Net Impacts from Upstream Lighting Programs: A Multi-State Model

Chris Russell, NMR, Bryan, TX
Lisa Wilson-Wright, NMR, Melrose, MA
Ralph Prahl, Prahl and Associates, University Park, FL
Lynn Hoefgen, NMR, Somerville, MA

ABSTRACT

This paper describes a multistate statistical model as an approach to measuring the net impacts of upstream lighting programs. Changes in the compact fluorescent lamp (CFL) market and the transparency of upstream programs for participants—with neither program administrators (PAs) nor participants knowing who is a participant—make it difficult to isolate program-induced impacts.

The multistate modeling evaluation utilizes Zero-Inflated Negative Binomial (ZINB) regression to model net impacts of upstream CFL programs on CFL purchases. It uses data gathered in 1,495 onsite lighting inventories and random telephone surveys in 11 CFL program areas and four non-program areas in the United States. The lighting inventories supplied information on CFL purchases, use, and saturation, while a complementary questionnaire provided data on participants' light bulb-purchasing behavior, attitudes towards select environmental issues, and demographic information. These data served as inputs to two different models describing CFL purchases. One model covers the eighteen-month period from January 2009 to June 2010 and the other covers the six-month period from January 2010 to June 2010. The evaluators used the model results to calculate net-to-gross (NTG) ratios for the program areas participating in the study.

The models demonstrate that the number of CFLs incented by the program per household in a given area boosted CFL purchases, while CFL saturation at the beginning of the time period contributed to fewer CFL purchases. Other demographic and social factors, however, also influenced CFL purchases behavior. This paper discusses the development of these models, their interpretation, and the resulting NTG ratios.

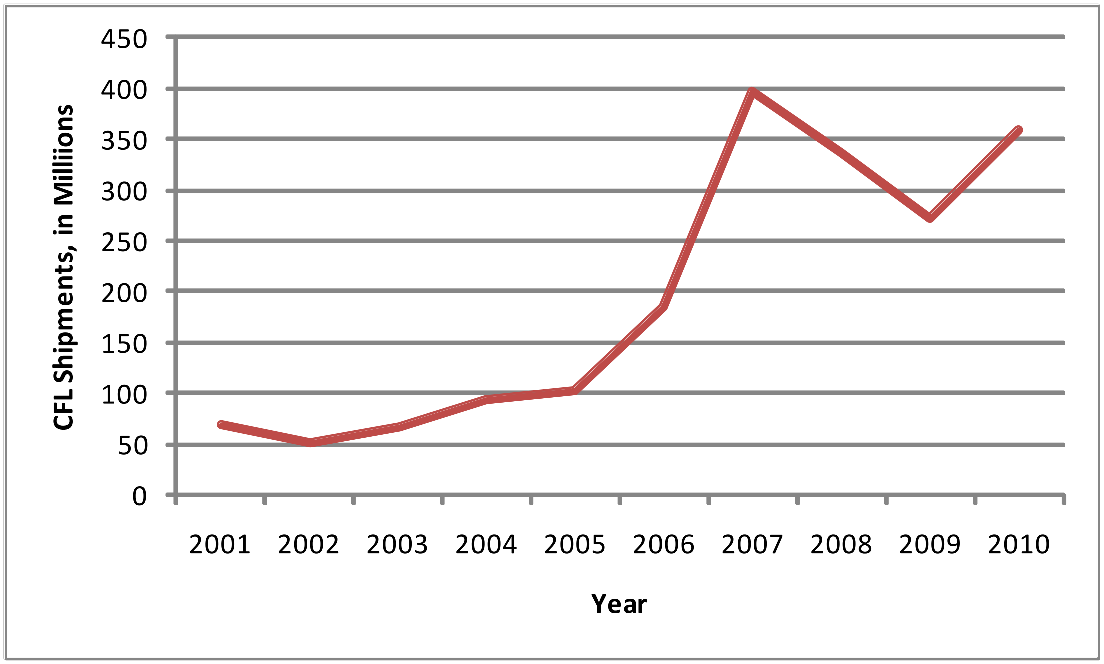
Introduction

Compact fluorescent lamp (CFL) program evaluators nationwide are finding it increasingly difficult to provide valid and defensible estimates of net-to-gross (NTG) ratios for CFLs. Numerous recent studies employing various methods have struggled to provide estimates that are widely accepted as realistic and valid estimates of NTG (KEMA 2010; NMR Group 2010; Summit Blue 2009). For this reason, many program administrators (PAs) across the nation are embracing innovative approaches to estimating NTG for CFLs in an effort to identify new ways of determining the impact of CFL program activity on actual CFLs purchases and energy savings. Multistate modeling is one of these approaches. In this approach, data from households in multiple PA service territories are entered into statistical models that attempt to capture the effects of program activity on CFL purchase and use behavior, net the impact of demographic, economic, and social factors that also affect such behavior.

This paper describes the reasons for embarking on the multistate modeling process, the efforts undertaken to ensure comparability of data to be entered into the model, and the process of developing multistate models. The authors share models that estimate CFL purchases in 15 different areas across the United States and compare the resulting NTG ratios for the 11 program areas included in the model. The modeling effort address purchases from January 2009 through June 2010, with one model covering the entire period and a second limited to the last six months of the period.

Background

The CFL market is changing rapidly. Trends in CFL shipments suggest gently increasing sales through 2006, followed by a spike in 2007, a precipitous decline in 2008, and a recovery in 2010. The volatility of the trends can largely be explained by Wal-Mart's 2007 campaign to sell 100,000,000 CFLs in 2007, the recession that began in 2008, and the slow economic recovery occurring in 2009 and 2010. The year 2010 also saw the commencement or expansion of CFL program activity in many areas, particularly in the Midwest, and substantial program revision in some long-running CFL programs in the Northeast.



Source: United States Department of Commerce

Figure 1: Number of CFLs Shipped in the United States, 2001 through 2010

Together, the rapid expansion of CFL programs throughout the nation, the increased availability of CFLs regardless of CFL program activity, and the role of the recession on CFL purchases have all increased the difficulty of estimating NTG, a task already made extremely difficult because of limited access to CFL sales data from participating and non-participating retailers in both program and non-program areas. Former "best practices" in CFL NTG estimation (*e.g.*, self reports of free ridership and spillover and simple comparison-state approaches) have become increasingly problematic given the changes in the CFL market, but no clear methodology currently stands out as the latest best practice in NTG estimation. In response, the CFL program evaluation community has turned to a diverse range of NTG estimation methods: self-reported free ridership and spillover, comparisons of CFL sales and self-reported purchase behavior in program and non-program areas, manufacturer and retailer estimates of program-induced "lift" in sales, revealed preference models, and multistate purchase models, among others—only to be frustrated by what some reviewers have seen as counterintuitive or unreliable NTG estimates. In fact, the comprehensive evaluation of the Upstream Lighting Program in California (ULP) completed in the Spring of 2010 for the California Public Utilities Commission (CPUC) assessed NTG using six different methods, with the results ranging from as low as 23% to as high as 74% (KEMA 2010).[1] The CPUC study and other recent CFL NTG studies make clear that all available estimation methods have strengths and weaknesses that ultimately influence the results.

Previous attempts to use multistate modeling to explain CFL purchases and use met with mixed success (KEMA 2010, NMR 2010). Some of the limitations of the previous efforts include inconsistency in data collection protocols and the time of year the data collection occurred, the failure to include variables that capture a household's environmental opinions or inclination to be an early adopter of technology, and the dominance in the model of program areas with long histories of supporting CFLs, with this last limitation reducing variation in the program score from which the authors estimated program effects. The previous effort also relied on a modeling approach that the authors of this effort concluded was not the most appropriate choice to model CFL purchases, as explained in the Methods section below. The multistate modeling effort discussed in this paper responded directly to these shortcomings of previous efforts in the following ways: by implementing greater consistency in the instruments and methods used to collect data and the timing of data collection; adding variables that capture environmental and other opinions that may affect adoption of CFLs; including programs with a wide range of histories of support for CFLs; and specifying models using a technique closely related to the one employed in the prior effort but that the evaluators believe is more suited to the unique nature of purchase data.

Scope

This paper presents statistical models that estimate the number of CFLs purchased by households in 15 areas across the United States from January 2009 to June 2010. Four of the areas have no sustained program activity, six of the areas began running CFL programs in 2009 or 2010, and the remaining five areas have administered CFL programs for between five and 12 years. The results presented here reflect the characteristics of these areas and their programs, and the authors caution that the results may not be reliably extrapolated to other areas of the country. Moreover, the evaluators prepared models explaining CFL purchases from January 2009 through June 2010 as well as CFL use and saturation at the time of the onsite visit. In order to keep the scope of this paper manageable, the authors present only the purchase models and their impact on NTG ratio estimation. The full set of models will become available as the program administrators release them to the public.

Methodology

This section provides an overview of the methods used in the multistate modeling process. Given the large scope of the project, this paper provides a high-level summary of the methodology related to survey procedures, data weighting, development of the program-support variables, and the modeling procedures. The authors suggest that readers seeking more detail on the methodology consult forthcoming final reports for individual PAs when they are made public.

Survey Procedures

The multistate models rely mainly on data gathered from random telephone surveys and onsite lighting inventories conducted in the same households. The telephone surveys of 5,363 respondents gathered

---

[1] The NTG ratios provided for the ULP were not all measuring the same time period; some were for the entire 2006 to 2008 period and others for blocks of that time. Taking the different time periods into account reduces the variation in the range of NTG ratios.

data on: CFL awareness and familiarity; general history of CFL use, purchases, and satisfaction; where respondents shop for lighting products; opinions on climate change and energy-related environmental issues; tendencies toward early adopter behavior; and demographics.

Importantly, the telephone surveys also served to recruit participants for the onsite lighting inventories. During the survey, respondents were asked if they would be interested in taking part in the onsite portion of the study, and were told that they would be paid an incentive if they agreed to the onsite. The incentives offered ranged from $75 to $150 depending on the cost of living in the area. The 1,495 households that took part in the onsite survey were randomly selected from among the subset of telephone survey respondents expressing interest in the onsite portion of the study. The onsite portion of the study provided information on the number of CFLs installed, the number of CFLs in use, and when the respondent recalled obtaining (*i.e.,* usually purchasing but sometimes being given) the CFLs found installed or stored in the home.

The onsite recruitment approach varied to some extent in eight of the 15 areas in the study. In three areas, some or all of the households taking part in the onsite had been previously selected to take part in CFL metering study. In other areas, the onsite participants were taking part in a larger residential appliance saturation study. The other four areas that varied from the approach had taken part in last year's multistate effort. The evaluators revisited a subset of last year's onsite participants to see how CFL use and storage had changed over the course of a year, and they also surveyed new onsite homes in each of these areas as well. The evaluators addressed these variations in approach either through the weighting scheme or through statistical controls used during the model process, when such controls were found to be statistically significant in the recommended models.

Weighting

In order to account for any potential bias in the onsite sample toward CFL enthusiasts or homeowners, the evaluators weighted the onsite sample back to the overall telephone survey-reported familiarity with CFLs as well as to Census data on the percentage of households that own or rent in each area. The evaluators had to adjust the weighting scheme slightly for households selected to take part in the CFL metering study. These households all had CFL installed, and, therefore, the respondents were familiar with CFLs. The evaluators addressed this bias in familiarity in two ways. In the areas in which some households had been previously selected to take part in a metering study, the evaluators weighted metering households back the familiarity responses of participants in the same areas that had been selected through the standard recruitment procedure. In one area *all* participants had been previously selected for a metering study, but this area had served as a comparison area in the 2009 effort. The evaluators used the 2009 data on CFL familiarity to serve as the base for weighting the 2010 sample.

Developing the Program Support Variable

The program support variables were the key components of the statistical models guiding the calculation of the NTG ratios. The development of these variables involved reviewing CFL program plans and documents, prior evaluation reports, and program summaries compiled by the Consortium for Energy Efficiency (CEE), the US Department of Energy (DOE), and ENERGY STAR in order to locate CFL programs in each state and gather information on CFL program activity through 2010 in each area. The evaluators searched for data on the program budgets; the number of CFLs incented; the percentage of the budget allocated to incentives, marketing and advertising, and overhead; the percentage of CFLs that had specialty features, and the method of support (*e.g.*, retail coupons, catalog, and/or upstream approaches).[2] The authors successfully collected this information for all programs for 2009 and 2010 and verified the data with the PAs. Ultimately, the recommended purchase models utilized the variable "number of CFLs incented per household," as this variable produced a consistently strong goodness of fit across all models developed.

The evaluators also gathered information on when (1) the current CFL program and (2) any of its predecessor programs had been launched in order to assess the impact of prior program activity on current purchases. Because these two variables capturing the length of prior program activity were closely correlated, we added the scores together to yield an overall "prior program support" variable. **Table 1** summarizes the current- and prior-program variables used in the recommended purchase models.

Table 1. Program-Support Variables used in Recommended Purchase Models

Area*	Eighteen-Month Model		First-Half of 2010 Model	
	CFLs Incented per Household	Prior Program Support	CFLs Incented per Household	Prior Program Support
1	0.8	17.0	0.2	19.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
4	2.5	0.0	2.5	2.0
5	1.1	1.0	0.4	3.0
6	2.8	2.0	1.1	4.0
7	0.0	0.0	0.0	0.0
8	0.6	10.0	0.3	12.0
9	0.5	0.0	0.2	1.0
10	3.8	4.3	1.4	6.3
11	1.8	17.0	0.6	19.0
12	0.6	10.0	0.3	12.0
13	1.2	0.0	1.1	1.0
14	0.0	0.0	0.0	0.0

* The authors suppress the data for individual PAs and comparison areas as the results in all areas are not yet publically available. Moreover, one area did not want its individual information reported in this paper.

Modeling Procedures

The evaluation team used a zero-inflated negative binomial (ZINB) model to predict CFL purchases. This model-type is similar to the procedures used in the 2009 multistate modeling effort, the negative binomial regression model (NBRM), in that both are more common methods of analyzing count data (e.g. the number of CFLs) with many cases falling at zero and with a fair degree of variability in the data (**Figure 2**). In contrast to the NBRM, ZINB has the additional benefit of not treating all zeros the same. The current evaluation team examined the assumptions of both NBRM and ZINB and concluded that the ZINB was the superior models because it had the capability of differentiating among reasons that households might purchase zero CFLs in the time period in question. Specifically, some households purchased zero CFLs because they did not need any CFLs during the time period, but other households did not buy CFLs because they do not use them or were not aware of them.

[2] Specialty features primarily included the following: dimmable and three-way capabilities, colored bulbs, small screw bases, and shapes other than the usual spiral.

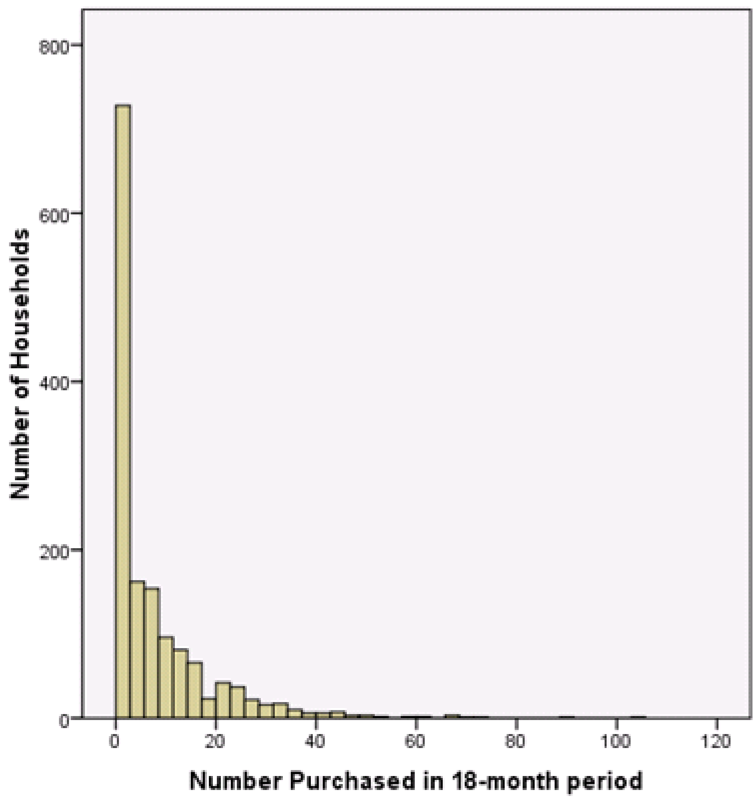


Figure 2: Histogram of CFLs Reported Purchased for the Eighteen-Month Period

The ZINB model runs two simultaneous models: a logistic model and a negative binomial model. The logistic model distinguishes between the zeros, identifying the variables associated with never buying CFLs (a positive correlation in the results, referred to as the "always zero group") and those variables only sometimes associated with buying zero CFLs (a negative correlation in the results, referred to as the "not-always zero group"). The negative binomial portion of the procedure runs models that predict the number of purchases using those households in the not-always zero group from the logistic portion as well as households that actually reported purchasing CFLs in the observation period. It is important to keep in mind that households sharing the characteristics of the "always zero group" may still have purchased CFLs; the logistic portion of the model simply says that, among those not buying CFLs, households having these characteristics were more likely never to buy CFLs in the time period.

To develop the models, the evaluators created models using the different program variables and other explanatory variables, including the following:

- CFL saturation at the beginning of the time period under consideration
- Demographic, economic, and social characteristics
- If household shops for CFLs and where
- Various measures of environmental opinions and early adoption behavior
- Average residential electricity price in the area during the time period (not found included in the recommended models)
- Concentration and travel time to Big Box stores (not found to be statistically significant in the recommended models)
- Length of CFL use (not found to be statistically significant in the recommended models)

The evaluators excluded explanatory variables found to be excessively collinear with other explanatory variables in the model or that had little statistical effect on CFL purchases or that made little theoretical sense from a programmatic standpoint.

Ultimately, multiple models worked for each time period under observation. In choosing among models, the evaluators chose the recommended models based on the probability associated with each variable in the model, the maximum likelihood R^2 statistic (related to, but different than, the explained variance for OLS regression models; see Long and Freese 2006, 110), and the ratio of predicted to self-report purchases. This paper focuses only on the recommended models, but the authors invite readers to review alternative models in forthcoming multistate modeling reports once individual PAs make these reports public.

Results

The multistate modeling effort yields two different sets of results. The first set of results focuses on the actual recommended purchase models. The second set of results presents NTG ratios resulting from the recommended purchase models.

Recommended Models

The evaluation team developed two different recommended purchase models. The first model, shown in **Table 2**, predicts purchases for the entire eighteen-month period of January 2009 to June 2010. The evaluators developed this model to coincide with the reporting needs of some of the PAs contributing to the effort, but also because using an eighteen-month model would reduce the self-report error concerning when households had obtained CFLs. This reason is based on the assumption that respondents would find it difficult to recall accurately if a CFL had been purchased in 2009 or the first half of 2010, but may answer in a more reliable manner for the entire period.

The logistic portion of the model predicts that:

- Households that own their homes were more likely to purchase some CFLs.
- Households with a greater CFL saturation at the beginning of 2009 were less likely to buy any CFLs, so they were considered to be in the always zero group. This is presumably because they already purchased CFLs and did not need any more.
- Households that strongly agree that it is not expensive to reduce energy use were less likely to buy any CFLs, presumably because they have already taken such low-cost options as buying CFLs.

The model's negative binomial portion predicts that the number of bulbs the program had incented per household had a significant and positive effect on CFL purchases. Other factors influencing the number of CFL purchased included:

- Households with a higher saturation of CFLs at the beginning of 2009 also were likely to buy fewer CFLs than those with a lower CFL saturation. Similar to the model's logistic portion, this implies that households with high levels of saturation simply did not need to buy CFLs because they already had enough.
- Households living in counties with high unemployment purchased fewer CFLs; considered with the logistic portion, this implies that households living in such areas bought CFLs, but not very many of them.

- The larger the participant's home the more CFLs they purchased.
- Households satisfied with their standard of living were more likely to buy CFLs, perhaps reflecting their greater comfort level with paying the higher price for CFLs.
- Households in which the respondent self-identified as white bought more CFLs.
- Finally, households that bought CFLs at various types of Big Box stores purchased more CFLs, presumably due to the larger package size typically sold at these stores versus grocery or lighting specialty stores. Note that, in the 2010 model presented below, a combined Big Box store variable performed better than these individual variables, but the individual variables performed better in the eighteen-month model.

Table 2. Best Fit Eighteen-Month Purchase Model

Variables	**Coef.**	**Prob z**
Logistic Model		
Intercept	-1.169	0.000
Homeownership (owner coded as 1)	-0.656	<0.001
CFL Saturation at Beginning of 2009	0.023	<0.001
Not expensive to reduce energy use (1 to 4, strongly agree coded as 1)	0.179	0.055
Negative Binomial		
Intercept	1.457	<0.001
Bulbs supported/household	0.062	0.012
CFL Saturation at the beginning of 2009	-0.012	<0.001
County unemployment rate at the beginning of 2009	-0.050	0.006
Size of home (by 2K sqft, ascending scale)	0.302	<0.001
Satisfaction with standard of living (1 to 5, strongly agree coded as 5)	0.054	0.066
Self-identify as white	0.328	<0.001
Purchase CFLs at Warehouse Store	0.858	<0.001
Purchase CFLs at Home Improvement Store	0.405	<0.001
Purchase CFLs at Mass Merchandise Store	0.279	0.002
Model Maximum Likelihood R^2	**18%**	
Model Sample Size*	**1,239**	
Average Ratio of Predicted versus Actual Purchases	**0.99**	
Range of Predicted versus Actual Purchases	**0.77**	**1.86**

* Reduction in sample size from the full 1,495 cases largely due to a large number of respondents who stated that they "did not know" the date of purchase for more than 25% of the CFLs found in their homes.

Table 3 presents the model limited to the first-half of 2010. The evaluation team developed this model to coincide with the programmatic and reporting needs of some clients. Moreover, households may have superior recall of the most recent purchases—that is, those made in the first half of 2010—so some advisors believed a 2010 model would be the most reliable one. The model for the first half of 2010 suggests the following:

The logistic portion of the model limited to the first-half of 2010 predicts that:

- Households with higher education levels had a greater probability of purchasing any CFLs, that is, of not being in the always zero group.
- Households visited in both 2009 and 2010 were more likely to purchase CFLs.

- Households with a greater CFL saturation at the beginning of 2010 were less likely to buy any CFLs, so they were considered to be in the always zero group. This is presumably because they already purchased CFLs and did not need them when asked.
- Households that like to have new technology were more likely to buy CFLs than those who do not like to have new technology. Conversely, households that did like to have new technology (indicated by responses of three or four) were more likely to have zero purchases, indicating a lower likelihood of buying CFLs.

The model's negative binomial portion predicts that the number of bulbs the program incented per household had a significant and positive effect on CFL purchases. Other factors influencing the number of CFLs purchased included:

- Homeowners were more likely to purchase a greater number of CFLs in 2010.
- The larger the participant's home the more CFLs they purchased in 2010.
- Even though they were more likely to buy CFLs than their counterparts who were skeptical of new technology, participants who responded that they like to have the latest technology purchased fewer CFLs than the technology skeptics who did buy CFLs, presumably because the early adopters already had more CFLs in their homes than the skeptics.
- Households with a higher saturation of CFLs at the beginning of 2010 also were likely to buy fewer CFLs than those with a lower CFL saturation. Similar to the model's logistic portion, this implies that those households with high levels of saturation simply did not need to buy CFLs because they already had enough.
- Households living in areas with longer running programs were likely to buy fewer CFLs. This variable indicates the cumulative impact of older programs, specifically that households in those areas have more CFLs because of the long program history. Therefore, they did not need to buy as many in 2010 compared to those in areas with newer programs.
- Households who purchased CFLs at Big Box stores were more likely to buy a greater number of CFLs, presumably due to the larger package size typically sold at these stores versus grocery or lighting specialty stores.
- Finally, two dummy variables associated with data collection were evident in the model. Revisit households surveyed in both 2009 and 2010 reported purchasing fewer CFLs in 2010 than households visited only in 2010. Also, areas where onsite technicians did not ask residents to guess the purchase period when they responded "don't know" to when the CFLs had been purchased were likely to have lower reported CFL purchases. This could be because those asked to "guess" when bulbs had been purchased tended to guess a more recent period (a common memory bias).

Table 3. Best Fit First-half of 2010 Purchase Model

Variables	Coef.	Prob z
Logistic Model		
Intercept	-0.453	0.185
Some college or higher education	-0.491	0.003
Revisit (yes coded 1; to account for potential impact of our first visit as evidenced in some MA, NY, Houston data	-0.517	0.007
CFL Saturation at Beginning of 2010	0.015	<0.001
Like to have new technology (1 to 4, strongly agree coded as 1)	0.318	0.001
Negative Binomial		
Intercept	1.000	<0.001
2010 Bulbs supported/household	0.385	<0.001
CFL Saturation at the beginning of 2010	-0.015	<0.001
Purchase CFLs at Big Box Store	0.441	0.008
Years supporting CFLs	-0.038	<0.001
Data Collection Protocol treatment of Don't Know	-0.801	<0.001
Homeowner	0.441	<0.001
Size of home (by 2K sqft, ascending scale)	0.353	<0.001
Likes to have new technology (1 to 4, strongly agree coded as 1)	0.157	0.008
Revisit household	-0.403	0.009
Model Maximum Likelihood R^2	**12%**	
Model Sample Size*	**1,349**	
Average Ratio of Predicted versus Actual Purchases	**1.01**	
Range of Predicted versus Actual Purchases	**0.66**	**1.94**

* Reduction in sample size from the full 1,495 cases largely due to a large number of respondents who responded "do not know" to questions about the date of CFL purchases, early adopter tendencies, and demographic questions.

The evaluators examined the differences between the two recommended models and believe they results from two possible sources. First, national CFL shipment data point to improved purchases in 2010 (see **Figure 1** above), raising the possibility that the model explaining purchases may also change in 2010. Second the eighteen-month and first-half 2010 models share some key CFL-related variables, such as the number of CFLs supported per household in the service territory (the program variable), CFL saturation at the beginning of the time period, and if and where households shop for CFLs. However, only the model for the first-half of 2010 successfully controls for the impact of prior program activity on purchase behavior. This variable is not significant in the eighteen-month model, but removing it from the 2010 model reduces the goodness of fit of that model. Importantly, many areas started supporting CFLs only in late 2009 or early 2010 and others revised their programs in 2010, which may help to explain the different relationship between prior program activity and CFL purchases in the two recommended models.

Net-to-Gross Ratios

To develop the actual NTG estimates, the evaluators used STATA (and verified the results with SAS) to calculate the predicted purchases in the presence (Row A, **Table 4**) and absence of the program (Row B). The non-program scenario removes *only* the impact associated with the number of CFLs incented per household. These calculations *predict* that each household in the program area represented in the table purchased an average 7.59 CFLs across the entire eighteen-month period and 2.39 in the first half of 2010.

The predicted non-program scenario suggests that 6.77 CFLs would have been purchased in the absence of the program across the entire period, and 1.93 in the absence of the program in early 2010. Subtracting the without-program estimates from the with-program scenario yields an estimate of net predicted program purchases (Row C). Dividing the net program purchase estimates by the incented CFLs per household (Row D) yields NTG estimates in Row E. The estimate for the entire eighteen-month period is 0.45 and for the first half of 2010 is 0.83.

Table 4. NTG Ratio Calculations for One Program Area

Input	Full 18 Months	First half of 2010
A. Per-household purchases with program	7.59	2.39
B. Per-household purchases without program	6.77	1.93
C. Net program purchases per household	0.82	0.46
D. Incented CFLs per household	1.83	0.56
E. Total NTG	0.45	0.83

Table 5 shows the range of NTG ratios resulting from these models across the program areas represented in the effort. The NTG ratios for the eighteen-month model range from a low of 0.34 to a high of 0.59 with a median of 0.45. The model limited to the first half of 2010 yields NTG ratios ranging from 0.70 to 1.30 with a median of 0.82. The higher ratios for the 2010 model reflect the inclusion of the control for prior program support in the model which is not significant in the eighteen-month model. If this variable is removed from the model, the NTG ratios fall into a similar range as those for the eighteen-month model, although the NTG ratio for individual states may be higher or lower in one model or the other.[3]

Table 5. Range of NTG Ratios across Program Areas

Range	Eighteen Months	First Half 2010
Minimum	0.34	0.70
Median	0.45	0.82
Maximum	0.59	1.30

Conclusions

The multistate modeling effort represents one of the methods currently being used by evaluators to estimate NTG ratios for CFL programs. The results presented here are the culmination of the second attempt to perform multistate modeling, which improves upon the initial multistate modeling effort through inclusion of programs with a more diverse history of supporting CFLs, closer coordination of data collection procedures, specification of variables that capture environmental opinions and tendencies toward early adoption of technology, and use of a model type that differentiates among the reasons why respondents may not have purchased CFLs in a particular time period.

The models exhibit a statistically significant relationship between the number of CFL incented by the program and CFL purchases, suggesting that CFL programs still increase CFL purchases and are having a

[3] Treating the prior program support variable as a program variable and setting its value equal to zero, however, forces NTG ratios to plummet in all areas. The implication of the behavior of this variable is discussed in detail in reports delivered to individual PAs and will be available when those areas make the reports public.

positive impact on CFL adoption. However, the lift associated with program activity may often be less than what the program had intended, leading to NTG ratios that fall below 1.0, suggesting relatively high levels of free ridership.

The differences between the model for the full eighteen-month period and the first-half of 2010 suggest a changing relationship between program activity and purchases, with the role of prior program activity serving as a key difference between the two models. The inclusion of this variable suggests that long-running programs still have an effect on CFL purchases, but the effect is less than in newer program areas or even non-program areas. Households in areas with long-running programs adopted CFLs in greater numbers in prior years, shifting purchases that would have happened now to earlier time periods. This means that these areas have reaped energy and demand savings for a longer time period, but it also means that their programs will have to continue to find innovative ways to increase CFL saturation. The future of CFL programs depends in large part on the future of the Energy Independence and Security Act of 2007, which is uncertain at the time of this writing.

Acknowledgements

The authors of this paper would like to acknowledge the efforts of the PAs who took part in this effort, including the following: Ameren Illinois; Ameren Missouri; ComEd; Consumers Energy in Michigan; Dayton Power and Light; EmPower Maryland; the five program administrators of the Massachusetts ENERGY STAR® Lighting Program which are the Cape Light Compact, NSTAR, National Grid in Massachusetts, Unitil, and Western Massachusetts Electric; National Grid in Rhode Island; the New York State Energy Research and Development Authority; and the Salt River Project. Various individuals at the Cadmus Group played an integral role in instrument design, data collection, and model development. In addition, the authors recognize the contributions of APPRISE, GDS Associates, Itron, KEMA, Navigant Consulting, Tetra Tech, and additional subcontractors for their efforts in helping to organize and implement data collection, reviewing prior drafts of the report, and advising the effort. Scott Dimestrosky, now of Opinion Dynamics Corporation but formerly of the Cadmus Group, deserves special recognition for his work to recruit the diverse PAs to take part in the multistate modeling effort.

References

KEMA 2010. *Final Evaluation Report: Upstream Lighting Program*. Delivered to the CPUC February 8.

Long, J.S and J. Freese 2006. *Regression Models for Categorical Dependent Variables Using STATA*. STATA Press: College Station, TX.

NMR Group, Inc. 2010. *Results of the Multistate CFL Modeling Effort*. Delivered to the Massachusetts ENERGY STAR Lighting Program Sponsors, February 4, 2010.

NMR Group, Inc. and Cadmus Group, Inc. Forthcoming. *Results of the Multistate CFL Modeling Effort.* Delivered to numerous Program Administrators but yet to be made public as of March 21, 2011.

Summit Blue Consulting 2009. *Energy Efficiency/Demand Response Plan Year 1 (6/1/2008-5/31/2009) Evaluation Report: Residential Energy Star Lighting*. Delivered to ComEd, November 16, 2009.