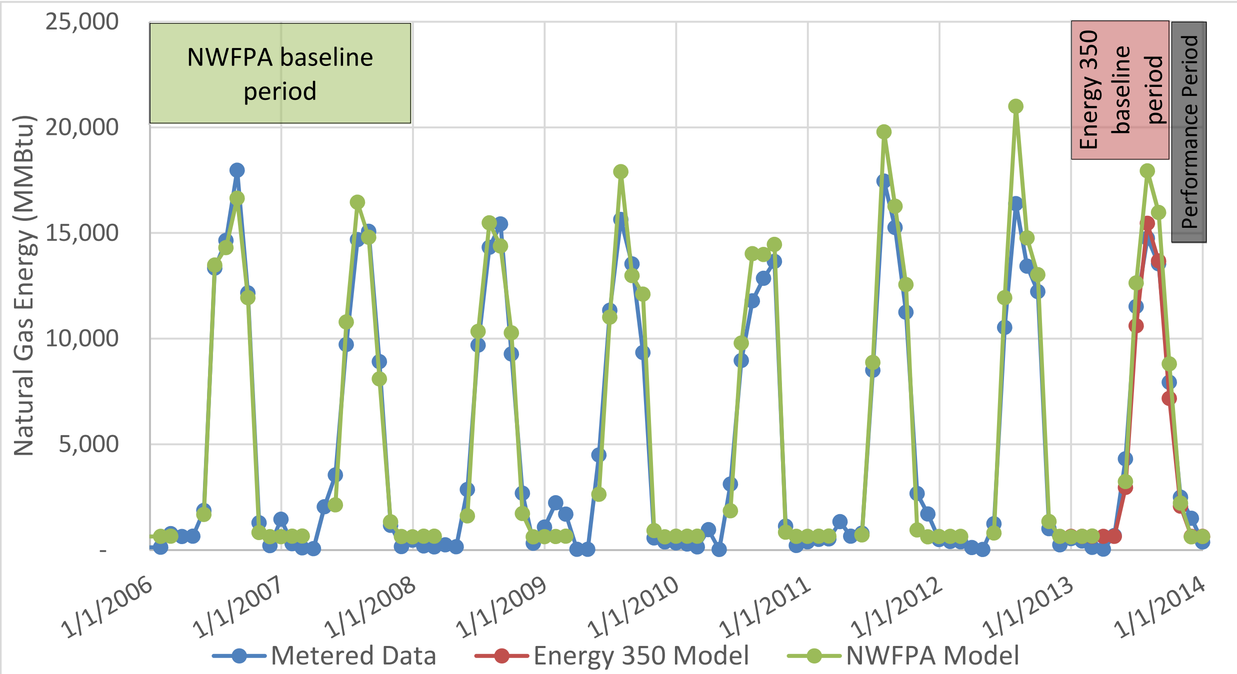
Energy use is plotted in Figure 5 and Figure 6 in order to better visualize the two models and understand differences between them.

Figure 5: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model[7]



[7] The NWFPA electric and natural gas models exclude data points from April and May for every year. Therefore these months are not shown in the NWFPA models in Figure 5 and Figure 6.

Figure 6: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model



This site likely implemented energy efficiency measures sometime between 2006 and 2010. These energy efficiency measures improved electric energy performance during non-production periods (December through May). This is supported by the NWFPA electric model predicting much larger savings than the Energy 350 electric model during non-production periods.

3.3 Site A040 Summary

Participant in NEEA's Continuous Energy Improvement Program: Yes

The NWFPA models for this site showed significant energy savings and the regressions had high adjusted coefficients of determinations (R^2). Key regression characteristics for the NWFPA and Energy 350 models are shown in Table 9.

Table 9: Key model characteristics for site A040

	Energy 350	NWFPA
Baseline Period	01/01/2013 – 09/30/2013	01/01/2006 – 12/31/2007[8] 01/01/2006 – 12/31/2006
Performance Period	10/01/2013 – 12/31/2013	10/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.993/0.994	0.981/0.960

The adjusted coefficients of determination (R^2) for both models are very high. However, the baseline periods are different between the NWFPA and Energy 350 models. As with other CEI sites, NEEA

[8] NWFPA used different baseline periods for the electric and natural gas models. The electric baseline period is shown on the first line and the natural gas baseline period is shown on the second line.

has previously claimed savings at this site. NWFPA used a baseline based on data from before the last time NEEA claimed savings. Additionally, they did not make any adjustments to account for improved facility performance based on savings that NEEA has already claimed, which results in double counting savings. The Energy 350 baseline does not double count savings because our baseline uses data from the last performance period when NEEA claimed savings. In addition to using a different baseline period, we elected to make several other changes to the models, including:

- Removal of the production indicator variable – As previously mentioned, we removed this because the production rate variable already captures the impact that production has on energy use. The insignificance of the production indicator variable was made evident by its high p-values. The production indicator variables' p-values for the electric and natural gas regressions were 0.078 and 0.641, respectively.
- Replacement of the ambient variable from average monthly dry bulb and wet bulb temperature to HDD and CDD. We implemented a heating and cooling degree day approach because it is considered best practice for energy estimating as it accounts for variations in temperature, which cannot be captured by using monthly average temperature.

The impact that removal of the production indicator variable and switching to a heating and cooling degree day approach has on the model is shown in Table 10.

Table 10: P-values for the ambient variables included the NWFPA's and Energy 350's models

	Energy 350	NWFPA
Electric Regression Ambient Variable P-Value	0.004	0.071
Natural Gas Regression Ambient Variable P-Value	0.051	0.497

The changes to the model improved the regression statistics while shortening the baseline period. The result is a better regression which does not double count savings. The baseline period is less than one year, however it covers a broad range of ambient conditions and production rates which reduce the risk of a seasonal bias in the model. The impact these model changes have on energy savings is shown in Table 11.

Table 11: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	0.117	0.262
Natural Gas Savings (MMBtu)	-10,535	6,875

The NWFPA models show much larger energy savings than the Energy 350 models. The large difference in savings is primarily driven by the baseline period. The NWFPA baseline uses data from before the last time NEEA claimed savings at this site and therefore the NWFPA model is accounting savings cumulatively whereas we are accounting for savings incrementally. In order to better visualize the differences between the models, they are shown graphically in Figure 7 and Figure 8.

Figure 7: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model

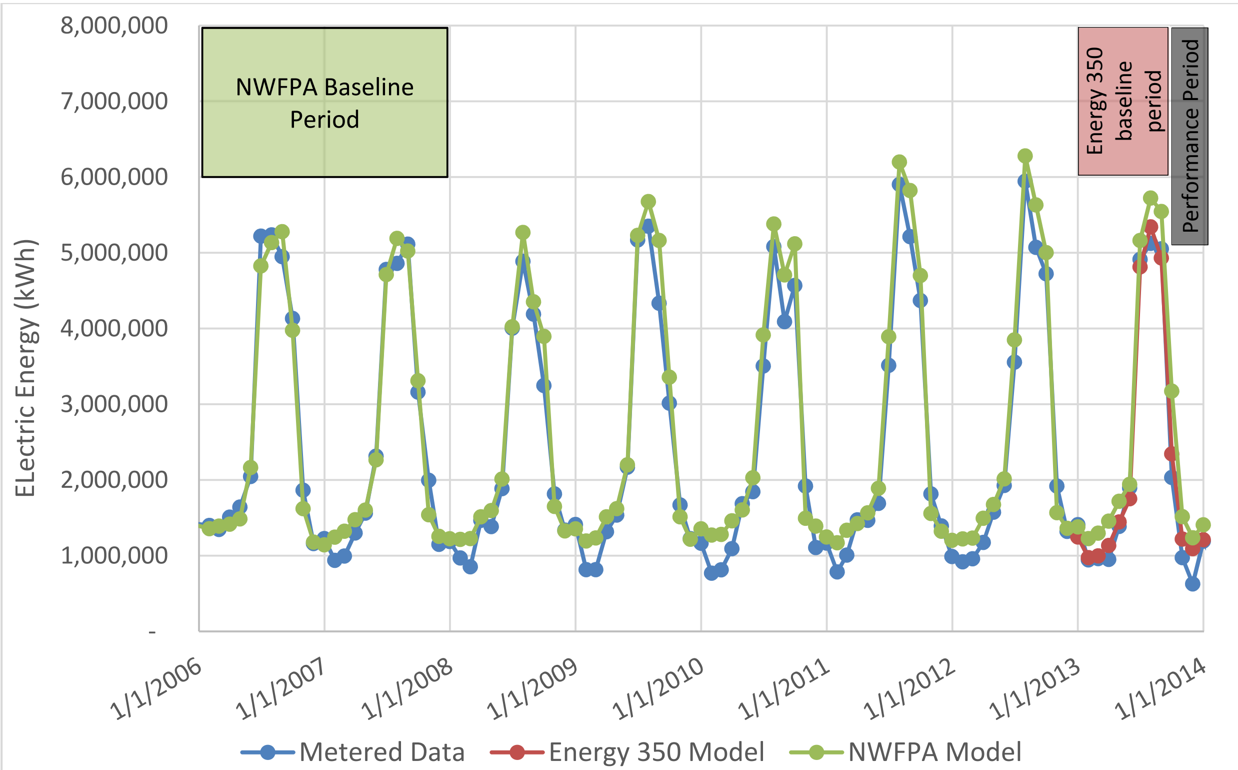
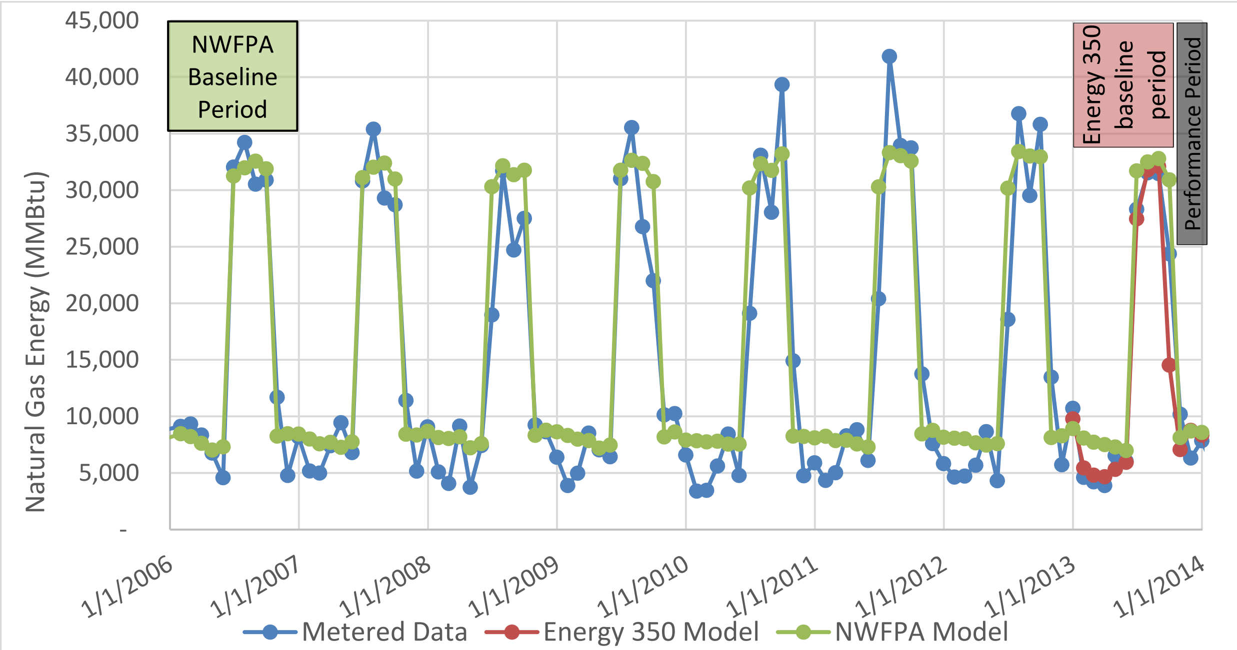


Figure 8: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model.



The NWFPA models closely track metered data during 2006. However after that both NWFPA models begin to show significant savings during low production periods (January through April). This suggests that energy efficiency measures were implemented sometime before 2007 and the NWFPA model continues to account for those savings even though they have already been claimed by NEEA.

The electric models differ the most during low production periods. The NFWPA model shows high savings during low production periods, whereas the Energy 350 model show savings, but they are not nearly as large.

The natural gas models differ considerably as well. The NWFPA model does not respond as much to changes in ambient conditions or production and therefore shows more repetitive annual pattern.

3.4 Site A014 Summary

Participant in NEEA's Continuous Energy Improvement Program: Yes

The NWFPA electric model resulted in a good fit, however the NWFPA natural gas model did not yield as good a fit. Key regression characteristics for the NWFPA and Energy 350 models are shown in Table 12.

Table 12: Key model characteristics for site A014

	Energy 350	NWFPA
Baseline Period	01/01/2013 – 09/30/2013	01/01/2006 – 12/31/2007[9] 01/01/2006 – 12/31/2006
Performance Period	10/01/2013 – 12/31/2013	10/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.996/0.838	0.988/0.789

The adjusted coefficients of determination (R^2) for both electric models are very high. However, the adjusted coefficients of determination for both natural gas models are not as high. As was performed at other sites, we elected to shift our baseline period to the last performance period when NEEA claimed savings, thus removing the possibility of double counting savings. In addition to using a different baseline period, we elected to make several other changes to the models, including:

- Removal of the production indicator variable – As previously mentioned, we removed this because the production rate variable already captures the impact that production has on energy use.
- Removal of the ambient variable – We investigated replacing the average monthly dry bulb temperature and average monthly wet bulb temperature ambient variables used by NWFPA with HDD and CDD. However, we found that HDD and CDD were still insignificant as independent variables. Therefore, we utilized a bivariate regression using production rate as the only independent variable.

The changes to the models prevent double counting savings already claimed by NEEA and improves the regression statistics. The impact these changes have on energy savings is shown in Table 13.

Table 13: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	-0.051	-0.025
Natural Gas Savings (MMBtu)	-4,428	2,369

The shift in baseline period results negative savings in the Energy 350 natural gas and electric models. In order to visually display the differences between the models, they are shown graphically in Figure 9 and Figure 10.

[9] NWFPA used different baseline periods for the electric and natural gas models. The electric baseline period is shown on the first line and the natural gas baseline period is shown on the second line.

Figure 9: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model

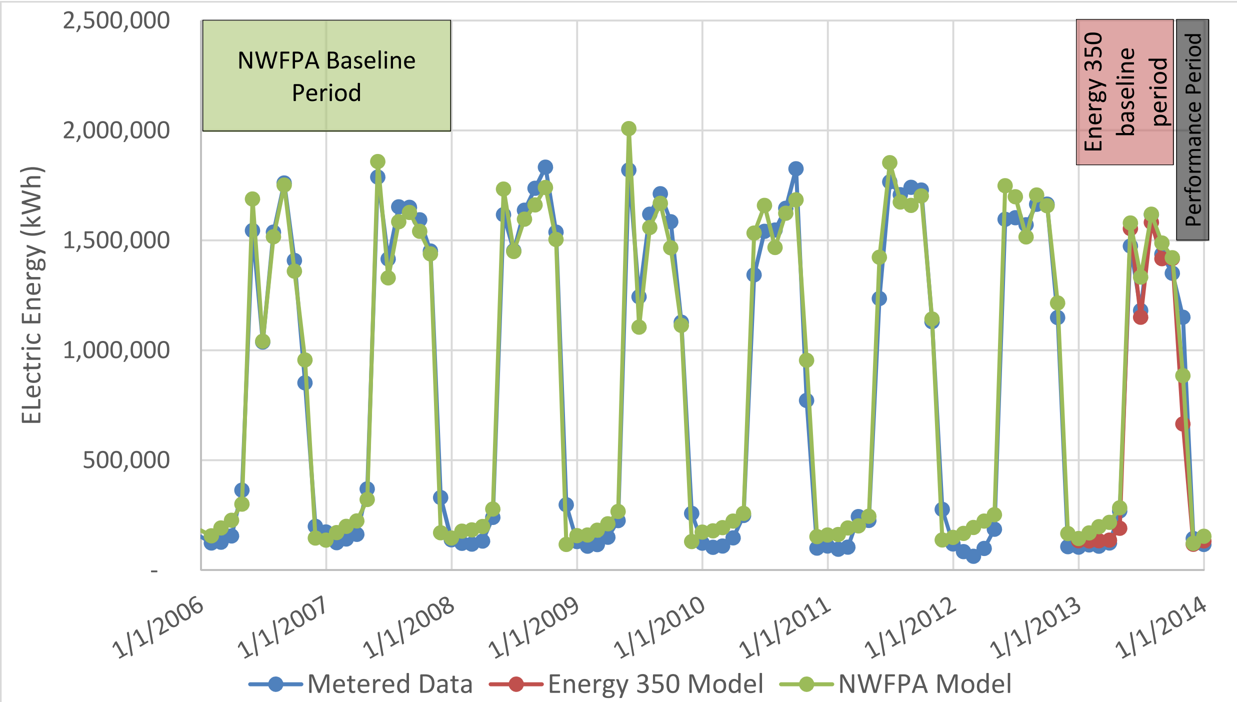
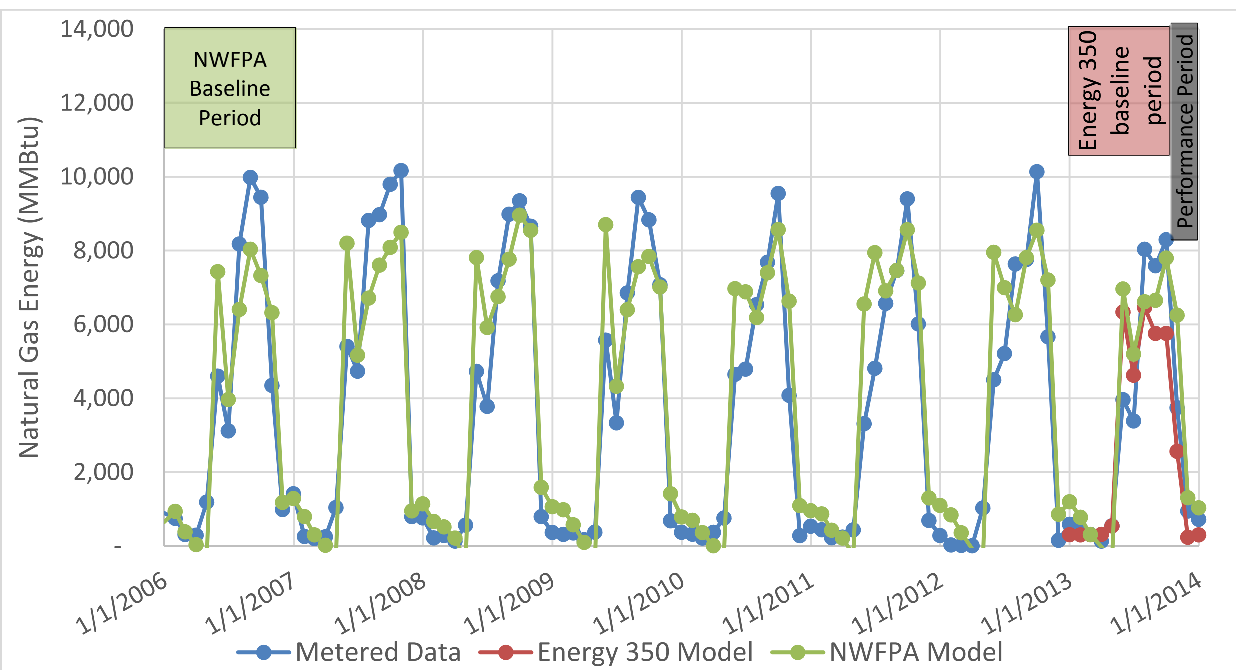


Figure 10: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model



Both electric models had very high adjusted coefficients of determination, which is can be seen by the close fit of the models during their baseline periods. The largest difference in the electric models occurs during the moderate production periods (November and December), when the NWFPA model shows less negative savings. The natural gas models do not have as high of adjusted coefficients of determination and thus the models do not fit the metered data as well in the baseline period. Both natural gas models overestimate natural gas energy in June and July and underestimate natural gas energy during September and October. This likely means that there is a change in production during the middle of the summer that is not captured by the production rate variable. Additional information from the site such as their production schedule may help to address this issue.

3.5 Site A034 Summary

Before submitting the analysis for this and all subsequent sites (sections 3.5 – 3.10), NWFPA met with Energy 350 to discuss their modelling method. Therefore, many of the improvements Energy 350 identified and implemented to the first four sites (sections 3.1-3.4) were incorporated into this and all subsequent sites before they were submitted for Energy 350's review.

Participant in NEEA's Continuous Energy Improvement Program: Yes

The regressions created by NWFPA resulted in a model with a good fit, however we were able to identify a couple of improvements to the models.

- Adjust the baseline period – As previously mentioned, we used a baseline period corresponding to when NEEA last claimed savings for this site. This prevents double counting savings that NEEA has previously claimed for this site. NWFPA used a baseline dating back to 2006 and did not make any adjustments to account for the savings NEEA has claimed.
- Change HDD and CDD reference temperatures – NWFPA utilized a HDD and CDD approach for this site. However, they used a 30 degree Fahrenheit reference temperature for heating and a 75 degree Fahrenheit reference temperature for cooling. While these reference temperatures may yield the best regression statistics, they are outside reasonable bounds for HDD and CDD reference temperatures. We elected to restrict the HDD and CDD reference temperatures to between 55 degree Fahrenheit and 65 degrees Fahrenheit. Performing an iterative analysis within these bounds revealed that using a 65 degree Fahrenheit reference temperature results in the ambient variable being statistically significant at the 95 percent confidence limit and yields an electric model with the highest adjusted coefficient of determination. A similar analysis was performed for the natural gas model, but all the ambient variables investigated were insignificant at a 95 percent confidence limit. Therefore we used a bivariate regression with production rate as the only independent variable for our natural gas model.

Changing the baseline period and independent variables improved the fit of resulting models. Key regression statistics for NWFPA's models and Energy 350's models are summarized in Table 14.

Table 14: Key model characteristics for site A034

	Energy 350	NWFPA
Baseline Period	01/01/2013 – 09/30/2013	01/01/2006 – 12/31/2007
Performance Period	10/01/2013 – 12/31/2013	10/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.960/0.996	0.838/0.969

While changing the baseline period and ambient variables improved the regression statistics, Table 15 shows that there were larger impacts on the estimated energy savings.

Table 15: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	-0.015	0.010
Natural Gas Savings (MMBtu)	-2,256	-1,787

Once again, the discrepancy in energy savings is largely driven by the baseline period selection. In order to better understand the differences between the models they are displayed graphically in Figure 11 and Figure 12.

Figure 11: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model.

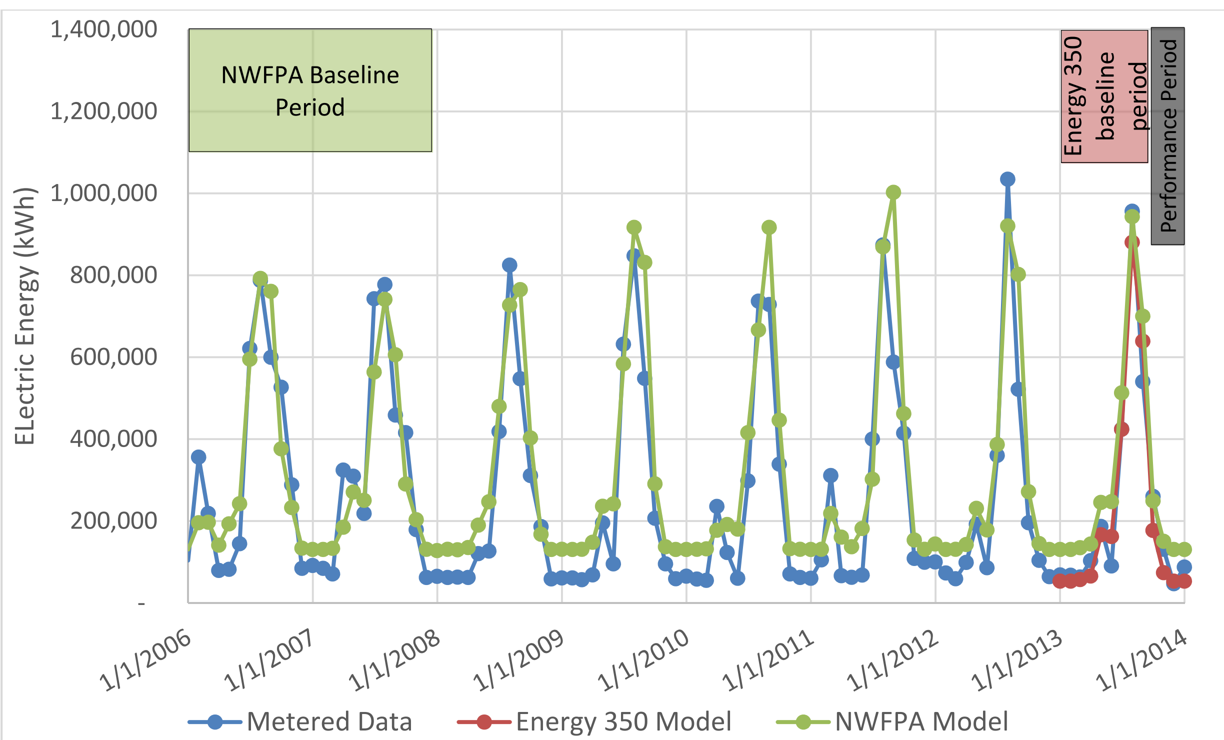
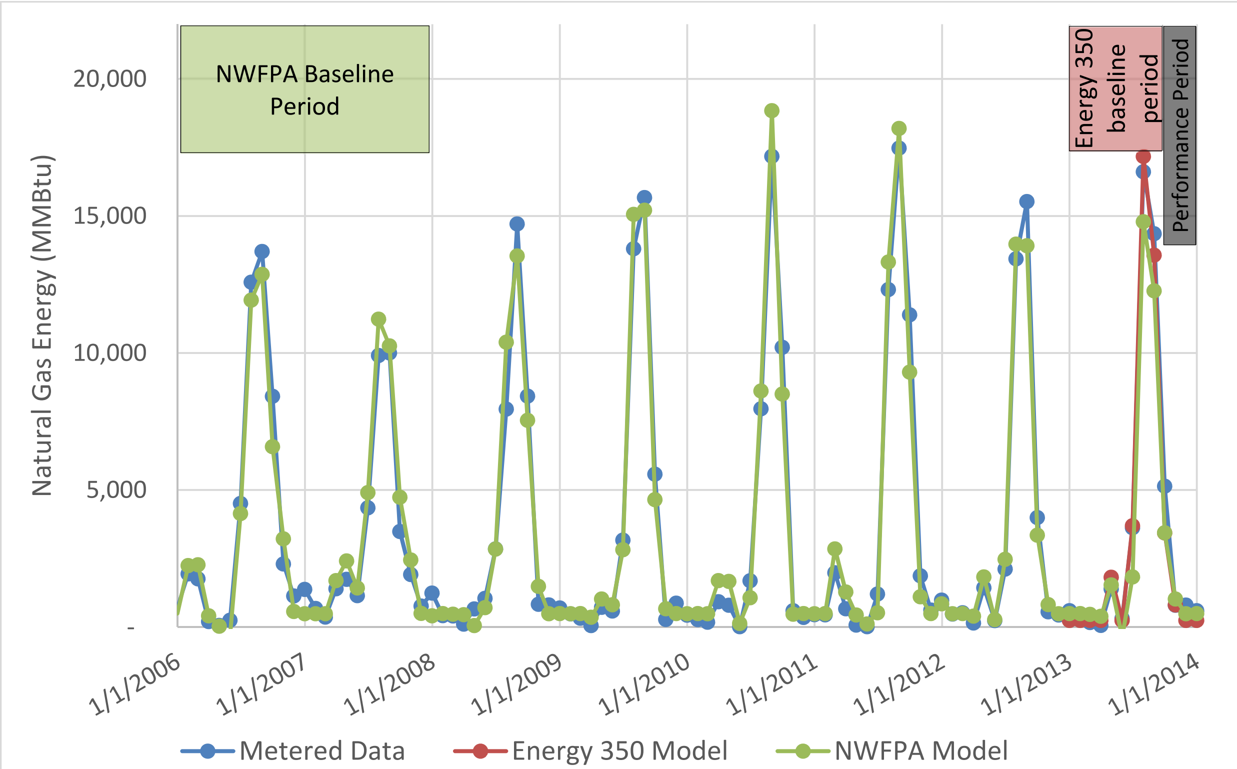


Figure 12: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model.



The large difference in electric savings is a result of the NWFPA baseline model using data from 2006 and 2007. During that time, energy use during non-production periods (December through March) was much higher than it has been in recent years. Once again this results in double counting savings already claimed by NEEA.

3.6 Site A041 Summary

Participant in NEEA's Continuous Energy Improvement Program: No

The regressions created by NWFPA resulted in a model with a fit that meets ASHRAE's regression requirements ($R^2 > 0.75$). However, upon closer inspection of the models, we identified a number of changes to the models.

- Ambient variable selection – The NWFPA models used HDD with a 50 degree Fahrenheit reference temperature for their electric model and used CDD with a 45 degree Fahrenheit reference temperature for their natural gas model. These were used because NWFPA found that they resulted in the highest adjusted coefficient of determination. However, this is an unusual application of these ambient variables and their use results in negative regression coefficients. Standard convention is to use HDD for natural gas models (in natural gas heated spaces) and to use CDD for electric models. Additionally, the reference temperatures are typically bound between 55 degrees Fahrenheit and 65 degrees Fahrenheit. We performed an iterative analysis and found that average monthly dry bulb and average monthly wet bulb yielded the best fitting regressions for the electric and natural gas models, respectively.

- Outlier identification – The NWFPA models excluded data from June 2009 because it appeared to be an outlier for electric energy use. It appeared to be an outlier because the electric energy use was considerably higher than would be expected for the given production rate and ambient conditions. Additionally, excluding this data point improved the fit of their model and the significance of their independent variables. We recommend including all data points in the models unless there is justification from the site for why the data point does not represent typical operation. We believe that data should only be excluded from the models under extreme circumstance, such as a meter failure or known anomalous occurrence at the site. NWFPA noted that they were not aware of any meter failures or other anomalous occurrences at this site, therefore we included all data points in our models.

Energy savings for this site have not previously been claimed by NEEA. Therefore, we were less restricted in our baseline period selection. However, we used 2012 as our baseline period because it resulted in the best models when including all data points. As shown in Table 16 the electric regression's adjusted coefficient of determination was significantly below 0.75 so we do not recommend claiming electric savings for this site.

Table 16: Key model characteristics for site A041

	Energy 350	NWFPA
Baseline Period	01/01/2012 – 12/31/2012	01/01/2009 – 12/31/2009
Performance Period	01/01/2013 – 12/31/2013	01/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.384/0.783	0.759/0.756

Changing the ambient variables, baseline period, and handling of outliers resulted in a significantly worse adjusted coefficient of determination (R^2) for electric model. As can be seen in Table 17, the savings that NWFPA estimated for this site during the performance period are large and therefore excluding this site from our reported savings will have a sizeable impact on the energy savings for the cohort of buildings included in this analysis.

Table 17: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	0.000	0.494
Natural Gas Savings (MMBtu)	29,358	152,481

Our models show much less savings, which is a result largely driven by the baseline selection period. A graphical representation of the models is shown in Figure 13 and Figure 14 to help demonstrate the differences between the models.

Figure 13: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model.

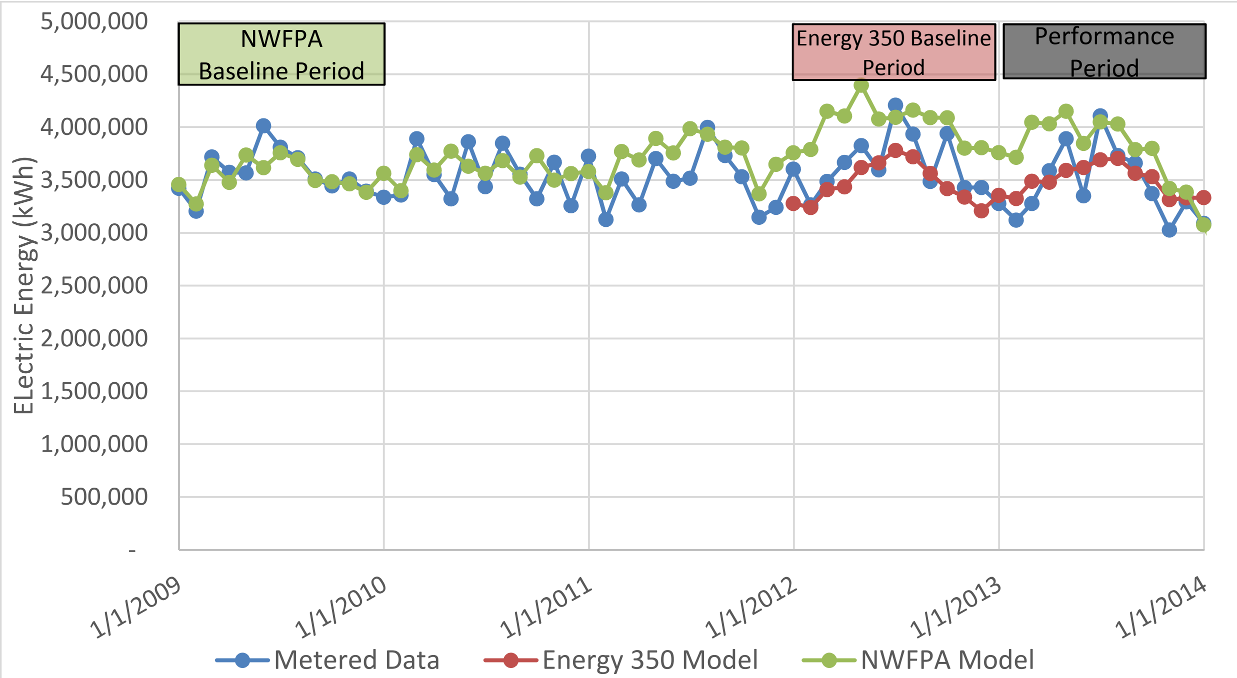


Figure 14: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model.

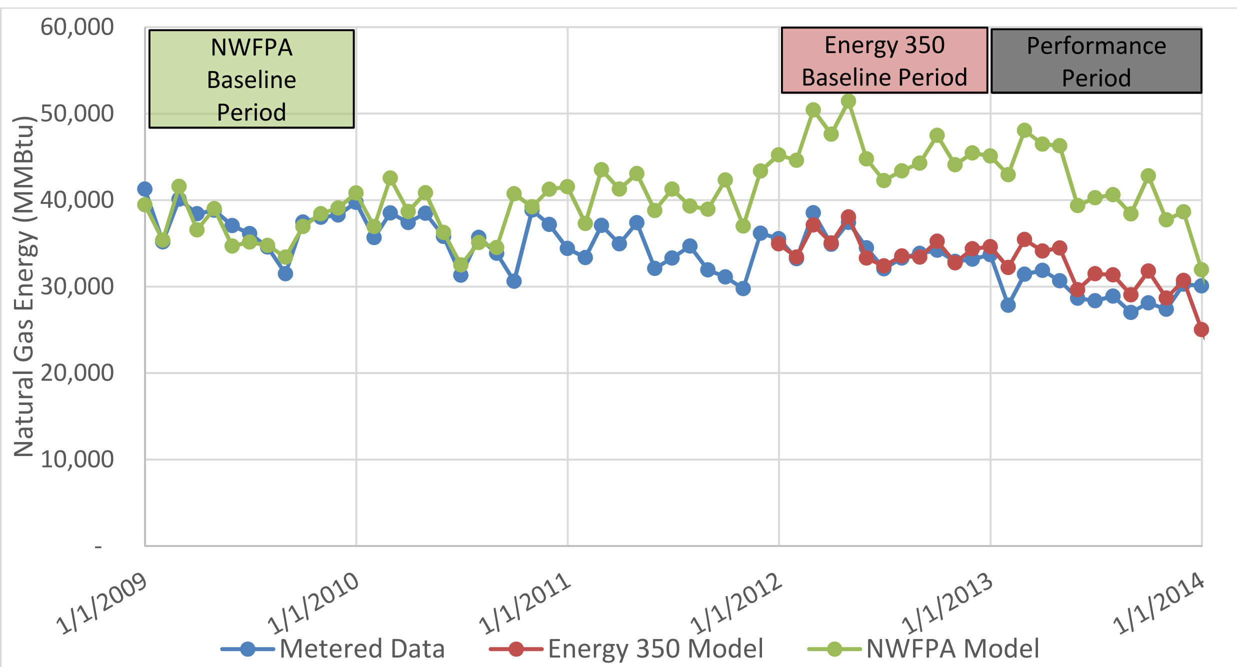


Figure 13 shows the poor fit of our electric model during the baseline period, which is expected because our electric model has an adjusted coefficient of determination of 0.384. Additionally, Figure 14 shows the large difference in natural gas savings due primarily to baseline period selection.

3.7 Site A028 Summary

Participant in NEEA's Continuous Energy Improvement Program: Yes

The regressions created by NWFPA resulted in a model with a good fit, however the NWFPA models were based on data dating back to 2006 and they did not adjust for any previously claimed savings by NEEA. We used a baseline period corresponding to when NEEA last claimed savings for this site, which prevents double counting savings.

NWFPA developed a natural gas model, however due to an oversight they did not provide details of the model. After multiple requests NWFPAs still did not provide details on their natural gas regression and therefore we were unable to compare natural gas regression statistics. Table 18 provides an overview of the available model characteristics.

Table 18: Key model characteristics for site A028

	Energy 350	NWFPA
Baseline Period	01/01/2013 – 09/30/2013	01/01/2006 – 12/31/2009
Performance Period	10/01/2013 – 12/31/2013	10/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.976/0.883	0.964/NA

Changing the baseline period marginally improved the adjusted coefficient of determination for the electric model. However, as shown in Table 19 the changes had a much larger impact on energy savings.

Table 19: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	0.115	0.307
Natural Gas Savings (MMBtu)	-1,691	-2,495

The Energy 350 electric model yields much less savings, which is the result of the baseline period selection. The electric and natural gas models are shown graphically in Figure 15 and Figure 16 to demonstrate the differences between the NWFPA and Energy 350 models.

Figure 15: Monthly electric utility data (metered data) compared to the energy 350 electric model and the NWFPA electric model

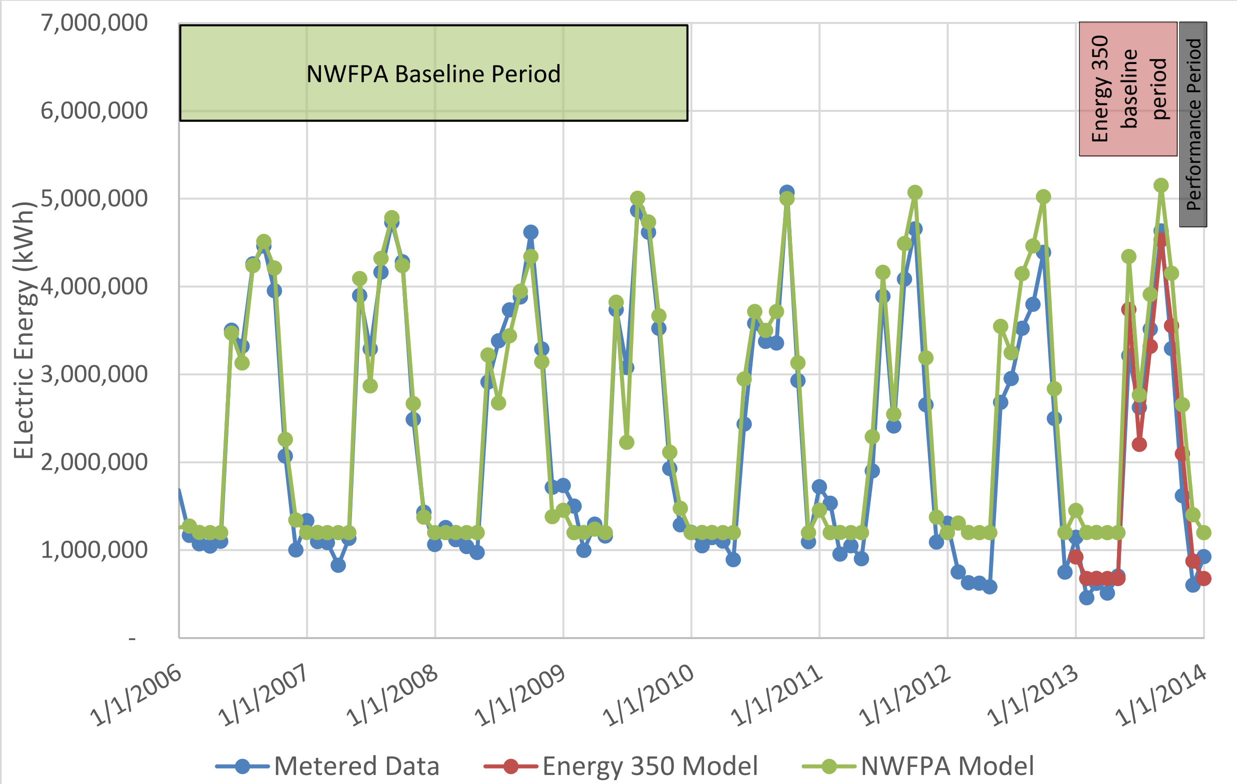
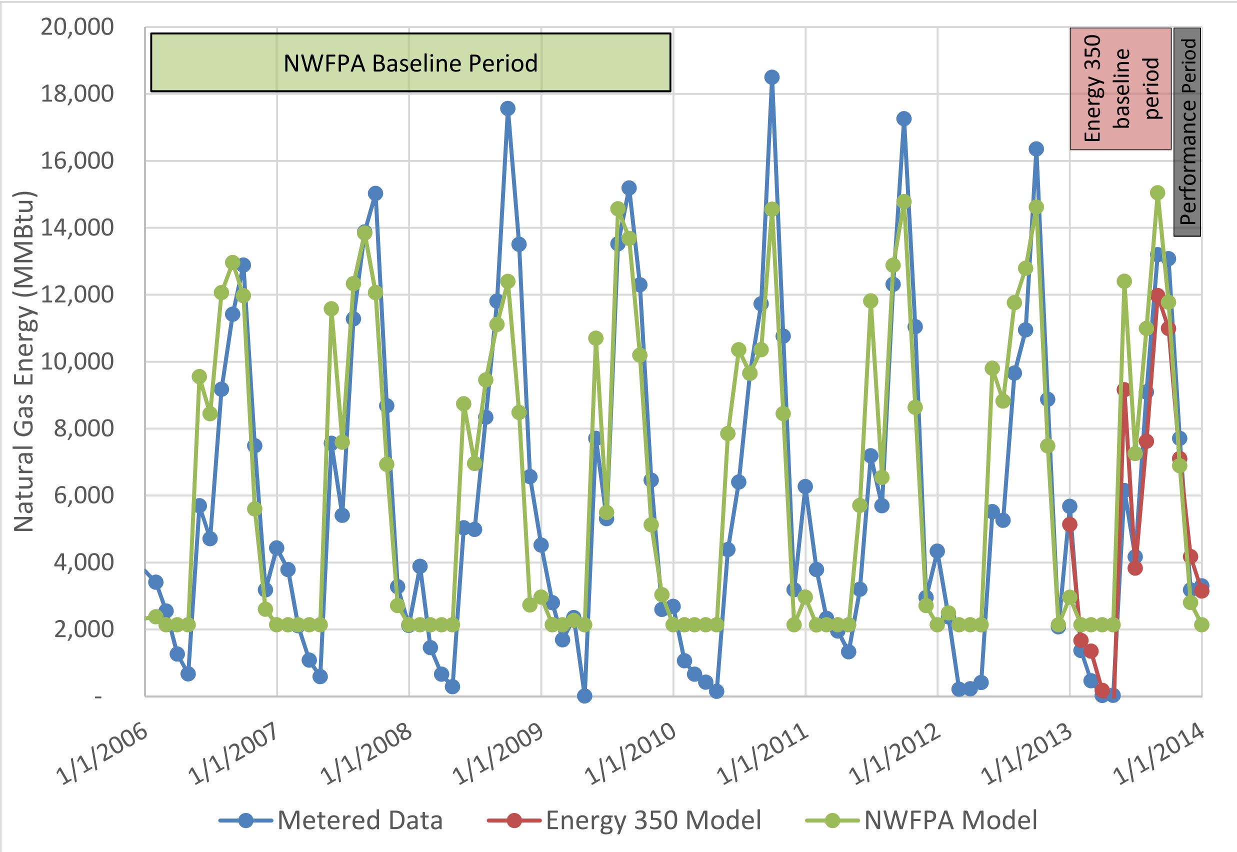


Figure 16: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model.



As would be expected by the high adjusted coefficients of determination for the electric models, Figure 15 shows that the electric models closely match the metered data during the baseline periods. However, this is not the case for NWFPA's natural gas model. While we were not provided regression statistics for NWFPA's natural gas model, Figure 16 shows a significant amount of variation between the metered data and NWFPA's natural gas model during their baseline period.

3.8 Site A030 Summary

Participant in NEEA's Continuous Energy Improvement Program: No

NWFPA created a model for electric energy use at this site but could not develop a natural gas regression with a good enough fit. We were also unable to develop a natural gas regression with a good enough fit. However, unlike NWFPA we could not develop an electric model with a good enough fit either. Our review of the NWFPA's models resulted in the following changes:

- Adjust the baseline period – As previously mentioned, we used a baseline period corresponding to when NEEA last claimed savings for this site, which will prevent double counting savings.[10] NWFPA used a baseline dating back to 2006 and did not make any adjustments to account for the savings NEEA has previously claimed.

- Outlier identification – The NWFPA models exclude data from April 2009 because it appears to be an outlier for electric energy use. However, NWFPA did not provide additional justification for why this data point should be excluded from the model. We do not recommend excluding any data points from the model unless there is justification from the site for why the data point does not represent typical operation.

As shown in Table 20, these changes to the models resulted in a reduction in the adjusted coefficient of determination for the electric model.

Table 20: Key model characteristics for site A030

	Energy 350	NWFPA
Baseline Period	01/01/2012 – 12/31/2012	01/01/2006 – 12/31/2009
Performance Period	01/01/2013 – 12/31/2013	01/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.289/0.667	0.781/NA

The fit of the electric model was significantly degraded by switching the baseline period and not excluding any data points. The Energy 350 model yielded a negative correlation between production rate and electric energy use. This is a counter-intuitive result and signifies that there are additional changes at the site that need to be quantified in order to develop a good model. We do not recommend claiming energy savings for this site because the low adjusted coefficients of determination and the negative production correlation. The energy savings as determined by NWFPA and Energy 350 are shown in Table 21.

Table 21: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	0.000	0.175
Natural Gas Savings (MMBtu)	0	0

The models are shown graphically in

Figure 17 and Figure 18 in order to better visualize their differences.

[10] NEEA last claimed savings for this site from January 1st, 2012 until December 31st, 2012 based on the findings from MPER 8 (DNV KEMA Energy and Sustainability, Research Into Action Inc. 2014).

Figure 17: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model. Note that the NWFPA baseline excludes the data point on 04/01/2009.

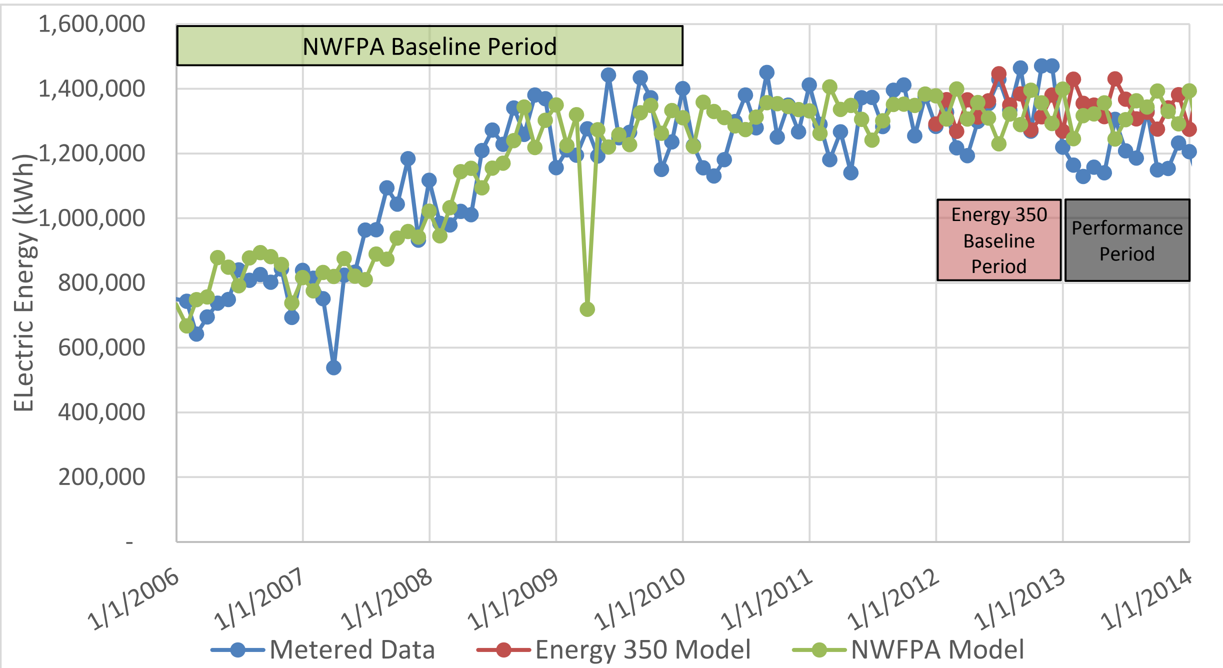
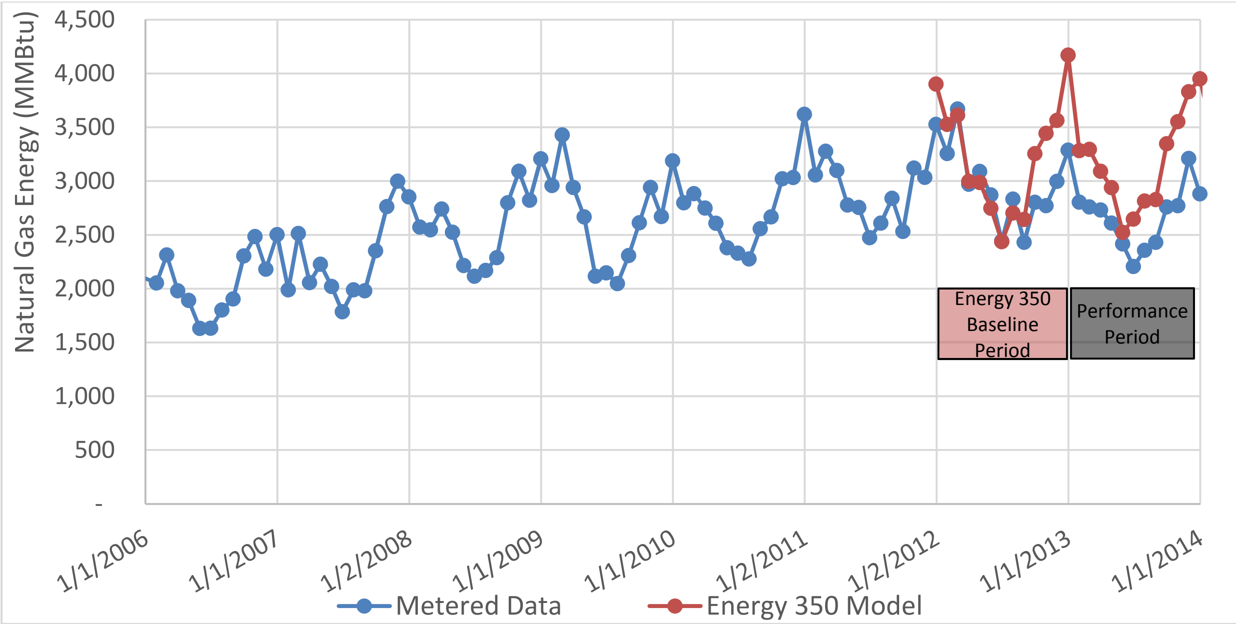


Figure 18: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model. Note that NWFPA did not create a model for natural gas for this site.



The large difference between the Energy 350 models and the metered data during the baseline period highlights the inability of the models to represent the system's performance. This supports our recommendation to not claim savings for this site.

3.9 Site A039 Summary

Participant in NEEA's Continuous Energy Improvement Program: No

NWFPA submitted an electric model, however they did not provide a model for natural gas. NWFPA analyzed the natural gas data and identified a model with a good fit. However, they opted not to include the model in their reported savings because it showed an increase in gas use during the performance period. The electric model created by NWFPA had good regression statistics however we were able to identify a couple of changes to the model:

- Adjust the baseline period – As previously mentioned, we used a baseline period corresponding to when NEEA last claimed savings for this site, which will prevent double counting savings.[11] NWFPA used a baseline dating back to 2006 and did not make any adjustments to account for the savings NEEA has claimed.
- Ambient variable selection – The NWFPA models used CDD with a 75 degree Fahrenheit reference temperature for their electric model. This was used because NWFPA found that it yielded the highest adjusted coefficient of determination. However, this is outside conventional bounds for cooling degree day reference temperatures. We investigated different ambient variables including reference temperatures between 55 degrees Fahrenheit and 65 degrees Fahrenheit, average monthly wet bulb temperature, and average monthly dry

[11] NEEA last claimed savings for this site from January 1st, 2012 until December 31st, 2012 based on the findings from MPER 8 (DNV KEMA Energy and Sustainability, Research Into Action Inc. 2014).

bulb temperature. Average monthly wet bulb temperature yielded the best regression for our electric model.

We also developed a natural gas model and performed the same iterative analysis to identify the best ambient variable. HDD with a 65 degree Fahrenheit reference temperature yielded the best model and was statistically significant at the 95 percent confidence limit. Table 22 shows that our changes to the electric model significantly decreased the adjusted coefficient of determination, however it also shows that we were able to develop a natural gas model with a good fit.

Table 22: Key model characteristics for site A039

	Energy 350	NWFPA
Baseline Period	01/01/2012 – 12/31/2012	01/01/2006 – 12/31/2009
Performance Period	01/01/2013 – 12/31/2013	01/01/2013 – 12/31/2013
Adjusted R^2 (Electric/Gas)	0.163/0.977	0.850/NA

After updating the electric model, the adjusted coefficient of determination (R^2) decreases below the ASHRAE's recommended limit of 0.75. Therefore, we do not recommend claiming electric savings for this site. The natural gas model has a very good fit and therefore we have reported natural gas savings. Energy savings from Energy 350's and NWFPA's models are shown in Table 23.

Table 23: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	0.000	0.054
Natural Gas Savings (MMBtu)	-38	0

The energy savings for this site are small. However, to better understand these small savings and the differences between the NWFPA and Energy 350 models, the models are shown graphically in Figure 19 and Figure 20.

Figure 19: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model.

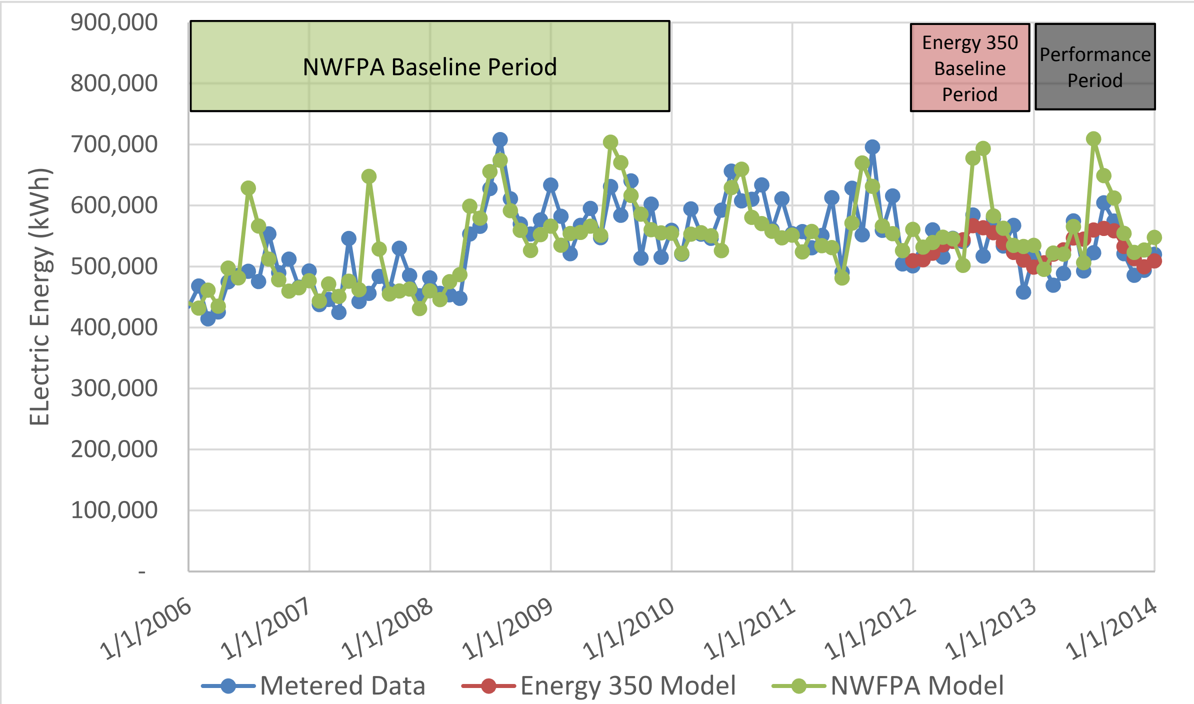
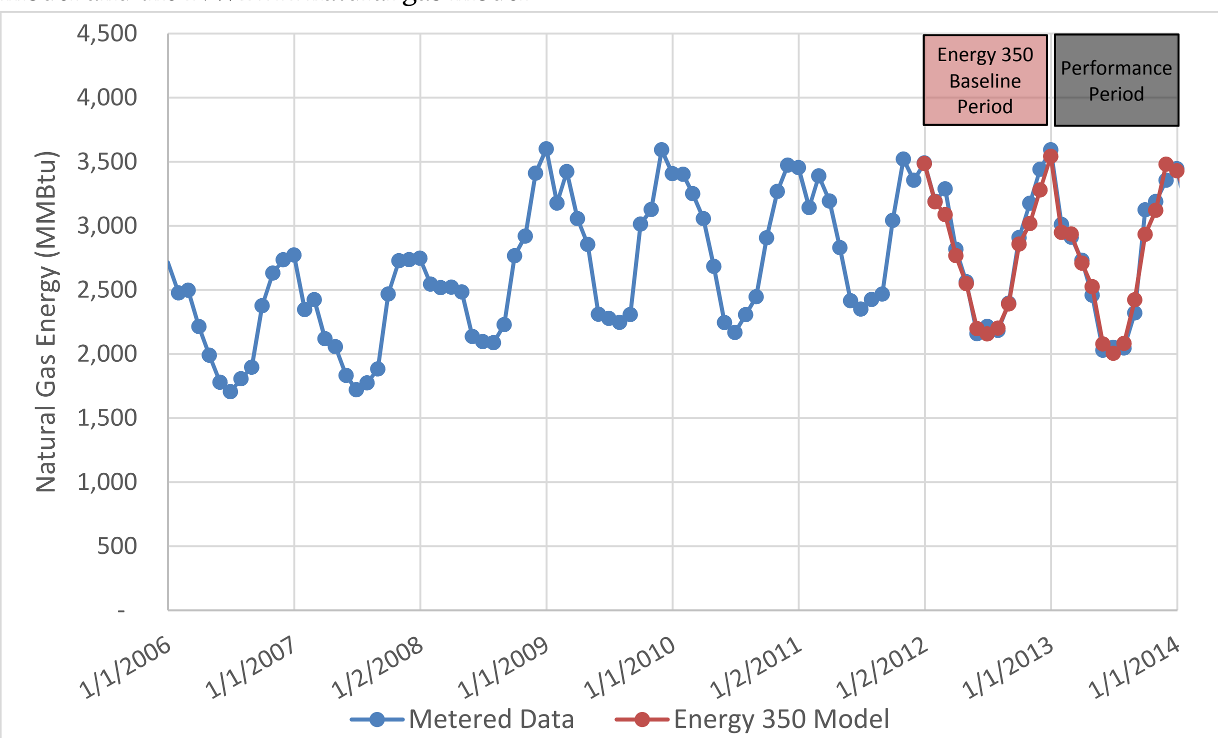


Figure 20: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model



3.10 Site A047 Summary

Participant in NEEA's Continuous Energy Improvement Program: No

The regressions created by NWFPA resulted in a model with a good fit, however the NWFPA models were based on data dating 2009 and they did not adjust for any previously claimed savings by NEEA. Energy 350 used a baseline period corresponding to when NEEA last claimed savings for this site, which prevents double counting savings.[12] The baseline period was the only change we made to the NWFPA's model. This change's impact on the regression statistics are shown in Table 24.

Table 24: Key model characteristics for site A047

	Energy 350	NWFPA
Baseline Period	01/01/2012 – 12/31/2012	01/01/2006 – 12/31/2009
Performance Period	01/01/2013 – 12/31/2013	01/01/2013 – 12/31/2013
R^2 (Electric/Gas)	0.830/0.884	0.964/0.9531

Our changes to the model decreased coefficients of determination (R^2). However, this degradation to the fit of the model is irrelevant because we do not recommend claiming savings for this site. We do not recommend claiming savings for this site because of the large outlier in the performance period.

The production for October 2013 was 8,994,373 pounds. This is 140 percent more production than any month in our baseline and 76 percent more production than any month in NWFPA's baseline. Data driven models such as these are very good at estimating energy by interpolating between data points in the baseline period, however they are not good at extrapolation beyond data in the baseline period. Extrapolating energy use based on such high production data significantly increases uncertainty in the model, which is why we do not recommend claiming savings for this site. Energy savings reported by NWFPA and Energy 350 are shown in Table 25.

Table 25: Energy savings estimates during the performance period for the NWFPA and Energy 350 models

	Energy 350	NWFPA
Electric Savings (aMW)	0.000	0.180
Natural Gas Savings (MMBtu)	0	50,556

The loss of savings is significant, especially for natural gas. However, we do not recommend claiming savings for this because of the outlier in the performance period. Our rationale for excluding savings from these models is illustrated in Figure 21 and Figure 22.

[12] NEEA last claimed savings for this site from January 1st, 2012 until December 31st, 2012 based on the findings from MPER 8 (DNV KEMA Energy and Sustainability, Research Into Action Inc. 2014).

Figure 21: Monthly electric utility data (metered data) compared to the Energy 350 electric model and the NWFPA electric model

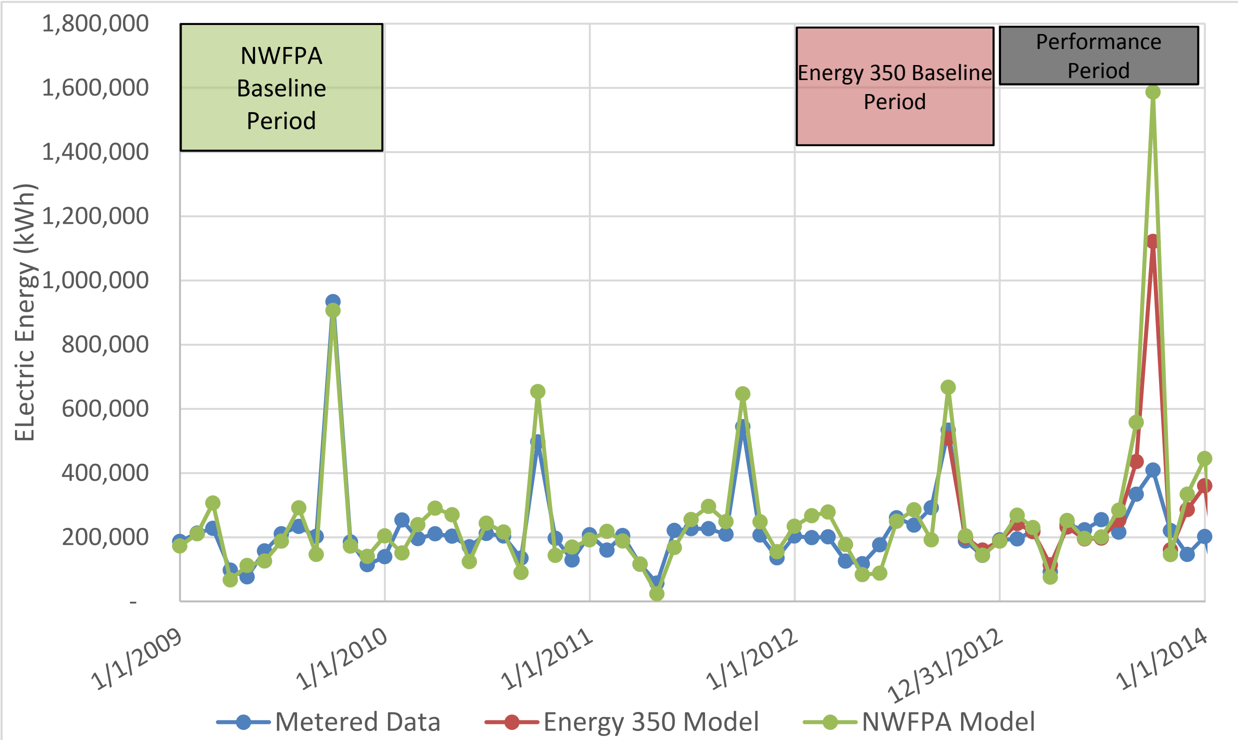
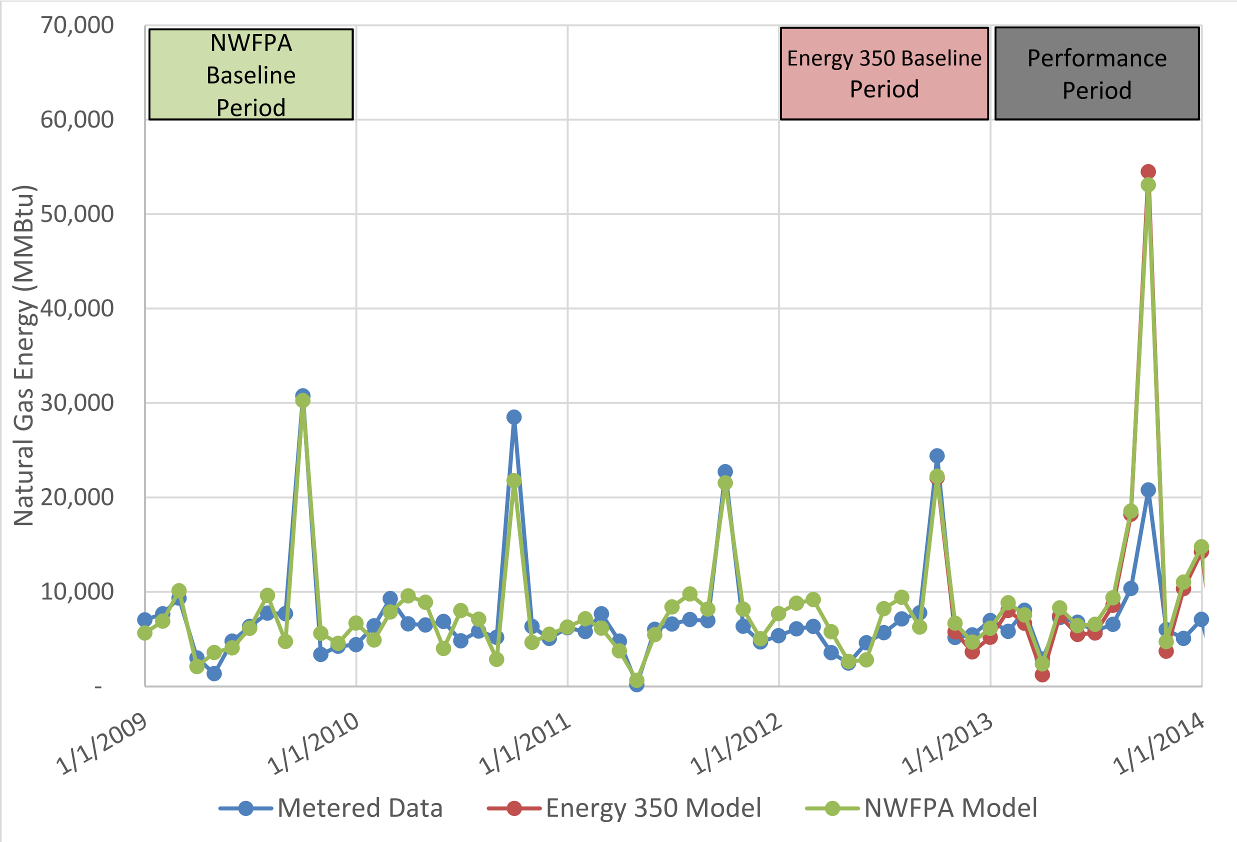


Figure 22: Monthly natural gas utility data (metered data) compared to the Energy 350 natural gas model and the NWFPA natural gas model



The large spike in the Energy 350 and NWFPA models in Figure 21 and Figure 22 occurs during October 2013 when this site outputs 8,994,373 pounds of product. As previously mentioned, the production during this month is outside what was experienced during the baseline, which forces the models to extrapolate and results in unreasonably large energy savings. Regression models become unreliable when extrapolating data outside of the boundaries established in baseline models, particularly when significant extrapolation is required, as it the case with this site.

4 Conclusion

Energy 350 was provided data and models for ten sites from NWFPA. We provided a comprehensive review of their models and developed models internally as well. We applied a methodical approach to identifying independent variables and selecting the best regressions for our models. Our effort resulted in excluding four out of the ten electric models because they did not have a good enough fit.

While some models were excluded because we could not develop a good enough model, we were able to develop robust electric models for six out of the ten sites and robust natural gas models for eight out of the ten sites. As shown in Table 26, we found very modest electric energy savings and more meaningful natural gas savings for the 2013 performance period at these sites.

Table 26: 2013 Net top-down energy savings for site submitted by NWFPA

Site	Able to Model?		Electric Savings (aMW)	Gas Savings (MMBtu)
	Electric	Gas		
A014	Y	Y	-0.051	-4,428
A028	Y	Y	0.115	-1,691
A030	N	N	0	0
A034	Y	Y	-0.015	-2,256
A039	N	Y	0	-38
A040	Y	Y	0.117	-10,535
A041	N	Y	0	29,358
A042	Y	Y	-0.029	2,239
A047	N	N	0	0
A052	Y	Y	-0.135	-2,042
Total			**0.001**	**10,607**

While it is difficult to draw sound conclusions from analyzing a small portion of NWFPA's members for one year of a multi-year engagement, we will discuss some potential hypotheses based on the observed data set. The ten sites in this study showed very little electric energy savings and moderate natural gas savings during the 2013 performance period. The overall performance of these sites may indicate that setting a goal and measuring progress towards that goal does not inherently mean that progress will be made. However, the long-term energy performance trends for this cohort of sites showed that energy performance has been consistently improving since the inception of NWFPA's energy reduction campaign. Therefore, we recommend testing this conclusion by expanding the number of sites and ensuring that a full year performance period is used for all sites.

An interesting finding of this analysis is the stark difference in savings between CEI facilities and non-CEI facilities. CEI facilities saved electricity while non-CEI facilities used more electricity; 0.031 aMW savings for CEI compared to 0.029 aMW increased use for non-CEI. This may indicate that in addition to setting a goal and measuring progress, active engagement is critical towards ushering improved energy performance.

This study also revealed the importance of collecting appropriate independent variables for each site. The large difference in industrial processes means that independent variable selection must be independently determined for each site. While production rate and an ambient variable are good starting points, additional independent variables such as production type (i.e. does a facility switch from processing squash in the fall to peas in the spring?) should be considered for facilities where there are major changes to production throughout the year that is not captured by a production rate variable.

Perhaps more important than the results from one year of performance for the relatively small number of sites we were able to create models for is the longer term trend of performance in those sites. What the data shown in Figure 1 reveals is that the sites are showing a trend of meaningful efficiency gains. This is an important indicator of success and should be weighted more heavily than a single year's performance (or three months in the case of CEI facilities).

Future Evaluation Recommendations

One important question that we recommend be answered as the effort and evaluation continues is the question of attribution. Is the setting of a goal a major contributing factor that explains the observed energy savings? Better understanding this topic will allow NEEA and NWFPA to better determine where resources should be allocated based on their effectiveness. For example, if savings are attributable to goal setting and measuring progress, more resources could be applied to this effort. But, perhaps research will suggest that additional engagement along the lines of Strategic Energy Management may be a better investment in influencing behavior and achieving energy savings. We recommend that future study explore:

- Survey NWFPA members to determine the level of influence the goal and related NWFPA activities had on achieving energy savings.
- Performance of non-participants – The performance of non-participants would be a key data point in understanding if the observed energy savings are attributable to the energy savings goal or broader market trends.
- Continued comparison of CEI facilities to non-CEI facilities. If the trend of improved performance of CEI facilities continues, this would support the hypothesis that embedding the elements of SEM yields greater effectiveness than simply goal setting and reporting of progress.

We were provided 20 models for validation, not all of which were statistically valid. We recommend the following steps be taken next year to try to increase the number of sites that can be modeled and approach a statistically valid sample of the population of members.

- An early and aggressive push to collect data and better understand independent variables or indicators that may affect energy use. The intended outcome will be more sites with complete data and fewer models that must be disregarded due to poor regression statistics.
- All sites with data should be submitted for evaluation, even if NWFPA has not been able to build a model. A proper model validation requires going back to the raw data and reconstructing the model. Given this, there is little incremental effort to being provided just

raw data without a model. The intended outcome of this is to grow the number of sites that can be successfully modeled.

5 References

1. ASHRAE. "Energy Estimating and Modeling Methods." *2013 ASHRAE Handbook: Fundamentals*. Atlanta: ASHRAE, 2013. 19.28. Print.
2. Barrow, P.,Thornton, J. “Mobilizing Industry: Energy Intensity Reduction Goal Setting for Competiveness” ACEEE. Monterey Bay, 2013.
3. DNV KEMA Energy & Sustainability, and Research Into Action Inc. *NEEA Industrial Initiatives - Market Progress Evaluation Report #8*. Rep. no. 8. Portland: NEEA, 2014. Web. <https://neea.org/docs/default-source/reports/neea-industrial-initiatives--market-progress-evaluation-report-8.pdf?sfvrsn=10>
4. Rumsey, Deborah J. *Statistics for Dummies*. Hoboken, NJ: Wiley, 2011. Web. <http://www.dummies.com/how-to/content/choosing-a-confidence-level-for-a-population-sampl.html>

6 Appendix A – Site Level Model Details

Site A014

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.787203	4.21	0.005	0.3	0.7754
60	0.78752	3.97	0.0073	0.31	0.7646
65	0.78771	3.79	0.0091	0.32	0.7584
Average Monthly Drybulb	0.788873	3.56	0.0119	0.37	0.7237
Average Monthly Wetbulb	0.836152	3.31	0.0163	0.24	0.8156
Production Only - Bivariate Regression	0.838032	6.02	0.005	NA	NA

The production only bivariate model yields the best fit and therefore will be used. It's regression coefficients are shown below.

Regression Coefficients
Z = a*X + b*Y + c
where,
Z = Natural Gas Energy (MMBtu/month)
X = Production Rate (lbs/month)
Y = Heating Degree Days Base 60 (F - Days)
a = 0.0005591
b = 0
c = 300.10737

Electric Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.996894	26.21	0.0009	2.35	0.0569

60	0.996573	26.49	<.001	2.11	0.0795
65	0.996212	26.97	<.001	1.86	0.1125
Average Monthly Drybulb	0.996791	26.97	<.001	2.27	0.0636
Average Monthly Wetbulb	0.996796	25.73	<.001	2.27	0.0633
Production Only - Bivariate Regression	0.995524	39.46	<.001	NA	NA

CDD 55 yielded the best regression statistics, however the ambient variable is insignifncant. Therefore, we looked into using a bivariate regression using production as the only independent variable. The production only bivariate regression resulted in very good regression stats and significant variables. Its regression coefficients are shown below.

Regression Coefficients
Z = a*X + b*Y + c
where,
Z = Natural Gas Energy (MMBtu/month)
X = Production Rate (lbs/month)
Y = Cooling Degree Days Base 60 (F - Days)

a =	0.0004491
b =	0
c =	452.23894

Site A028

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2012 until 09/30/2012.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.883197	7.55	0.0003	2.75	0.0331
60	0.873837	7.1	0.0004	2.56	0.0426
65	0.862818	6.67	0.0005	2.36	0.0563
Average Monthly Drybulb	0.826476	5.65	0.0013	1.77	0.1266
Average Monthly Wetbulb	0.836213	5.9	0.0011	1.92	0.1034

HDD with a 55F balance temperature yielded the best regression statistics. The ambient variable is significant at the 95% confidence limit so we will therefore use that as the regression for our model. Below are the regression coefficients.

Regression Coefficients
Z = a*X + b*Y + c
where,
Z = Natural Gas Energy (MMBtu/month)
X = Production Rate (lbs/month)
Y = Heating Degree Days Base 55 (F - Days)
a = 0.0004318
b = 6.6423254
c = -1349.665

Electric Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2012 until 09/30/2012.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.972234	11.38	<.001	1.77	0.1271

60	0.974093	12.17	<.001	1.95	0.0996
65	0.975547	12.98	<.001	2.09	0.0816
Average Monthly Drybulb	0.96062	9.8	<.001	0.66	0.5322
Average Monthly Wetbulb	0.959738	9.84	<.001	0.55	0.6049
Production Only - Bivariate Regression	0.968304	14.62	<.001	NA	NA

CDD 65 yielded the best regression stats, however the ambient variable is still insignifncant. Therefore, we looked into using a bivariate regression using production as the only independent variable. This resulted in a good regression where all independent variables are signifncant. Therefore we elected to use bi-variate regression with production as the only independent variable.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Cooling Degree Days Base 60 (F - Days)

a =	4.35E-04
b =	0
c =	2305.9452

Site A030

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify appropriate ambient variable. It is not explicity called out in the MPER 8, however it appears as though NEEA claimed savings for this facility based on a performance period from 01/01/2012 until 12/31/2012. Therefore, we will use that as our baseline period. The below analysis evaluates different ambient variables over that period of time.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.66729	2.01	0.0756	3.25	0.01
60	0.646184	1.81	0.1038	3.06	0.0136
65	0.627283	1.71	0.1213	2.9	0.0175
Average Monthly Drybulb	0.600578	1.77	0.111	2.69	0.0246
Average Monthly Wetbulb	0.625946	1.75	0.1144	2.89	0.0178
Production Only - Bivariate	0.350439	2.63	0.25	NA	NA

The regressions above do not meet the requirments for adjusted R^2 (>0.75) and therefore natural gas savings will not be reported for this site. Below are the regression coefficients for the HDD 55 model, which results in the best regression.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Heating Degree Days Base 55 (F - Days)

a = 6.74E-05

b = 1.3460639

c = -385.7418

Electric Summary

Objective: Identify appropriate ambient variable. It is not explicity called out in the MPER 8, however it appears as though NEEA claimed savings for this facility based on a performance period from 01/01/2012 until 12/31/2012. Therefore, we will use that as our baseline period. The below analysis evaluates different ambient variables over that period of time.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.131665	-1.69	0.1259	0.01	0.9928
60	0.131691	-1.71	0.1217	0.02	0.9853
65	0.13171	-1.76	0.113	0.02	0.9818
Average Monthly Drybulb	0.132726	-1.76	0.1131	0.11	0.9184
Average Monthly Wetbulb	0.132062	-1.73	0.1177	0.06	0.9498
Production Only - Bivariate	0.289537	-2.02	0.0711	NA	NA

The regressions above do not meet the requirments for adjusted R^2 (>0.75). Therefore we do not recommend claiming savings for this site. The regression coeficients below are for the production only bivariate regression because it had the highest R^2.

Regression Coefficients
Z = a*X + b*Y + c
where,
Z = Natural Gas Energy (MMBtu/month)
X = Production Rate (lbs/month)
Y = Cooling Degree Days Base 60 (F - Days)
a = -8.34E-05
b = 0
c = 8418.3564

Site A034

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.996177	42.05	<.001	1.4	0.2121
60	0.995983	39.24	<.001	1.25	0.2576
65	0.995896	37.72	<.001	1.18	0.2808
Average Monthly Drybulb	0.995442	33.32	<.001	0.82	0.4454
Average Monthly Wetbulb	0.995332	31.89	<.001	0.71	0.5022
Production Only - Bivariate Regression	0.995659	42.85	<.001	NA	NA

HDD 55 yielded the highest adjsuted r^2 , however the ambient variable is insignifncant. Therefore, we will use the bivariate regression using production as the only independent variable. Below are the regression coefficients

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Heating Degree Days Base 60 (F - Days)

a =	0.0020841
b =	0
c =	240.34098

Electric Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|

55	0.944339	6.87	0.0005	2.57	0.0424
60	0.953063	7.69	0.0003	2.99	0.0243
65	0.959661	8.78	0.0001	3.37	0.015
Average Monthly Drybulb	0.916305	6.37	0.0007	1.54	0.1737
Average Monthly Wetbulb	0.908157	5.95	0.001	1.28	0.2479

CDD 65 yielded the best regression statistics and the ambient variables are significant. Therefore, it will be used. The regressions coefficients are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Cooling Degree Days Base 65 (F - Days)

a = 0.0002609

b = 3.6980717

c = 180.70923

Site A039

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify appropriate ambient variable. It is not explicity called out in the MPER 8, however it appears as though NEEA claimed savings for this facility based on a performance period from 01/01/2012 until 12/31/2012. Therefore, we will use that as our baseline period. The below analysis evaluates different ambient variables over that period of time.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.950255	2.58	0.0295	13.2	<.0001
60	0.971078	3.19	0.011	17.5	<.0001
65	0.977438	3.49	0.0068	19.88	<.0001
Average Monthly Drybulb	0.943143	2.59	0.0294	12.3	<.0001
Average Monthly Wetbulb	0.939385	1.85	0.0968	11.89	<.0001

A 65F balance temperature yielded the best regression statistics and will therefore be used. Below are the regression coeficients for the HDD 65 model.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Heating Degree Days Base 65 (F - Days)

a = 7.52E-05

b = 1.1410881

c = 513.43097

Electric Summary

Objective: Identify appropriate ambient variable. It is not explicity called out in the MPER 8, however it appears as though NEEA claimed savings for this facility based on a performance period from 01/01/2012 until 12/31/2012. Therefore, we would prefer to use that as our baseline period. The below analysis evaluates different ambient variables over that period of time.

Production Rate Variable	Ambient Variable

CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	-0.04616	-0.02	0.988	1.2	0.2604
60	-0.06835	-0.06	0.9563	1.11	0.297
65	-0.09043	-0.1	0.9217	1.01	0.3393
Average Monthly Drybulb	0.125762	0.17	0.8694	1.87	0.0943
Average Monthly Wetbulb	0.163394	0.3	0.7705	2.01	0.0748
Production Only - Bivariate	-0.09244	-0.26	0.7978	NA	NA

Average monthly wetbulb yielded the best regression statistics, however the ambient variable is insignificant. However, this is the best regression we could develop for this site so it's regression coefficients are shown below. Note that we do not recommend claiming savings for this site.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Average Monthly Wetbulb Temperature (F)

a = 9.72E-06

b = 6.1387827

c = 1343.37

Site A040

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	degree
55	0.994423	34.82	<.001	4.53	0.004
60	0.99358	30.68	<.001	4.13	0.0062
65	0.992937	28.04	<.001	3.86	0.0083
Average Monthly Drybulb	0.982414	19.74	<.001	5.53	0.0004
Average Monthly Wetbulb	0.990418	20.91	<.001	3.07	0.0219
Production Only - Bivariate Regression	0.98152	19.28	<.001	NA	NA

HDD 55 yields the best fit and therefore will be used. The regression coefficients for the HDD 55 model will be used and are shown below.

Regression Coefficients
Z = a*X + b*Y + c
where,
Z = Natural Gas Energy (MMBtu/month)
X = Production Rate (lbs/month)
Y = Heating Degree Days Base 55 (F - Days)
a = 0.0008365
b = 9.2831642
c = 2413.7113

Electric Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.992431	15.33	<.001	2.34	0.0581
60	0.992732	15.77	<.001	2.44	0.0508
65	0.992729	16.56	<.001	2.43	0.0508

Average Monthly Drybulb	0.988601	16.13	<.001	1.27	0.2516
Average Monthly Wetbulb	0.988049	15.67	<.001	1.12	0.305
Production Only - Bivariate Regression	0.989158	25.27	<.001	NA	NA

CDD 60 yields the best fit, but does not quite meet the 95% limit for significance. However, it is so close to that limit that we will still use it for our regression. Its regression coefficients are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Cooling Degree Days Base 60 (F - Days)

a = 0.0003649

b = 6.857213

c = 3318.8679

Site A041

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify appropriate ambient variable. Because NEEA has never claimed savings for this facility we are not limited to a particular basline period. Therefore, the 2008 calendar year was first investigated for use as a baseline because that is immediately before the begining of NWFPA setting their energy intensity reduction goals. However, the regressions that came from that effort were very poor (adjusted R^2 <0.10). We then evaluated a variety of different baseline period and ambient variable combinations. We found that the 2012 caldendar year resulted in the best models. Data during that time period is shown below.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.670056	4.92	0.008	3.65	0.0053
60	0.609888	4.38	0.0018	3.15	0.0118
65	0.743045	5.75	0.0003	4.44	0.0016
Average Monthly Drybulb	0.775831	6.14	0.0002	4.89	0.0009
Average Monthly Wetbulb	0.782718	6.23	0.0002	4.99	0.0007
Production Only - Bivariate Regression	0.329618	2.22	0.0509	NA	NA

Average monthly wetbulb results in the best regression and meets our regression criteria. Therefore it will be used. It's regression coefficients are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Average Monthly Wetbulb Temp (F)

a = 0.0019825

b = -141.5665

c = -10273.58

Electric Summary

Objective: Identify appropriate ambient variable. Because NEEA has never claimed savings for this facility we are not limited to a particular basline period. Therefore, the 2008 calendar year was first investigated for use as a baseline because that is immediately before the begining of NWFPA setting their energy intensity reduction goals. However, the regressions that came from that effort were very poor (adjusted R^2 <0.20). We then evaluated a variety of different baseline period and ambient variable combinations. We found that the 2009 caldendar year resulted in the best models. An analysis to evaluate independent variable selection was performed on 2009 data. The results of which are shown below

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.516712	1.65	0.1332	1.87	0.0938
60	0.494752	1.65	0.134	1.72	0.1192
65	0.505445	1.53	0.1603	2.59	0.0294
Average Monthly Drybulb	0.578427	1.91	0.00885	2.31	0.0462
Average Monthly Wetbulb	0.573993	2.02	0.0744	2.28	0.0487
Production Only - Bivariate Regression	0.450412	2.86	0.0169	NA	NA

Average monthly drybulb yielded the best regression statistics, however all of the regressions are very poor and should not be used to claim savings. We ended up updating the baseline period to 2012 so that it aligns with all other sites in our analysis. We used the average monthly drybulb temp as the independent variable because the above analysis showed that it was the most significant independent variable. The results of that regression are shown below along with its regression coefficients.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
Average Monthly Drybulb	0.384	0.708	0.4967	1.879	0.0902

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Average Monthly Dry Bulb Temp (F)

a = 0.0001865

b = 33.360073

c = 5.93E+03

Site A042

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is not CEI so the baseline period used is 01/01/2012 until 12/31/2012.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.983884	22.87	<.001	1	0.343
60	0.983428	22.23	<.001	0.85	0.4161
65	0.983248	21.8	<.001	0.75	0.4698
Average Monthly Drybulb	0.982351	20.99	<.001	0.36	0.7239
Average Monthly Wetbulb	0.982465	21.11	<.001	0.44	0.6713
Production Only - Bivariate Regression	0.985346	25.93	<.001	NA	NA

A bivariate regression using production as the only independent variable yields the best fit. All of the ambient variables are insignificant for this site. The regression coefficients for the bi-variate model will be used and are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Heating Degree Days Base 65 (F - Days)

a = 0.0003197

b = 0

c = 1253.5624

Electric Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is not CEI so the baseline period used is 01/01/2012 until 12/31/2012.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.936395	10.4	<.001	0.55	0.5962

60	0.935945	10.47	<.001	0.49	0.6385
65	0.93551	10.57	<.001	0.42	0.6863
Average Monthly Drybulb	0.938118	10.47	<.001	0.75	0.4731
Average Monthly Wetbulb	0.939358	10.53	<.001	0.87	0.4071
Production Only - Bivariate Regression	0.946215	13.26	<.001	NA	NA

A bivariate regression using production as the only independent variable yields the best fit. All of the ambient variables are insignificant for this site. The regression coefficients for the bi-variate model will be used and are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Cooling Degree Days Base 60 (F - Days)

a = 4.52E-05

b = 0

c = 600.23015

Site A047

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify appropriate ambient variable. The analysis below is performed using a baseline period of 01/01/2012 until 12/31/2012.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.867192	8.61	<0.001	-0.84	0.4251
60	0.867064	8.58	<0.001	-0.8	0.4454
65	0.865761	8.54	<0.001	-0.74	0.4798
Average Monthly Drybulb	0.860218	8.35	<0.001	-0.41	0.6942
Average Monthly Wetbulb	0.861352	8.39	<0.001	-0.49	0.636
Production Only - Bivariate Regression	0.883538	8.71	<0.001		

The production only bivariaite regression resulted in the best fit. It will be used for this model. Its regression coefficients are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Heating Degree Days Base 60 (F - Days)

a = 0.0061587

b = 0

c = -912.1634

Electric Summary

Objective: Identify appropriate ambient variable. The analysis below is performed using a baseline period of 01/01/2012 until 12/31/2012.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.841694	7.69	<0.0001	1.68	0.128
60	0.835327	7.52	<0.0001	1.53	0.1594

65	0.828402	7.35	<0.0001	1.38	0.202
Average Monthly Drybulb	0.846491	7.83	<0.0001	1.78	0.1083
Average Monthly Wetbulb	0.848825	7.86	<0.0001	1.83	0.0997
Production Only - Bivariate Regression	0.830045	6.99	<0.0001	NA	NA

Average monthly wetbulb results in the best adjusted R^2 however the ambient variable is insignificant and therefore we will use the production only bivariate regression. Its regression coefficients are shown below.

Regression Coefficients
Z = a*X + b*Y + c
where,
Z = Natural Gas Energy (MMBtu/month)
X = Production Rate (lbs/month)
Y = Cooling Degree Days Base 60 (F - Days)
a = 3.97E-04
b = 0
c = 251.74092

Site A052

This regression summary outlines the process completed in JMP in order to identify appropriate regression parameters

Natural Gas Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
HDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|
55	0.986024	19.78	<.001	-1	0.3558
60	0.986852	18.64	<.001	-1.2	0.2751
65	0.987467	17.88	<.001	-1.34	0.2275
Average Monthly Drybulb	0.989261	15.95	<.001	-1.76	0.1282
Average Monthly Wetbulb	0.98881	15.32	<.001	-1.66	0.1487
Production Only - Bivariate Regression	0.987769	23.78	<.001	NA	NA

A bivariate regression using production as the only independent variable yields the best fit. All of the ambient variables are insignificant for this site. The regression coefficients for the bi-variate model will be used and are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Cooling Degree Days Base 60 (F - Days)

a =	0.000444
b =	0
c =	636.04092

Electric Summary

Objective: Identify the ambient variable that yields the best regression fit. This facility is CEI so the baseline period used is 01/01/2013 until 09/30/2013.

		Production Rate Variable		Ambient Variable	
CDD Reference Temperature (F)	Adj R^2	t Ratio	Prob > |t|	t Ratio	Prob > |t|

55	0.992889	19.15	<.001	-1.5	0.1843
60	0.993775	21.12	<.001	-1.85	0.1138
65	0.994251	23.27	<.001	-2.05	0.0862
Average Monthly Drybulb	0.990741	19.13	<.001	-0.58	0.5833
Average Monthly Wetbulb	0.990446	18.31	<.001	-0.37	0.721
Production Only - Bivariate Regression	0.992667	30.78	<.001	NA	NA

CDD with a 65F reference temperature yielded the highest adjusted r^2, however the ambient variables are not signifncant at the 95% limit. Therefore, we will go for the bivariate regression. The bivariate regression coefficients are shown below.

Regression Coefficients

Z = a*X + b*Y + c

where,

Z = Natural Gas Energy (MMBtu/month)

X = Production Rate (lbs/month)

Y = Heating Degree Days Base 60 (F - Days)

a = 0.0003758

b = 0

c = 1600.414