Recession Impacts: Savings During and After the Recession

Dr. Lori (Lewis) Megdal, Megdal & Associates, LLC, Groton, MA
Tracey DeSimone, New York State Energy Research and Development Authority (NYSERDA), Albany, NY
Dr. Juliet Nelson, Megdal & Associates, LLC, Groton, MA

ABSTRACT

A great deal of discussion and hypotheses occurred surrounding how the 2008-2009 recession would affect energy savings versus the measurement of energy savings. A National Grid residential gas efficiency program run by the New York State Energy Research and Development Authority (NYSERDA) was evaluated in early 2010 using regression (billing analysis) of natural gas consumption from 2006 through September 2009 for 2007 and 2008 participants. This time period overlapped with the beginning of the 2008-2009 recession, the trough of this recession, and the time period before the recession. These different recession levels were taken into account within the billing analysis. Significant recession impacts on program savings were found and the realization rate for program savings changed by 16% by incorporating the differences caused by the recession.

Introduction

The New York Public Service Commission (PSC) issued orders that directed the New York State Energy Research and Development Authority (NYSERDA) to administer natural gas energy efficiency programs in 2004 through September 2009 on behalf of Con Edison and National Grid (formerly Niagara Mohawk). The order establishing the Con Edison Natural Gas Efficiency Program did not prescribe specific implementation programs and NYSERDA elected to use eight existing System Benefit Charge delivery programs as the delivery vehicle. The order concerning the Niagara Mohawk Grid Low-Income Gas Efficiency Program prescribed certain delivery programs that included existing NYSERDA offerings.[1]

NYSERDA hired an evaluation team led by Energy & Resource Solutions, Inc. (ERS) to conduct a natural gas efficiency program impact evaluation to report the net impact for the natural gas-funded projects completed between June 2005 and March 31, 2010. The assessment also included targeted studies of natural gas-fired condensing boiler performance and of non-energy impacts (NEIs) associated with natural gas measures. Multiple programs were evaluated in groups. Site-specific measurement & verification (M&V), regression (billing) analysis and telephone surveys were used. One of the billing analyses examined the gas program impact through the use of NYSERDA's Home Performance with ENERGY STAR®. The latter analysis was conducted by Megdal & Associates, LLC.

[1] NYPSC order dated September 27, 2004, Case 03-G-1671, established the Con Edison Natural Gas Efficiency Program with a recommendation that NYSERDA serve as program administrator. Another order on May 16, 2007, Case 03-G-1671, continued the program through September 30, 2008. Case 06-G-1332 order continued the program through September 30, 2009. NYPSC order dated September 18, 2008, Case 08-G-0609, established the Niagara Mohawk Power Low-Income Gas Efficiency Program. The order directed that Niagara Mohawk transfer funding and administration of the Residential Low-Income Program to NYSERDA.

The Home Performance with ENERGY STAR (HPwES) Program is a 1-4 family residential market transformation program that is designed to change not only the way home improvement contractors deliver their services, but also the types of services that customers demand. Emphasis is on the development of a robust energy efficiency service infrastructure, balanced with mechanisms for ensuring consumer awareness and demand. Contractor training, certification, accreditation, and robust quality assurance procedures also ensures that high-quality services are delivered. Capturing the effects of these program designs can be complicated by significant changes in the economy. The current evaluation accounted for these conditions in an effort to identify true program savings.

Theory of Billing Analysis Bias Where Recession Effects Not Taken into Consideration

A unique feature of the current billing analysis is its ability to capture the effects of volatile economic conditions on program savings estimations. If the economy is in recession, production contraction and/or an income effect will cause a decreasing consumption trend. Decreasing consumption, an income effect, is provided in Figure 1 as a downward sloping line, less income leads occupants to lower their usage to attempt to stay within their new income level. If this is not accounted for in the econometric analysis, savings will be overestimated as shown in Figure 1. The movement from point A to point B is the observed consumption change. The estimated savings from this difference is represented by the shaded box. If there is an income effect due to recession then the participants will have decreased consumption due to that effect and not just a program effect. Part of the difference observed could be due to the recession (moving from point A to point C). Only the blackened box in Figure 1, from point C to point B, is the true program savings. This darker box represents the difference in consumption caused by the program.[2]

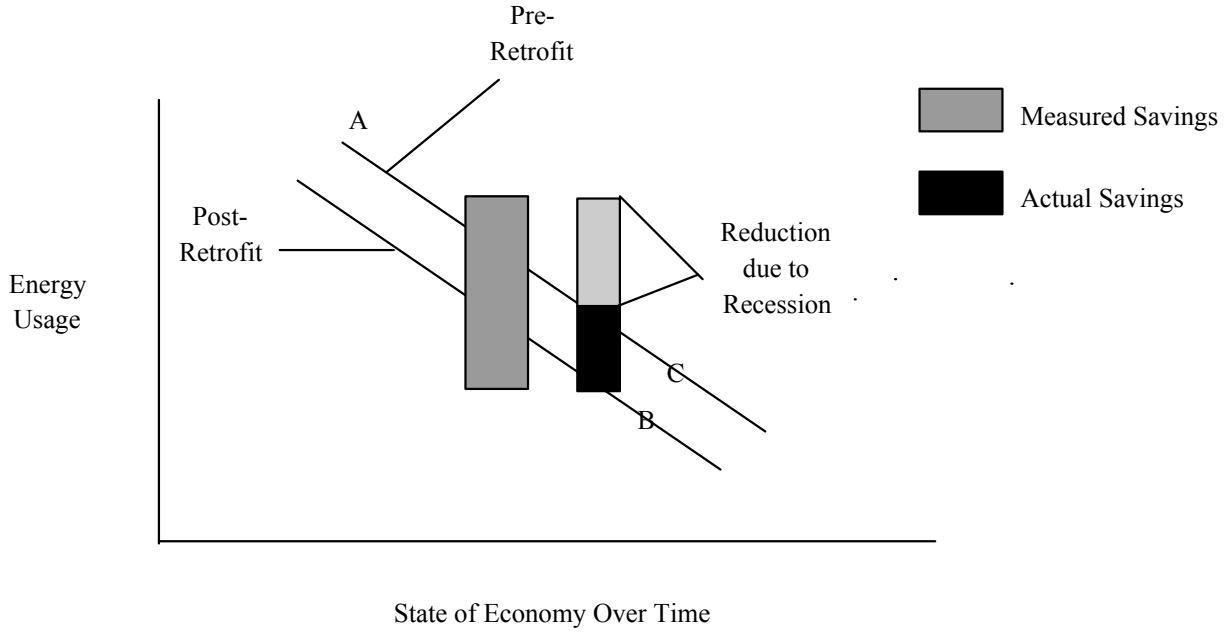

Figure 1. Regression Analysis on Consumption and an On-going Recession

Conversely, billing analysis will underestimate true savings during recovery and growth periods, if

[2] Author provides this section from prior publication by this author: Megdal, Lori M., R. Eric Paquette, and Jerry Greer. 1995. "The Changing Economy as Part of DSM Impact Evaluations: Evidence from a Large C&I Retrofit Program Evaluation", *Proceedings from the 1995 Energy Program Evaluation Conference*, Chicago: IL, pp. 326 and 327.

the changing economic conditions are not properly controlled in the analysis. In the economic growth example pictured in Figure 2, the billing analysis would estimate almost zero savings when true energy savings are much greater, the shaded box being much smaller than the blackened box in Figure 2. An income effect from economic growth could create increased energy usage. The true savings is the difference between the actual post-retrofit consumption at point B and what the consumption would have been without the program, point C. These examples highlight the importance of controlling for changing economic conditions.

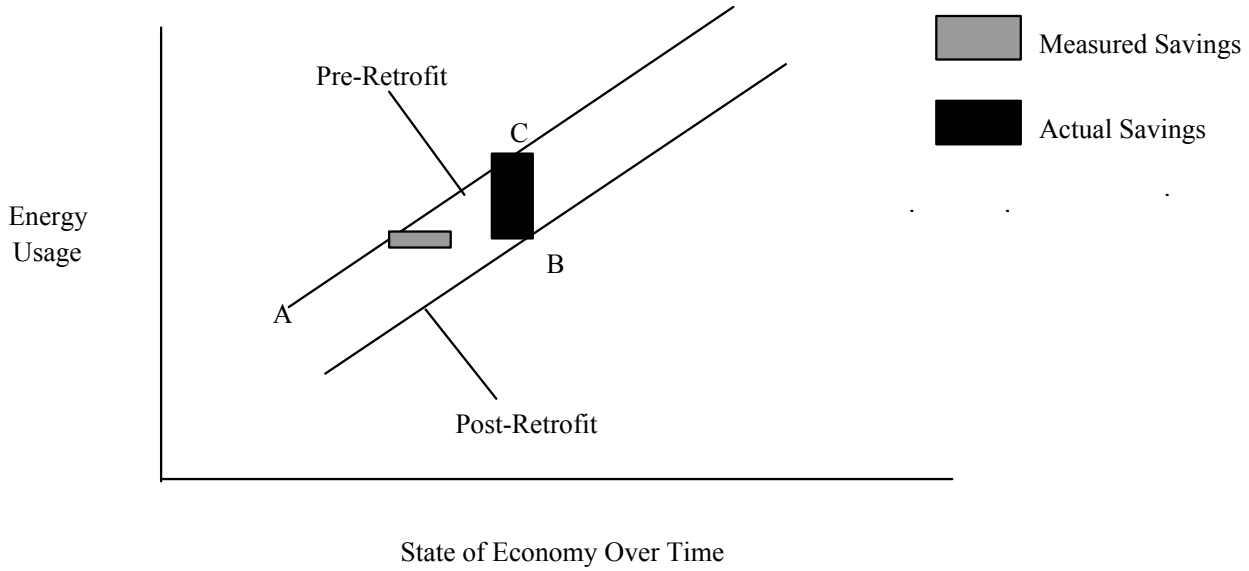

Figure 2. Regression Analysis on Consumption and an On-going Recovery

Prior Supporting Evidence from a 1994 Commercial/Industrial Billing Analysis

The 1995 IEPEC paper that first developed and illustrated the above theoretical expectations regarding the interaction of the economy and impact evaluation of energy savings also provided strong supporting evidence for the importance of the effects of economic change. That evaluation was conducted on a Large Commercial/Industrial Program and included economic effects of recovery. The evaluation's savings estimates in that study for the manufacturing sector, and an individual large customer, were differentiated between those expected to have actually occurred (in 1992 and 1993), and those to be expected during, and after economic recovery (1994, 1995 and beyond). That is, the savings estimates vary over time, as they are expected to change with the changing economic conditions. The application of this concept to the HPwES residential gas program evaluation expands our understanding of the changing economic effects on savings estimation to a broader market.

Method

The National Grid Assisted Home Performance with ENERGY STAR (HPwES-Assisted) efforts were evaluated using a regression analysis method on pre- and post-consumption as provided in billing records, referred to as program-level "billing analysis." The impact evaluation natural gas billing analysis was conducted by delivery program for the participants in their respective programs.

The billing analysis, at a minimum, requires three major types of data:

1. Program data on measures installed in each home (NYSERDA HPwES program records)

2. Consumption history pre- and post-retrofit (billing records) from the utility, National Grid
3. Weather data

The regressions on consumption, billing analysis, for this evaluation were the first billing analyses conducted for NYSERDA programs. NYSERDA implements energy efficiency programs across the state of New York not including Long Island. These programs are financed through a system benefit charge on customer utility bills. One of these utilities is National Grid, whose gas program run by NYSERDA was the subject of this evaluation. NYSERDA is not the customer's utility and utility bills had to be obtained from the utility in order to conduct this analysis. Not being an efficiency program administered by the customer's utility means that the NYSERDA program does not have direct access to customer account numbers to use this as an identifier or to check whether the account number being provided by the customer is the correct account number. Consumption for the participants as seen in their utility bills was requested by NYSERDA of National Grid, with NYSERDA providing a list of account numbers in the program database for the participants in the evaluation.

Combining NYSERDA program data with the utility bills from the utility provided significant unanticipated challenges. Matching the HPwES projects to the billing data is a step that is often not necessary for efficiency program administered by utilities, as the utility directly obtains the account numbers for their participants. Accurate matching of consumption data with the homes treated through the program is essential for analyzing consumption for program impacts. The program impacts are derived by regression to measure the change in average usage after the program compared to usage before the program while controlling for the non-program effects of weather on energy usage. It is important that each participant is correctly matched with their consumption/billing data so the correct program date (for installation) is used, otherwise the pre-retrofit and post-retrofit periods will be misclassified. It is the average difference of these from the regression that is the measurement of the program impact.

The HPwES program dataset for the 2007-2008 participants contained 9,513 HPwES projects for which 5,708 listed National Grid as either the electric utility or the natural gas utility and an account number was present. The evaluation team was able to successfully match the account number on 5,123 of those.

The National Grid billing file and the program dataset both provided name and address fields. These were used to conduct additional tests to ensure projects within the billing analysis dataset only included those with reliable matches between the consumption records and the program records. A ranking system was developed as the first of three steps within the HPwES matching process, whereby:

- Four points were awarded for an exact match on the street address.
- Two points were awarded for an exact match on the last name.
- One point was awarded for an exact match on the city.
- One half point was awarded for an exact match on the first name.

In conjunction with this rank a "spelling distance" calculation was employed as the second step when the street address did not match exactly. This value was the result of a SAS function called SPEDIS, which measures the similarity of two strings. SPEDIS works by assigning a "cost" to each operation required to convert one string to another, such as adding or removing a letter. The total cost is then divided by the length of the comparison string. (See 2011 IEPEC Poster-5 by Doyle, et. al. for further information on this process and work conducted.)

Data cleaning on the billing and program dataset was conducted. Weather data were added by participant location according to billing cycle information (each participant having average daily heating degree days for the exact period of their billing data at their closest weather station). The dataset for the regression analysis was then complete.

The HPwES impact analyses included testing dummy variables and ex ante program savings estimates (*i.e.*, testing Statistically Adjusted Engineering (SAE) models) by measure group and for measure aggregates of base load measures versus heating load measures with the latter interacted with the heating

degree days. Though these measure group regressions did not provide statistically significant and stable measure level impacts, models that included a program impact variable interacted with heating degree days (an alternative specification to derive program impacts on heating load) did prove to be significant and reasonable. Pre-post regressions and SAE regressions were both tested on their own and as part of Analysis of Covariance (ANCOVA), fixed effects, models. Separate regressions were also tested excluding participants with fuel switching measures and just for those with heating fuel switches versus domestic hot water measures (including hot water fuel switches).

A variable for the time period of the beginning of the recession and one representing the timing of the recession trough (the worst part of the recession) were included. The National Bureau of Economic Research stated (in December 2008) that the "Great Recession" began in December 2007. The effects of the recession on the program induced savings were estimated through program impact variables interacted with both of these recession variables (a non-linear representation of the recession and its effects on program savings) and both of these were statistically significant as further described in the next section.

Consumption Regression Results (from Participant Bills)

The impact evaluation for the natural gas programs using Home Performance with ENERGY STAR (HPwES) was based upon regression analysis of consumption as given in utility bills for NGRID's 2007 and 2008 natural gas program HPwES participants. Several regression model variations were examined. These included pre-post retrofit and statistically adjusted engineering (SAE) regression models within standard regressions and within analysis of covariance (ANCOVA) models. Most of the measures and 95% of the NGRID's program estimated savings are from measures affecting heating usage. Given the emphasis on heating measures in a natural gas savings program all models tested found statistically significant results for program savings as related to how cold the weather, *i.e.*, post-retrofit interacted with the average daily heating degree days (HDD) at a base of 65.

The final selected HPwES regression model was an Ordinary Least Squares regression with a pre-post dummy variable (taking a value of 0 for dates prior to completed installation, *i.e.,* participation and 1 after the program install date). The program effect is measured by the coefficients on the post dummy variable and any post retrofit interactive variable.

National Grid in New York provides natural gas service to a strip of mid-state areas from the eastern side of Lake Ontario to the Massachusetts border. This area experiences colder and longer winters then most of the U.S. excluding Canada. The weather variable of HDD base 65°F provides the number of degrees below 65 for each day with a temperature below 65. Above 65 degrees is assumed to be a non-heating days and are given a HDD of 0. Table 1 provides the means, median and quartiles for HDD base 65, average HDD (the variable used in the model where average daily consumption for a participant is the dependant variable), consumption per day (CONSPERDAY), and the distribution and range as shown in quartiles for HDD in winter and HDD in summer. There were 235 participant homes in the evaluation analysis resulting in 5,282 bills.

Table 1. Pre-Post National Grid HPwES Regression with Post Interactive Effects with Non-linear Recession Timeline

Variable	Number of Bills	Mean	1st Quartile (25%)	2nd Quartile (Median, 50%)	3rd Quartile (75%)

HDD65	5,282	543	57	426	1018
AVGHDD65	5,282	18	2	14	33
CONSPERDAY	5,282	3	.63	2	4
HDD_WINTER	892	39	35	38	44
HDD_SUMMER	1,330	2	.19	.71	2

Several of the examinations pointed to an underlying non-linear effect over time on usage beyond controlling for heating degree days and the interaction of the program measures and heating degree days. Two types of non-linear impacts were examined through a variety of regression models. These were a non-linear weather effect (a relatively common billing analysis variable, particularly in commercial billing analysis) and a non-linear timing effect that represented stages in the significant recession occurring throughout the post-retrofit period. The non-linear weather effect was represented by including the average daily heating degree days and the square of this. Heating degree days squared was often significant, but a program impact interaction with that was not. Controlling for heating degree days squared also did not change the final result.

The second non-linear effect examined was based upon the recession being experienced during the period analyzed. The consumption data in this impact evaluation is from January 2006 until October 2009. The National Bureau of Economic Research stated (in December 2008) that the "Great Recession" began in December 2007 (the beginning of the post-retrofit period for the earliest 2007 participants). The trough of the recession occurred around July 2009. Two recession dummy variables were created to test their ability to capture the non-linear effects seen in usage. Time periods prior to January 2008 were non-recession periods (both recession variables set to zero). Time periods after January 2008 captured the first recession variable (*i.e.,* RECESSN1 equaled one). The recession trough, July 2009[3] (and the date that the recession ended, *i.e.*, economic indicators slightly rose after this date) is used as the base for the second recession variable used in this evaluation. The second recession variable was defined as the three months before and after the recession trough, *i.e.,* April 2009 through October 2009. (October 2009 was the latest billing date for this evaluation's billing analysis dataset and unemployment in October 2009 was 10.1%.)

The two recession variables were significant across several models as well as statistical significance in some of the interactive variables between the program and the recession. That means that there is evidence that the program effect seen in consumption is being affected by the recession. The final selected impact evaluation regression model is summarized in Table 2. This model shows statistical significance, besides weather, for the program (POST), the program interacted with weather, the program at the beginning of the recession, the program interacting with the recession trough, and the variable for the beginning of the recession.

Table 2. Pre-Post National Grid HPwES Regression with Post Interactive Effects with Non-linear Recession Timeline

Independent Variable	**Coefficient**	***t*-statistic**
POST	0.19	2.53
POST Interactive with avg. HDD	-0.054	-8.89

[3] As determined by the National Bureau of Economic Research.

POST Interactive with beginning of recession	0.016	2.9
POST Interactive with recession trough	-0.01	-1.64
Beginning of recession	-0.318	-5.34
Recession trough	0.086	0.96
Average daily HDD (base 65)	0.145	82.12
R2 = 0.6919; *n* = 5,282 (bills); Homes = 235		

The "Impacts" of the Recession on the Savings Impacts

All billing analysis models for impact evaluations are analyzed with the actual weather occurring during the billing periods. Then the impact of the program is estimated based upon including any changes due to long-term weather. Regressions with interactive variables like the one above require similar "fitted values" to interpret the regression coefficients and the affect on the estimate of program savings provided from the regression results.

Variables that are not the program variable ("Post" for the final selected model shown in Table 2, but could be an SAE variable or a number of program measure variables) or a variable interacted with a program variable are in the regression model to "control" for their independent effects on energy usage. Weather is always a primary driver of energy usage. The final model shown has a control variable of average daily heating degree days (HDD), accounting for lower temperatures is particularly important for a natural gas program that primarily affects heating usage. The other two control variables in this model are indicators for the beginning of the recession (December 2007) and the estimated worst part of the recession, the three months surrounding the recession trough (April through December 2009). The t-statistic of 5.34 shows the beginning of the recession as statistically significant. The recession trough control variable does not prove to be statistically significant. However, the interactive variable of the program and recession trough is statistically significant, so the control variable of recession trough is included in the final model.

The model shows that the program impact varies by the economic climate in that the two program interactive variables with the two recession variables are both statistically significant with t-statistics of 2.9 for the program at the beginning of the recession and 1.64 for the program at the recession's trough. The latter does not appear very strong, but given the number of recession variables and number of program interactive variables it is reasonable to accept this variable at a lower level of statistical significance. (The number of variables used as controls and interactive, three sets, increases the likelihood of weakening the regression's ability to distinguish between them.)

Showing recession variables that are statistically significant is interesting, but the true test is what is seen with the fitted values analysis and whether those results make sense within likely theories of the effect of recession on program impacts. The fitted value of the model above provides an average daily therm savings of 0.665 which is a realization rate on program ex ante savings of 39.4%. The fitted value with the long-term average weather provides an average energy savings of 0.664 and a realization rate of 39.3%. (Obviously, the weather during the regression time period was not unusual and quite close to normal weather for these areas.) These fitted values, however, do not provide estimates of the impacts caused by the recession.

The fitted values for early in the recession ("zeroing out" the recession trough impacts) provide an average energy savings of 0.486 and a realization rate of 28.8%. Late in the recession provides the realization rate of 39.3%. The fitted value of most interest is what the program savings is expected to be after the recession. These carry an average daily energy savings of 0.772 and a realization rate of 45.7%.

The program's savings estimate is over six (6) percentage points higher taking into account the affects of the recession and estimating what program impacts will be after the recession. This is 16% higher, demonstrating the importance of controlling for the changing economic conditions.

Conclusion

One of the questions going into this impact evaluation regarding the recession is whether diminishing financial resources will cause people to have greater energy savings (an income effect) or whether more people being laid off and, therefore, greater occupancy in the home will mean that the evaluation will show less savings. The theoretical discussion early in this paper suggests that not accounting for the recession would likely lead to a downward bias in the savings estimate. The work in this study clearly supports the ideas that program savings estimates derived by billing analysis during a recession underestimate true program savings if the recession is not taken into account. This evaluation found that the impact of the recession lowered the realization rate for program savings by 16%.

Theory and evidence from this billing analysis for a residential program, the National Grid gas program operated through NYSERDA's Home Performance with ENERGY STAR (HPwES) program, strongly suggests that the changing state of the economy in terms of significant economic change needs to be considered to properly estimate program savings without bias. This evaluation supports prior evidence regarding the importance of including the changing economy in a program savings estimate for a large commercial and industrial program (1995, Megdal, Paquette, and Greer), while demonstrating its applicability to residential program savings estimations.

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