Modeling Technology Adoption and DSM Program Participation Decisions

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There has been significant research interest in distinguishing "net" energy savings attributable to DSM program from the "gross" energy savings associated with the program measures. Differences arise insofar as there is "free ridership" that reduces net impacts, and "spillover" that increases net impacts. Failure to adequately account for these factors can distort analyses of overall program impacts. The problem for researchers, however, has been that all existing methodologies have limitations affecting their ability to isolate these factors.

To address these issues, PG&E commissioned a major study to analyze the net-to-gross impact relationship associated with its commercial, industrial and agricultural retrofit rebate programs. A four-pronged approach was used:

1. Direct surveys of participating rebate customers, focusing on free ridership effects.

2. Direct surveys of dealers and wholesalers to obtain data on shifting sales patterns.

3. A decision analysis model comparing behavior of participants and non-participants, to assess how participants behave differently in their decisions to install energy conserving equipment.

4. A statistical analysis comparing baseline saturations of high efficiency equipment in PG&E electric customers' facilities with business entities in areas where the rebate program was not offered.

Each method had advantages and limitations. some only looked at free riders or spillover. Others estimated both, but the effects could not be estimated separately. The limitations of any single method were compensated for by the use of more than one method. Consequently, the final net-to-gross estimate was more robust.

Introduction

DSM program savings can be grouped into two general categories: hardware and behavioral. The first can be measured using several methods all of which create a high degree of comfort: billing analysis, engineering modeling, building simulation modeling, end-use metering, etc. However, DSM program savings are also affected by a behavioral component, including free ridership, market spillover, naturally occurring savings, take-back, etc. These latter factors can be measured using a variety of techniques, almost none of which engender feelings of comfort or confidence in their accuracy or reliability.

During 1992 and 1993, PG&E, a major west coast utility, undertook a comprehensive measurement and evaluation of its nonresidential retrofit energy efficiency programs. As a part of this effort, four independent studies (by the same team of analysts) were performed that attempted to estimate the impact of the behavioral component of DSM programs.

There are several factors that affect "net" program savings that were not addressed in this effort. First, the California Public Utilities Commission (CPUC) has defined savings impacts as "for the same level of service" (CPUC, 1993), so rebound (or takeback, snap-back, etc.) was not addressed. Further, this estimate of behavioral effects supplemented a first year impact evaluation and did not address changes in impacts over time. The study focused on estimating free ridership and market spillover.

A four-pronged methodology was used:

1. Direct surveys of participating rebate customers, focusing on free ridership effects.

2. Direct surveys of dealers and wholesalers, to obtain data on shifting in sales patterns.

3. Decision analysis modeling that compared behavior of participants versus non-participants, to assess how participants behave differently in their decisions to install energy-conserving equipment.

4. Statistical analysis comparing baseline saturations of high efficiency equipment in PG&E electric customers' facilities with those in areas where the rebate program was not offered.

This paper describes the method used to collect data; the behavioral categories and their definitions; the models used for each method; and the results. The next section contains a statement of the issues inherent in any net-to-gross analysis and includes definitions of some terminology. The Methods section includes a more in-depth description of the models and the estimation techniques, including discussion of the advantages and limitations of the methods and the section following describes the results of the four estimations. Finally, the Conclusions section analyze the "lessons learned" from this analysis and makes recommendations for future estimations of customer behavioral choices.

Issues Affecting Analysis of Net-to-Gross

The net impact of a DSM program is the marginal effect of the program on energy savings over and above "naturally occurring savings" (Buller, 1992). Naturally occurring are those energy savings that would have occurred anyway. Insofar as some participants in DSM incentive programs would naturally have adopted the same energy efficient measures even without the program's financial incentives, they are referred to as "free riders". Thus, the free ridership rate is the rate of naturally occurring conservation among program participants.

Free ridership can never be exactly measured. This is because it is never possible to know with absolute certainty what customers would have done had the DSM program never existed (Buller, 1992). The best that can be done is to estimate the extent of free ridership through one of several estimation processes:

1. Customer Survey-Based Method - Survey customers to find out what they think would have been the extent of their naturally occurring conservation (i.e., adoption of energy efficient technologies) under a different situation wherein the DSM program did not exist. This method was used in the first approach.

2. Econometric Model Method - Utilize econometric methods of Discrete Choice Analysis, to statistically distinguish DSM program participation decisions from technology adoption decision, and then predict the extent to which customers would have adopted energy efficient technologies without the DSM program. Econometric modelling was used in the third and fourth approaches of this study.

3. Manufacturer and Distributor Survey Method - Study rates at which energy efficient technologies are being purchased and installed in areas where no DSM programs exist, and compare them with trends in the study area, to identify local increases in the rate of technology adoption that are over-and-above prior trends in this area and normal trends elsewhere. Information on sales trends was collected for the second approach of this study.

4. Billing Analysis Method - Compare changes in energy consumption before and after participation in the DSM program, with that of a comparison group over the same period. This method was not used in this study.

The field of DSM program impact evaluation contains a number of metaphorical jargon terms that can be misleading in the context of attempts to clarify and define net impacts. A prime example of this is the concept of "free driver", a label originally intended to be juxtaposed with that of a "free rider", and that would seem to be applicable to one who freely drives a series of energy savings behaviors. However, as previously noted, spillover impacts can be "driven" by (i.e., led by the actions of) many different actors. In actual practice, the term is used differently in various studies. Accordingly, this paper tries to adopt a consistent set of definitions.

- The impact of (or savings from) a DSM program is typically measured as the reduction in overall energy use (kWh) and peak demand (kW) caused by the utility program.

- Gross impact is the impact achieved by installation and use of eligible measures by participants under the DSM program. It is typically estimated based on engineering data, survey and/or billing meter data. Less frequently, end-use metering is used to estimate gross impacts. The cost of this latter approach is relatively high due to equipment and labor requirements.

- Net impact is the marginal effect of the program over and above naturally occurring patterns of equipment installation and use. Typically, it has been measured based on survey and/or billing data.
- Naturally occurring conservation is the increase in energy efficiency by all utility customers that would naturally have occurred anyway without the program. Naturally occurring conservation is driven by normal market forces, such as increases in energy costs, and by the effect of federal or state equipment or building standards.
- Free ridership is the portion of participants (or participant actions) that would naturally have occurred anyway (without the program).
- Take-back or snap-back is offsetting increases in consumer use of equipment because of their higher efficiency.
- Dealer free driver effect is additional sales of energy efficient equipment beyond program participants, due to dealer stocking, pricing and marketing induced by the program.
- Market spillover is increases in adoption of energy efficient equipment and conservation in use of equipment by non-participants or participants as a result of increased conservation awareness induced by the program.

There can be variations of the above definitions. For instance, there are many behavioral variants of free ridership. Viewed in terms of customer adoption of new technologies, there can be "pure free riders" and "partial free riders" in DSM programs. Pure free riders would have installed the same equipment without the incentive program. Partial free riders are those participants who would otherwise have installed somewhat less efficient models of the same equipment, or few quantities of the energy conserving item ("incremental free ridership") or would otherwise have not installed the new items so soon ("deferred free ridership"). For the analysis described in this paper, all of these behavioral options were accounted for.

Methods

A series of approaches were undertaken to estimate the most robust net-to-gross ratio for the CIA Retrofit Rebate Program. Each method had advantages and limitations. The application of several methods allowed for "triangulation" (or in this case "quadrangulation") onto the most accurate estimate, which synthesized the results of all the studies. The studies were complimentary, in that one method's limitations were another method's strengths.

The next section discusses the advantages, limitations and biases of each method.

Direct Surveys of Participating Rebate Customers

Surveys were conducted to ask customers directly how the rebate program affected the process of their decision making, and what they would have done without the rebate program. This approach focuses on free ridership effects and ignores spillover effects.

There are potential biases in the analysis of customers' self-reports. Some of these potential biases operate in opposite directions, so either could dominate. For example, the customer might answer that they would have installed the measure without the rebate (which, on face value, would indicate that the customer is a free rider); and yet, without the rebate, the customer might have installed a less efficient version of the equipment, or might have installed the same efficiency level but at a later time. In both of these cases, part of the savings from the measure is attributable to the program. As another example, customers might also say they would have installed the measure without the rebate (even though they would not have) because of "cognitive dissonance". Cognitive dissonance is the tendency of people, when looking at their own past decisions, to want to affirm that they made the correct decision.

On the other hand, customers might perceive that they have a vested interest in having the incentive program continue at as high a level as possible and might tailor their responses so as to further this outcome. For example, a customer might say that the measure would not have been installed without the rebate, when indeed it would have, because the customer wants PG&E to keep paying rebates. Or, from a less Machiavellian perspective, the customer might simply be embarrassed to admit that they received money for something that they were going to do anyway. These factors influencing customers' responses would tend to bias the estimate of net-to-gross ratio upwards, making the program appear more effective than it actually is. In reality, the use of consistency tests in the calculation of the net-to-gross ratio acts to minimize such bias.

There is an important potential bias that could operate against the program. Under the various methods for combining questions, inconsistencies in customers' responses are generally handled by attributing part of the customers' savings to the program and considering the other part not to be attributable to the program. Therefore, inconsistencies tend to push the estimated net-to-gross ratio toward some moderate level. If in actuality, the program has a very high net-to-gross ratio, and inconsistencies simply reflect the vagaries of customers' memories and self-awareness, then the procedure for dealing with these inconsistencies would tend to bias the estimated ratio downwards. (Of course, if the true ratio is very low, the procedure would bias the estimate upwards, for the same reasons.)

It is also clear that customers sometimes provide seemingly contradictory answers. For example, a customer might report that it would have installed the measure without the rebate but, in response to another question, state that the rebate was very important in its decision to install the measure. Seeming inconsistencies of this type require more questions to determine what the decision process actually was. For example, if a further question reveals that the customer learned about the rebates after agreeing with a contractor to install the measure, then it is reasonable to consider the customer a free rider: the response that the rebate was very important is interpreted as meaning that the customer was very happy to receive it.

The customer survey included a series of questions that served as consistency checks and could be used to resolve, insofar as possible, seeming inconsistencies that arose. These included questions about how far in the purchase decision process that customer had gone prior to hearing about the rebate, and the significance of the rebate for the decision made. These consistency checks were combined with the basic survey questions to derive a free ridership "probability" for each participant. Additional versions of the net-to-gross ratio incorporated other questions about the decision process, prior behavior, how they learned about the program and importance ratings.

In any case, there still remains a degree of uncertainty regarding how to combine the questions. for example, if a customer definitely would have installed a measure without the rebate but "probably would have installed a less efficient version", what portion of the savings should be attributed to the program?

To deal with this issue a variety of different methods were applied to the survey responses, resulting in a range of net-to-gross ratios. For example, we assigned different weights to different questions. Another method of combining seemingly contradictory answers was to assign "probabilities of free-ridership" to different answers.

Because of the potential biases in self-report data (and its omission of spillover effects), it is useful to apply methods that utilize other types of data, particularly methods that examine the actual behavior of customers rather than their reported behavior. This is the motivation for the participant/non-participant and the treatment/control studies described below.

Contractor and Dealer Survey

To the extent that the rebate program is having an effect on customers' purchases, contractors and dealers should experience this effect through greater sales and more frequent installation of energy efficient equipment. A survey was conducted in which contractors and dealers were asked to report how much their sales of energy efficient equipment had increased during the program period. It was recognized, however, that sales could have increased over time for reasons other than the program. Contractors and dealers were therefore surveyed in two areas: in PG&E's service territory and in a control area in which no conservation programs had been offered. (The control area was Reno, NV except for lighting measures, where Birmingham, AL was used.) The percent increase in sales of energy efficient equipment that contractors and dealers in PG&E's area reported was compared to the percent increase reported by their counterparts in the control area, and the difference was attributed to the program.

An important feature of the dealer and contractor survey analysis is that it includes spillover in its estimated effects of the program. Sales trends in PG&E's area were compared with sales trends in a control area that does not have any program; consequently, the difference in trends incorporates all effects of the program, including spillover.

Translating the percent rise in sales due to the program into a net-to-gross ratio for the program is not straightforward. If it were known how many measures were installed in the entire PG&E area and how many of these were installed under the program (i. e., received an incentive payment)—as well as the savings from these measures—then a net-to-gross ratio could be calculated. However, data do not exist on the total number of measures and the savings from measures installed by customers outside of the program. Consequently, assumptions about these factors are required to estimate a net-to-gross ratio from the dealer survey information. In particular, it was assumed (based on program data) that 15 percent of the total sales of energy efficient products are attributable to program participants. The overall program effect on net-to-gross ratio is also affected by assumptions regarding the extent of free ridership underlying those sales.

The survey of dealers and contractors is susceptible to the same bias as the customer survey, namely, that dealers and contractors have a vested interest in the programs and might respond to survey questions with this fact in mind.

Because of this, it is possible that the extent of spillover that is implied by the dealer contractor survey is biased upwards. However, the emphasis on factual changes in sales levels should minimize bias and error more so than relying solely on a survey of stated intentions under hypothetical situations, as was done for the customer survey described above.

Participant/Non-participant Model

With the incentives program, PG&E customers have the following options for each energy-saving measure:

Option 1: Do not install the measure,

Option 2: Install the measure and do not obtain a rebate, or

Option 3: Install the measure and obtain a rebate.

The question for net savings estimation is: what would customers who chose Option 3 do if rebates were not available? Stated alternatively, which option would customers choose if Option 3 were not available and their only options were to choose Option 1 or Option 2.

Discrete choice models (Train 1986) were estimated and applied to examine this question. In particular, for a sample of PG&E customers, data were obtained on which measures the customer could have taken over the last three years, which of the measures the customer did take, and whether the customer received a rebate for installing the measure. For each measure that the customer could have taken, a discrete choice model (using the simultaneous nested logit technique) was estimated of their choice among the three options. The estimated model was then used to predict what the customer would do if faced with only two options (do not install or install without a rebate). Free riders were those customers who were predicted to install without a rebate when the option of receiving a rebate was not available, but who had received a rebate for their installation.

This approach has advantages and limitations. The advantage is that it is based on observed behavior of choices actually made, rather than stated intentions under hypothetical situations. The limitation is that it requires that customer decisions be classified into discrete choices (e.g., a customer either does or does not install a measure). This leaves no room for partial implementation of measures or installation of less efficient versions of measures.

This technique also requires an estimate of the potential cost and savings associated with each choice alternative faced by each customer. Data collection costs for this information can be expensive. Sometimes, assigning potential costs and savings can include judgment because it involves hypothetical situations.

Since the discrete choice models were “revealed choice models”, based on observations of actual behavior, they were not subject to survey response biases of the type that could have affected the direct survey of participating customers and to a lesser extent, the contractor and dealer survey. There is, however, potential for error introduced by the data collection procedures concerning classification of measures installed outside the program and estimation of the costs and benefits for measures either not installed or installed outside the program. This increases uncertainty and limits precision of estimates under conditions of small sample sizes, although there is no clear indication of bias affecting net-to-gross ratios in any one direction.

Treatment/Control Comparison of Equipment Saturation

The basic approach here is to gather data on the saturation of program measures among PG&E’s electricity customers (treatment group) that are eligible for the CIA Retrofit Program, and among a control group population that did not have access to the program. The assumption is that the control group acts exactly as the treatment group would have if they had not been exposed to the program thus reflecting naturally occurring conservation. Therefore, any difference in the saturations between the treatment and control groups would be due to the influence of the program. The difference would be due to both direct impacts and induced spillover benefits.

This approach is designed to avoid the pitfall of self-selection bias inherent in comparisons of participants with non-participants. Here, the treatment group is the entire population of PG&E’s electricity customers, whether or not they participated in the rebate program. The control group, in turn is a population that is not PG&E electricity customers and was not offered any energy efficiency incentives. Because the control group represents an entire population (both those who would have been participants and those who would have been non-participants, had they been offered the program), their behavior can more accurately reflect the full actions of how the treatment group would be expected to behave without the program. Thus, a comparison of the two groups theoretically allows a proper estimate of the program’s true effect.

Binary logit models were used for the analysis for this report. They were used to estimate how customer actions vary depending on the availability of program incentives. Very simply, customers can either:

1. Choose to implement energy efficient measures, or

2. Choose to not implement energy efficient measures.

An advantage of this approach, like the participant/non-participant study described above, is that is based on observations of all decision choices that were actually made. In that sense, it avoids the pitfalls of direct surveys, which are subject to uncertainty, error and inherent biases associated with self-reporting and use of hypothetical scenarios.

A distinguishing feature of this approach is that it compares behavior in PG&E's service territory with that of an external control group where no such incentive program exists. Thus, overall program effects, including spillover benefits as well as naturally occurring conservation effects, can be captured by the treatment/control comparison. Here, the control groups are PG&E gas customers who obtain electricity from municipal utilities. That ensures similarity in climate and economic conditions.

There are, however, also limitations to the approach used in this study. The first limitation is that the approach is dependent on information that itself has uncertainty; in particular, the estimation of how much energy savings a non-implementing customer would have saved had that customer chosen to implement. The second limitation is that it necessarily requires the simplification of implementation decisions into discrete decisions. It does not allow for intermediate gradations of energy savings associated with purchases of equipment. While it does have a control group, which is influenced by similar geographic, historical, social and economic factors, there may be some inherent differences between the control group and the treatment group.

A final concern is that while the control group are not PG&E electricity customers, they do receive gas from that utility. Consequently, they are exposed to PG&E's energy efficiency marketing efforts, In addition, the vendors and suppliers from whom the control group purchased energy using equipment also served PG&E's electricity customers. PG&E's programs probably have influenced these suppliers. Consequently, this analysis will measure some behavior that was induced as part of market spillover, but the estimation technique will identify it as naturally occurring.

Results

Customer Surveys

The customer survey produced a net-to-gross ratio that incorporated free ridership effects but not spillover effects. The analysis provided alternative estimates of net-to-gross ratios that ranged from .39 to .60, depending on the method that was used to handle seeming inconsistencies in customers' responses. The most sophisticated, and probably the most accurate method, provided a net-to-gross ratio of .58. Table 1 shows the net-to-gross ratios for specific program components using the overall ratio of .58.

Table 1. Net-to-Gross Ratios Using Customer Survey Approach

Type of Measure	Net-to-Gross Ratio (without spillover)
Space Conditioning	.41
Controls	.47
Refrigeration	.49
Motors	.58
Process Equipment	.60
Lighting	.61
Agricultural Measures	.62

The overall net-to-gross ratio of .58 was calculated as a weighted average of the component ratios, weighted by energy savings. This survey-based estimate of net-to-gross was based on a sample size of 742 participants. It yielded a statistical confidence interval of .54 - .62 at 80% confidence (or .52- .64 at 95% confidence). It is important to note, however, that this confidence interval reflects only the confidence that our statistical sample proportion was representative of the true population proportion. It does not reflect our level of confidence that the survey questions are appropriately reflecting the true net-to-gross ratio. There are omissions and biases in this measure that can make the final net-to-gross figure outside of this range. These were discussed above in the section on method.

It is important to note that this figure does not include spillover effects—that is, the effect of the program on changing the market as a whole, thereby affecting the rates at which non-participants as well as participants implement additional energy efficiency measures outside of the rebate program. By their nature, self-report data on participants do not reflect this spillover. The estimate of .58 is therefore an indication of the net-to-gross ratio excluding spillover.

Contractor and Dealer Survey

The survey of contractors and dealers produced a net-to-gross ratio that includes spillover as well as free ridership effects. Using different assumptions, the estimated net-to-gross ratio from this analysis ranges from .72 to .86. The extent of spillover that is implied by these figures depends on the amount of free ridership in the program. If the net-to-gross ratio without spillover is .60 (meaning that the free ridership rate is .40), then the spillover increases the net-to-gross by .22 percent to .82. If, however, the net-to-gross ratio excluding spillover is .58, .75, or .68, then the spillover increases the ratio by .28, .12, and .04, respectively. (Of these three sets of values, the first is that indicated by the customer survey reported above, the second is that indicated by a composite of the customer survey and the participant/non-participant analysis).

The confidence interval for these results is determined by both the sample size of the contractor and dealer survey (52 in the PG&E service territory and 20 in the control territories), as well as the confidence interval associated with the customer survey. The resulting statistical confidence interval is plus or minus .30. For example, if the net-to-gross (including spillover) is .77, then the confidence interval is estimated to be in the range of .47 to 1.07 at 95% confidence.

Participant/Non-participant Analysis

The customer-survey based approach estimated a net-to-gross ratio that represents the effect of free ridership. That is, a net-to-gross ratio of .80 would indicate that 20% of the program participants would have installed the energy efficient equipment even if PG&E did not offer a rebate for the installation. Net savings were defined as:

Net Savings = Gross Savings - Free Ridership

The net-to-gross ratio is net savings divided by gross savings.

What was not estimated in the customer survey approach was the effect of market spillover. In fact, any program-induced effects among the non-participants would have been included in the estimates as "naturally occurring, " thus overestimating the effects of free drivership. Thus this study can be viewed as setting an upper bound for free-drivership. That is, free drivership would be no more than that found in this study.

The treatment/control group results, on the other hand, estimate a net-to-gross ratio that incorporates (at least theoretically) all program effects. The control group behavior is representative of naturally occurring. Thus both free drivers and market spillover are accounted for in this analysis. In short the net savings are defined as:

Net Savings = Gross Savings - Free Drivers + Market Spillover

Again, the net-to-gross ratio is calculated by dividing net savings by gross savings.

Table 2 compares the results of the participant/non-participant study and the treatment/control study.

Treatment/Control Study

The weighted average of these commercial and industrial ratios, using the total savings obtained under the program from each of the measures as weights, is .73. The standard errors of these ratios were very high for individual types of measures. This result reflects the intrinsic difficulty of estimating the impact of programs by examining the behavior of customers, all of who were offered the program. Given the standard errors, the hypotheses that the true net-to-gross ratio is 1.0 cannot be rejected; nor can the hypotheses that the true ratio is zero for any one measure. This is not the case for the net-to-gross of the six measures combined.

The overall net-to-gross ratio for commercial and industrial measures, .73, is a weighted average based on the total savings obtained under the program for each of the six component measures that were modeled, weighted by the associated energy savings. While there is a chance that one of the six components of the overall net-to-gross may differ significantly from the estimate, it becomes increasingly unlikely that two, three, four, five, or all six estimates will all differ significantly from their estimate. Furthermore, even if all six did, in order for the overall net-to-gross to differ significantly from the .73 estimate, all or most would have not only to differ significantly, but differ significantly in one particular direction.

Utilizing a Monte Carlo method of repeated calculations under alternative coefficient estimate assumptions, a simulation of the distribution of the overall net-to-gross ratio was derived. The result was a statistical confidence interval of .48 to .98 with 80 percent confidence and a weighted mean value of .73 for commercial and industrial measures.

It is important to note that, since the analysis examines PG&E customers only, the estimated ratios necessarily exclude spillover effects.

The overall commercial and industrial net-to-gross ratio for the treatment/control study was .75. This ratio includes both free ridership and spill over effects.

Table 2. Net-to-Gross Ratios Using Participant/Nonparticipant Approach

Measure Category	Net-to-Gross Ratio accounting for Free Riders Only	Net-to-Gross Ratio including Free Riders and Market Spillover
Lighting Upgrades	.84	.85
Lighting Conversions	.55	.52
Lighting Controls	.80	1.10
HVAC Adjustments	.84	—
HVAC Maintenance	—	.85
HVAC Controls	.75	.63
HVAC Installations	.43	.73

Synthesis of Study Results

Two of the studies estimated net-to-gross ratios that excluded spillover: the customer self-report survey and the participant/non-participant decision analysis. The most reliable estimate from the self-report survey of customers was .58, and the best estimate from the customer decision analysis was .73. Each of the methods has inherent advantages and limitations. There are reasons that the self-report results could be biased either upwards or downwards, and the direction of any bias is not known. The results from the customer decision analysis have large standard errors, meaning that the true ratio could be very different from the point estimate of .783. A weighted average of the two, adjusting for differences in sample size, statistical precision and bias potential, yields a composite value of .65 as the net-to-gross ratio excluding spillover.

The dealer/contractor survey estimated the amount of spillover given various possible levels of the net-to-gross ratio excluding spillover. At a ratio of .65 for net-to-gross without s pillover, the dealer/contractor survey indicated that spillover constitutes a .12 increase in the net-to-gross ratio, although this may fall in the range of .08 to .16 (depending on the assumption regarding participants portion of total observed sales volume). In this case, given the possibility that dealers and contractors based their responses on their desire that rebate programs continue it is prudent and appropriate to adopt a conservative value of .10. With this amount of spillover, the net-to-gross ratio including spillover is 0.75 (O. 65 excluding spillover and 0.10 for spillover). This value of .75 is a program composite value including commercial, industrial and agricultural measures.

Using a parallel methodology for specific program components, the estimated average net-to-gross ratio excluding spillover is .66 for lighting measures, .61 for HVAC measures, .65 for other commercial and industrial measures; and .69 for agricultural measures. The weighted average is .65. There is no corresponding breakdown available for spillover, for which the uniform estimates of .10 was adopted. The sum of these values yields the overall net-to-gross ratio of 0.75.

The treatment/control comparison offers an alternative comparison of overall net-to-gross ratio. That study also found an overall value of 0.75, which tends to confirm this conclusion of overall program impact.

Conclusions

All the methods used to determine the net-to-gross ratio were effective when the separate study results were combined. The combined results offset the individual approaches' sources of error, constraints and biases. The application of several methods allowed for "triangulation" onto a more reliable estimate, which synthesized the results of all the studies. The studies were complimentary, in that one method's limitations were another method's strengths.

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