# Using Market Models to Evaluate Market Effects/Transformation of Multi-year Energy Efficiency Programs

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## Abstract

Market transformation doesn't happen in a single year. The long-term, cumulative effects of program activities (including incentives, marketing, education, and outreach) on the market are frequently under-represented. Therefore, innovative alternative methods are needed that can assess trends in actual market activity relative to baseline trends that would have evolved in the absence of the multi-year program. This paper presents an approach Navigant developed to capture cumulative long-term market effects of a compact fluorescent lamp (CFL) incentive program offered by DTE Energy, a utility serving the greater Detroit, Michigan area.

Navigant's "market model" method estimates total market effects by examining the entire CFL market over a 20-year historic period. The results account for the long-term, cumulative effects of the program on the market since the program was launched in 2009. They also account for the fact that incentive programs offered in other parts of the country, and general market advancements would have resulted in some growth in sales of CFLs in Michigan in the absence of DTE Energy's program.

This paper provides readers with an understanding of the types of data and modeling approaches that can yield an estimate of a program's long-term cumulative effects. The approach presented is applicable to CFLs and other technologies where cumulative program efforts materially affect the market, as may be evident in trends in sales, stocking, and pricing. Readers will be better equipped to capture the full effects of programs, and to ensure collection of the types of data that can ultimately support such analysis.

## Introduction

This document describes Navigant's market model approach to develop a comprehensive net-to-gross[1] (NTG) estimate for CFLs in DTE Electric's service area—one that encompasses not only free-ridership and spillover, but also includes other market effects. In simplistic terms, the approach used was to pull together many pieces of available market data, model what the CFL market would have been in the absence of DTE Electric programs and compare it to the market with DTE Electric's programs. Navigant used national and DTE-specific saturation data (data on the average percentage of total bulbs in sockets in a home that are CFLs), and Bass diffusion curve modeling (a widely accepted equation for the rate of adoption of a new technology), to predict the saturation that would have existed in DTE's service territory in 2012 in the absence of the program. This result was compared with data reflecting actual saturation of CFLs in DTE territory in 2012. The result is a net-to-gross (NTG) ratio estimate of 103% that accounts for the long-term, cumulative effects of the program on the market since its inception in 2009.

The following sections describe the challenge in NTG research that the CFL Market Model addresses, followed by a detailed discussion of the method Navigant used and a summary of findings. Navigant then concludes with a review of strengths and limitations of the method. Some of

1 Net-to-gross (NTG) ratios are estimated to determine the portion of sales of energy-efficient products that can be attributed to the program or market intervention.

the terminology used is unique to NTG analysis as a whole, and some is unique to this particular analysis. The next section provides a glossary of terms to assist readers.

## Glossary

Naturally occurring baseline (NOB) – Reflects the installations of an energy efficient measure that would still have happened if the intervention in question (utility program, etc.) had never existed. NOB is the counterfactual to the formation and continued operation of the intervention.

Free rider (free-ridership) – Customers purchasing energy efficient equipment through a utility program and who are also part of the naturally occurring baseline. These customers would have purchased the energy efficient equipment in the absence of the formation and continued operation of the utility incentive program, but do take advantage of discounts from the utility when the program is offered.

Naturally occurring non-participants (NONP) – The portion of the NOB that are not free riders. These customers purchase energy efficient equipment even in the absence of a utility incentive program and do not purchase the utility-discounted energy efficient equipment even when it is available.

Program-influenced participants (PIPs) – The participants that install energy efficient equipment as a result of the utility program, taking advantage of the available discounts in the process. These participants are incremental to the NOB.

Spillover – Spillover accounts for purchases influenced by the program of additional energy efficiency equipment by a customer, without a program discount, after a customer has already purchased a program-discounted product.

Market effects – Consists of untracked purchases (those occurring without a discount from a utility) of energy efficient equipment; untracked participation includes spillover and program-influenced non-participants.

Net Program Impact – Purchases of energy efficient equipment, whether tracked or untracked, that occur as a result of the program's existence. This consists of the PIPs and market effects.

Gross Program Activity – Purchases of program-discounted energy efficient equipment, whether influenced by the program or not. This consists of the PIPs and free riders.

Net-to-gross ratio (NTGR) – The ratio of net program activity to gross program activity, or the ratio of purchases influenced by the program to what can be tracked by the program.

## The Challenge of Estimating a NTG Ratio that Includes Market Effects

The CFL Market Model uses multiple years of data on CFL program activity and national market activity to estimate net-to-gross ratio (NTGR), market effects, and free-ridership associated with DTE's CFL programs. Multi-year program influences are not accounted for in most NTG methods, and spillover is often ignored due to the challenges of its estimation. This method addresses these limitations by using saturation, rather than annual sales data, to account for program influences that carry over from year to year.

Figure **1** illustrates the framework to examine multi-year program influences. Traditional evaluation methodologies quantify free-ridership for a one-year snapshot and determine the NTGR from this single measure. Nevertheless, directly estimating the NOB is a preferred approach for evaluating the NTGR.

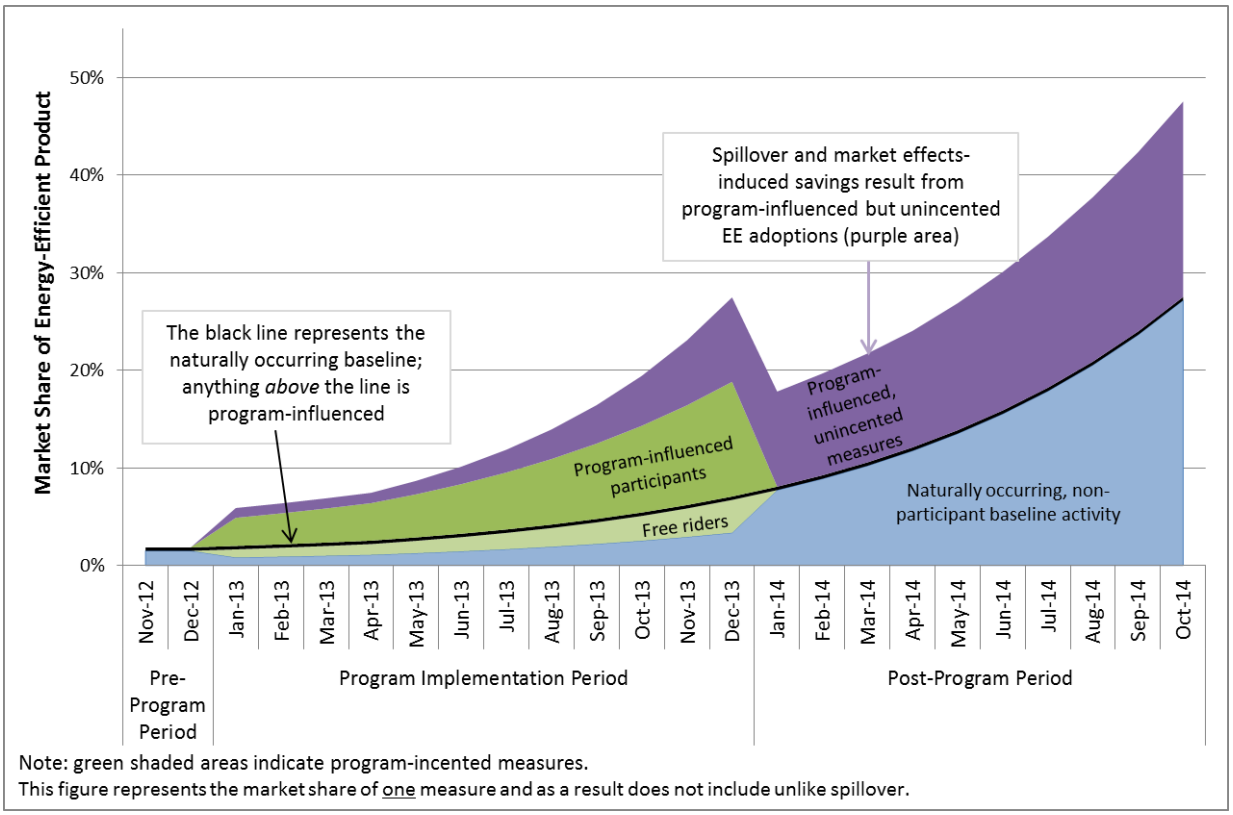

Figure 1. Generic Framework for Examining Multi-year Program Influences

The CFL Market Model is an analysis that estimates the NOB of CFL activity in DTE territory as a preliminary step in the estimation of the NTGR. Ideally, the following steps would be taken to estimate the NOB and NTGR of CFLs in DTE territory:

- Obtain CFL annual sales data within DTE territory from 1990 to 2013.
- Split CFL annual sales data into two sets:
  - CFL sales from 1990-2008 (prior to DTE programs)
  - CFL sales in 2009 and beyond (after DTE programs came into effect)
- Use 1990-2008 CFL sales to project the sales of CFLs in 2009 and beyond. This forecast represents CFL activity absent any DTE program influence (i.e., the NOB).[2]
- The NOB can be compared to actual CFL sales and CFLs discounted by DTE in 2009 onward to estimate the NTGR.[3]

2 This model inherently includes the influence of all non-DTE programs. The DTE NOB represents the NOB that would occur in DTE territory if DTE programs did not exist but other CFL programs did exist..

3 In order to use sales data to estimate a multi-year effect, sales data in each category would need to be summed over the life of the program.

This ideal analysis is not possible because reliable CFL sales data within DTE territory from 1990 to 2013 are unavailable. Thus, Navigant developed an approach to estimate the NOB and NTGR using reliable data that was available, including:

- CFL annual sales in the United States from 1990 to 2012 (U.S. ITC)
- Residential CFL saturation in the United States from 2008 to 2010[4]
- DTE program-discounted bulbs sold from 2009 to 2012[5]
- DTE residential CFL saturation 2009 to 2012[6]

The next section describes how Navigant used these data to estimate the NOB and the NTGR.

## Method

Figure **2** presents a generic framework for understanding the components of the NTGR, put into the terms used in this analysis. While gross program saturation can be estimated from program tracking data, net saturation must be calculated using information about the NOB and market effects. The NOB includes free riders and naturally occurring non-participants (NONPs). In this NTG analysis for DTE Electric's CFL programs, Navigant applies CFL saturation information to this framework.

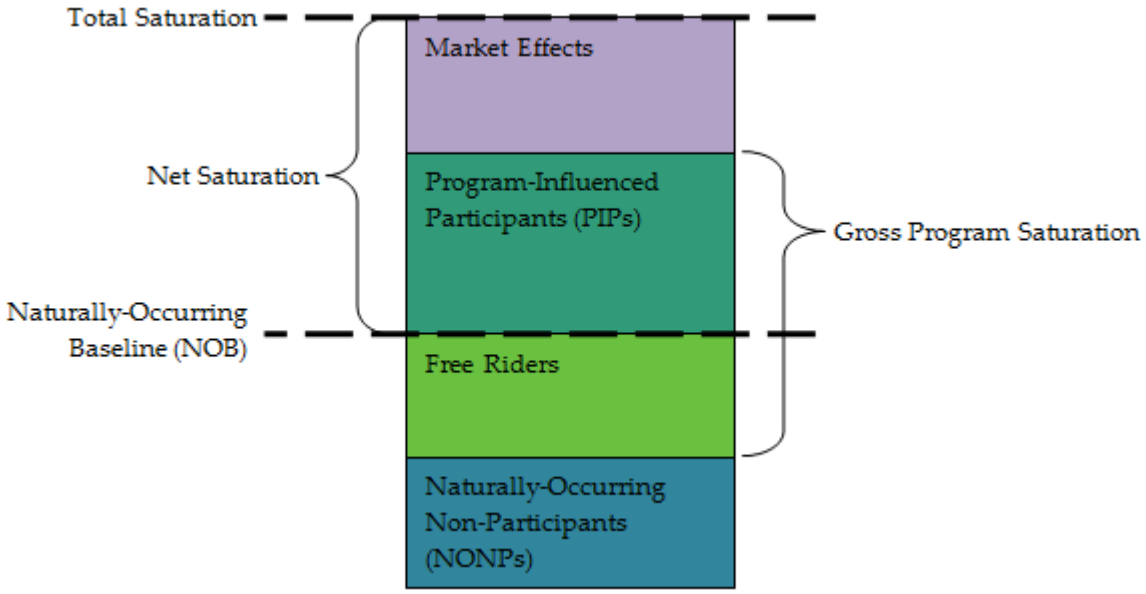


Figure 2. Generic Framework for Net-To-Gross Terminology (Navigant analysis, 2013)

4 The 2008 value is calculated (DOE 2009, 5; DOE 2010, 20, Table 9), the 2009 value is based on a weighted average of data from 16 regions (DOE 2010, 17), and there's the 2010 value (DOE 2012, 24, Table 4.2).
5 DTE Energy ENERGY STAR Products Residential and Small Business Program records, 2009-2012.
6 The 2009 value (ODC 2010). The 2011 value (ODC 2012) sample was reweighted to match Navigant's 2012 weighting. The 2012 value is from analysis conducted (Navigant August 2013).

To estimate the NTGR using this framework, Navigant took the following steps:

Step 1: Model the DTE NOB by (a) estimating DTE NONPs and (b) estimating DTE free-ridership, and adding them together, as shown in equation 1 below.

$$\text{DTE NOB} = \text{DTE NONPs} + \text{DTE Free Ridership} \quad (1)$$

Step 2: Calculate DTE *net* saturation based on total DTE saturation and the estimate of the DTE NOB, as shown in equation 2 below.

$$\text{DTE Net Saturation} = \text{DTE Total Saturation} - (\text{DTE NOB}) \quad (2)$$

Step 3: Calculate DTE PIPs based on DTE gross program saturation and DTE free-ridership, as shown in equation 3 below.

$$\text{DTE PIPs} = \text{DTE Gross Program Saturation} - \text{DTE Free Ridership} \quad (3)$$

Step 4: Calculate DTE market effects based on DTE net saturation and DTE PIPs, as shown in equation 4 below.

$$\text{DTE Market Effects} = \text{DTE Net Saturation} - \text{DTE PIPs} \quad (4)$$

**Data Sources**

Data availability naturally influenced Navigant's approach to calculating DTE's NTGR. As shown in Figure 3, DTE's gross program saturation was calculated based on DTE program bulb sales and a stock accounting model; however, DTE's net saturation required many more inputs and calculation steps. The most direct method to determine DTE's net saturation is to subtract the DTE NOB saturation from the DTE total saturation (Step 2). A framework for using national data to inform DTE NOB saturation was generated, as seen in Figure 4. This framework was necessary because no pre-2009 CFL data for DTE territory is available, and without this data a DTE NOB cannot be directly derived. Navigant assumed that in 2008, the year before DTE programs started, DTE territory had the same total CFL saturation as in the rest of the United States (7.6%, a conservative assumption for the purpose of this analysis).[7] For the 2012 analysis, data collected as part of a baseline study for DTE was used as the basis for estimating total saturation for the DTE electric service territory (26.3% for all CFLs in 2012).[8]

7 Calculated saturation based on total household sockets so that it is consistent with other saturation data used for this report (DOE 2009, 5; DOE 2010, Table 9).

8 These data were collected early in 2013 to account for all 2012 market activity (Navigant August 2013).

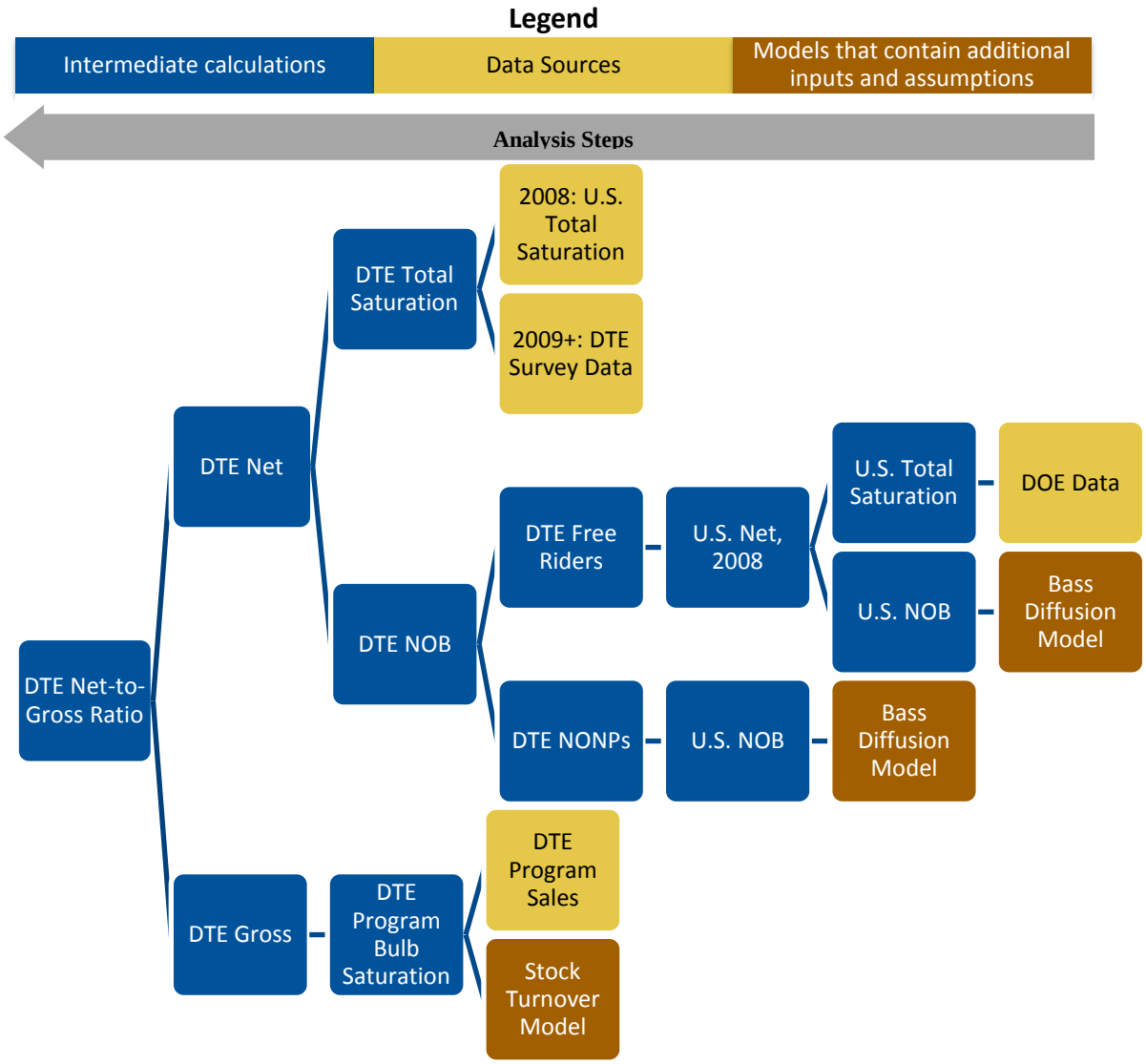


Figure 3. Calculating DTE NTGR from Available Data (Navigant analysis, 2013)

## Detailed Methods

**Step 1: Model DTE's Naturally-Occurring Baseline.** DTE's NOB is comprised of two parts – DTE NONPs and DTE free riders. As demonstrated in Figure **4**, Navigant used the following methods to estimate DTE NONPs and DTE free riders.

- DTE NONPs: U.S. NOB is used as a proxy for DTE NONPs. CFL saturation due to DTE NONPs is assumed to be equal to the CFL saturation that would have occurred in the absence of national programs (U.S. NOB). To calculate the U.S. NOB, pre-2000 U.S. sales data were fed into a Bass diffusion model and projected forward to estimate the national CFL sales without the effect of U.S. programs. This was run through a stock accounting model to calculate the U.S. NOB in terms of saturation.
- DTE Free Riders: DTE customers that were influenced by national or other utilities' programs to install a CFL in 2008 or before (prior to DTE programs) are assumed to participate in DTE programs as free riders when DTE programs start in 2009. To calculate DTE free riders, the U.S. NOB in 2008 was subtracted from the U.S. total CFL saturation in

2008 to calculate U.S. net saturation. The amount of U.S. net saturation was then assumed to increase at a nominal rate of 1.3% per year from 2009 through 2012 (explained in greater detail in the following pages) to produce a value for DTE free-ridership in 2012.

The methods and assumptions used to calculate DTE NONPs and DTE free riders are documented in greater detail below.

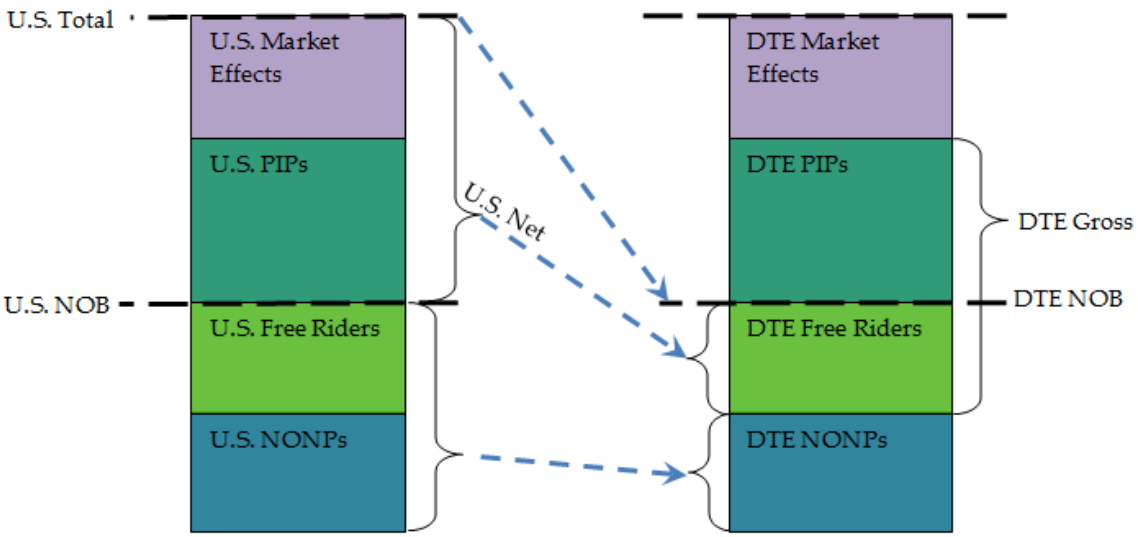


Figure 4. Mapping National Saturation Data to DTE Saturation Data (Navigant analysis, 2013)

**Step 1A: Estimate DTE Naturally-Occurring Non-Participants (NONPs).** Historical CFL sales data were used to calculate the U.S. NOB (U.S. ITC). As part of this analysis, Navigant determined, from historical data, the pivot point at which U.S. programs began to affect the CFL market, so that the calculation of the U.S. NOB would exclude these influences. From this historical perspective, Navigant chose the year 2000 as the national pivot point, since little program activity had occurred anywhere in the country up to this point.

Building on this historical bulb sales data through 2000, a Bass diffusion model was used to project the U.S. NOB from 2001 through 2012. The model is calibrated to data prior to the pivot point to allow the model to forecast national CFL market activity in the absence of any utility, regional, or national programs and other influences. The Bass diffusion model is a dynamic approach to simulate market adoption that accounts for the parameters shown in Figure **5**.

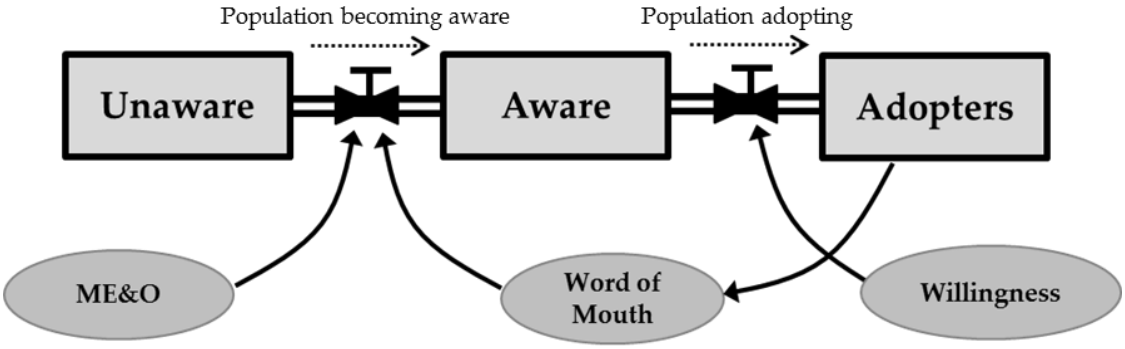


Figure 5. Illustration of Bass Diffusion Approach to Forecasting CFL Adoption (Adapted from Sterman, 2000)

» *Marketing, Education, and Outreach* (ME&O) moves customers from the unaware group to the aware group. Unaware customers have no knowledge of CFLs. Aware customers are those that have knowledge of CFLs and understand their attributes. ME&O may be conducted by manufacturers and distributors of a product, as well as utilities or by other groups. In the context of calculating NONPs in this analysis, the ME&O effect represents marketing efforts by CFL manufacturers and retailers only. This NONP case assumes utility programs and other national programs do not exist; thus the ME&O component is not subject to influences from utility program spending.

» *Word of Mouth* represents the influence of adopters (or other aware consumers) on the unaware population by informing them of CFLs and their attributes. This influence increases the rate at which customers move from the unaware to the aware group. When a product is new to the market with few installations, often ME&O is the main source driving awareness. As more customers adopt, however, word of mouth can have a greater influence on awareness than ME&O, and leads to exponential growth. This exponential growth is ultimately dampened by the saturation of the market, leading to an S-shaped adoption curve, which has been repeatedly observed for new technology diffusion.

Historic analysis of new technology diffusion provides a range and average for ME&O and Word of Mouth factors. Navigant used an average Word of Mouth factor for electric appliances as documented in literature (Mahajan, Muller & Wind 2000). The ME&O factor was exogenously set by Navigant during a calibration process. The calibration process sought to match modeled U.S. CFL sales to actual U.S. CFL sales from 1990 to 2000. The calibrated ME&O value falls within the range of historically observed ME&O values from literature (Mahajan, Muller & Wind 2000).

» *Willingness* is the key factor affecting the move from an aware customer to an adopter. Once customers are aware of the measure, they consider adopting the technology based on the financial attractiveness of the measure, as modeled using a payback acceptance curve.

Navigant's projected U.S. NOB of CFL annual sales is illustrated in Figure **6** relative to actual U.S. CFL sales. To calculate the U.S. NOB in terms of saturation, annual sales were run through a stock accounting model that accounted for the number of households, number of sockets per household, percent of sales that went to the residential sector, percent of bulbs installed the year of purchase, the expected lifetime of a CFL and an incandescent bulb, and the rate at which CFLs are taken out of storage for installation.[9] Finally, because saturation is expressed as a percentage, this U.S. NOB can be used directly as DTE NONPs.

Step 1A Conclusion: Using the CFL Market Model, Navigant estimates that in DTE Electric's service territory, 6.5% CFL saturation results from 2012 DTE NONPs.

9 Specific details can be provided upon request.

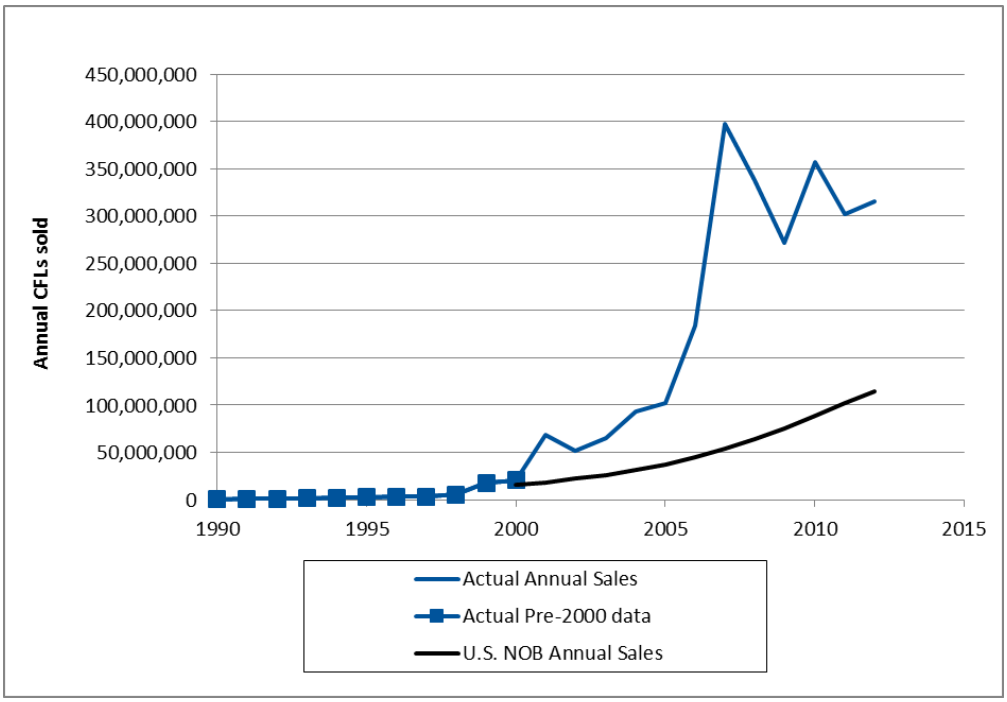

Figure 6. Comparison of Projected U.S. NOB Annual Sales to Actual U.S. Annual CFL Sales (Navigant analysis, 2013)

**Step 1B: Estimate DTE Free Riders.** As noted previously, for the purposes of this model, DTE customers influenced by national CFL programs before DTE CFL programs began fall into the category of DTE free riders. Navigant assumes that DTE total CFL saturation in 2008 was equal to U.S. total CFL saturation in 2008. The U.S. NOB was subtracted from the 2008 U.S. total saturation, as shown in Figure 9, to estimate U.S. net saturation. For the purposes of calculating DTE free riders, we assume a rate of increase of 1.3% per year over the life of the programs. This value is obtained from the 2009 and 2010 U.S. saturation data points (not illustrated in Figure 9). U.S. total saturation from 2009 to 2010 increase from 22.5% to 22.8% (a 1.3% year over year change).

Step 1B Conclusion: Using the CFL Market Model, Navigant estimates that in DTE Electric's service territory, DTE free riders constitute 4.1% CFL saturation in 2012.

Using the results of these modeling efforts to estimate DTE's NONPs and free riders, Navigant calculates the DTE NOB in 2012 using equation 1, below.

$$\text{DTE NOB} = \text{DTE NONPs} + \text{DTE Free Ridership} \quad (1)$$

$$\text{DTE NOB} = 6.5\% + 4.1\%$$

Step 1 Conclusion: Using the CFL Market Model, Navigant estimates that the 2012 NOB is 10.6% in DTE Electric's service territory.

**Step 2: Calculate DTE Net Saturation.** Using the results of the modeling effort to estimate DTE's NOB and total saturation, Navigant calculates DTE net saturation in 2012 using equation 2, below.

$$\text{DTE Net Saturation} = \text{DTE Total Saturation} - \text{DTE NOB} (2)$$

$$\text{DTE Net Saturation } = 26.3\% - 10.6\%$$

Step 2 Conclusion: Using the CFL Market Model, Navigant estimates that 2012 CFL net saturation is 15.7% in DTE Electric's service territory.

**Step 3: Calculate DTE Program-Influenced Participants (PIPs).** Using an estimate of gross program saturation based on program sales data and a stock accounting model, Navigant calculates DTE PIPs using equation 3, below.

$$\text{DTE PIPs} = \text{DTE Gross Program Saturation} - \text{DTE Free Ridership} \quad (3)$$

$$\text{DTE PIPs} = 15.2\% - 4.1\%$$

Step 3 Conclusion: Using the CFL Market Model, Navigant estimates that in DTE Electric's service territory in 2012, 11.1% CFL saturation can be attributed to DTE PIPs.

**Step 4: Calculate Market Effects.** Using the results from Steps 2 and 3, Navigant calculates market effects using equation 4, below.

$$\text{DTE Market Effects} = \text{DTE Net Saturation} - \text{DTE PIPs} \quad (4)$$

$$\text{DTE Market Effects} = 15.7\% - 11.1\%$$

Step 4 Conclusion: Using the CFL Market Model, Navigant estimates that in DTE Electric's service territory in 2012, 4.6% CFL saturation can be attributed to DTE market effects.

## Summary of Findings

Figure **7** brings all of the pieces together. It illustrates DTE CFL program gross program saturation stacked on top of the DTE NONPs projection to allow for a visual correlation that matches up with the original framework presented in Figure 2.

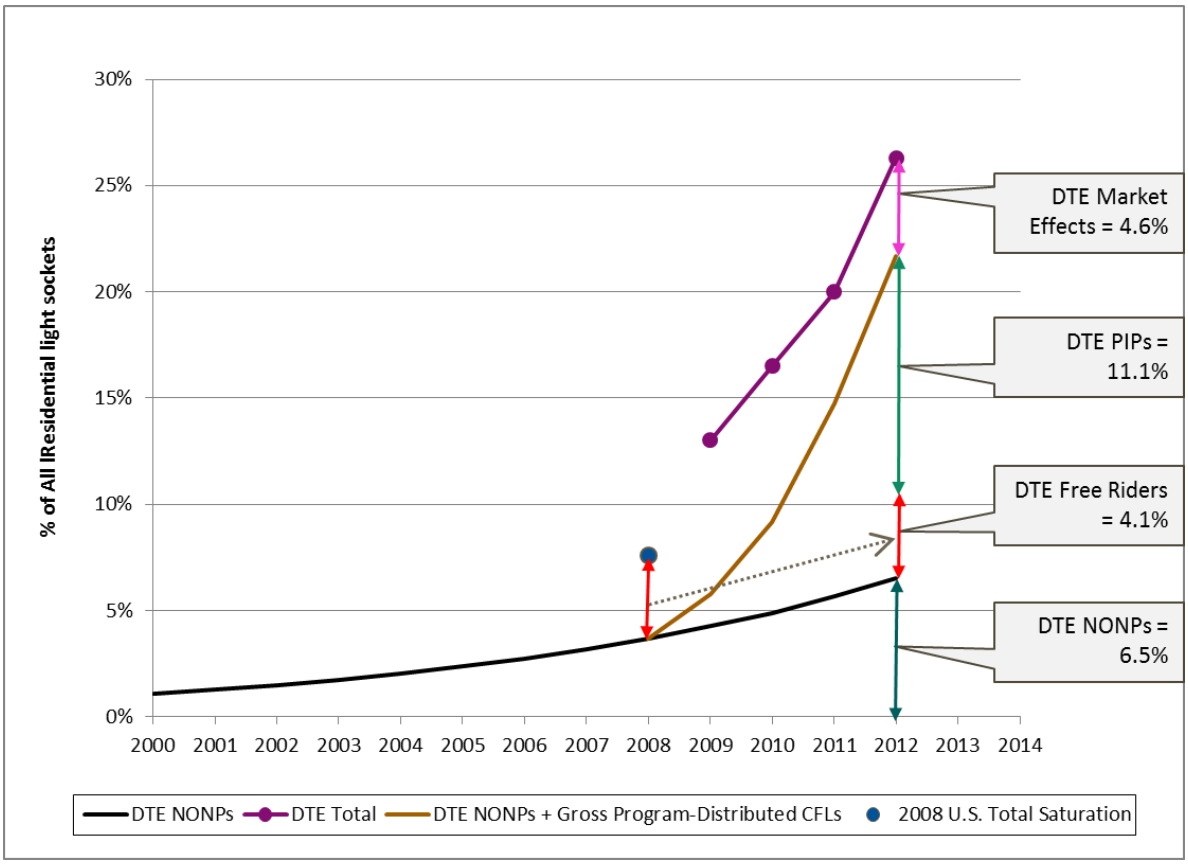


Figure 7. DTE CFL Saturation Components as Related to NTGR Terminology (Navigant analysis, 2013)

The NTGR components, expressed in saturation percentage points, are translated into ratios common to NTGRs in Table **1**. This method estimates a free-ridership of 27% with 31% market effects resulting in a 103% NTGR. (Numbers do not appear to add up due to rounding). These values are reflective of cumulative DTE program activity from 2009 through 2012. Therefore, 27% of the cumulative CFLs that were discounted by DTE's programs since 2009 would have been installed in the absence of the program and are considered free riders. Since 2009, DTE's CFL programs have influenced the installation of additional un-discounted CFLs (equal to 31% of the CFLs discounted by DTE since 2009); this is DTE's effect on the local market for CFLs. Some of these un-discounted CFLs may be counted in traditional NTG research as participant spillover, while others would be purchases by non-participants influenced by the program and typically missed in CFL NTG research.[10] The net activity generated by DTE's CFL programs since 2009 is equal to 103% of DTE's gross CFL activity since 2009.

10 Participant spillover only accounts for the additional purchases of non-rebated CFLs after a customer has already purchased a discounted CFL. Traditional measurement of participant spillover does not account for non-rebated CFL purchases that were independently made without a customer ever purchasing a discounted CFL.

Table 1. Final Calculated Values for DTE, 2009-2012 (Navigant analysis, 2013)

| | Saturation Percentage Points | Ratio (to Gross)* |
|---|---|---|
| Gross Program Activity | 15.2% | 1.00 |
| Net Activity | 15.7% | 1.03 |
| Free Ridership | 4.1% | 0.27 |
| DTE Market Effects | 4.6% | 0.31 |

*Numbers do not add up due to rounding.

While these values represent the cumulative DTE program activity from 2009 through 2012, they could be used as an estimate of the NTGR for 2014 – 2015 programs as well. Cumulative measurements of data do not change from year to year as much as annual measurements of the same set of data.

## Strengths and Limitations

Every method used to conduct a NTG analysis has both strengths and limitations; this method is no exception.

The key strengths of this approach include:

- The method accounts for multi-year program influences. This method estimates the NOB as opposed to just relying on free-ridership to account for multi-year program influences.
- The use of saturation takes into account the multiple cumulative effects of program influence. Using saturation to reflect how program impacts accumulate allows DTE to claim savings in later program years for those participants influenced by the program since its inception. Further, a focus on saturation facilitates a complete accounting of non-discounted bulbs installed, which are otherwise underrepresented in standard NTG values.

The key limitations of this approach include:

- The assumption that 100% acceptance occurs for a CFL when CFL price per bulb equals the price of an incandescent bulb. While the longer expected life of a CFL and incremental energy savings translate into cost savings, these are not the only factors in residential light bulb purchasing decisions. So, even when the retail price of a CFL is equal to that of an incandescent bulb, there may be factors, such as familiarity, that interfere with the rational decision presented when both bulb types are equally priced.

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