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BEFORE
THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of the Protocols for the Measurement and Verification of Energy Efficiency and Peak-Demand Reduction Measures.	))))	Case No. 09-512-GE-UNC

COMMENTS ON DRAFT TECHNICAL REFERENCE MANUAL BY THE OFFICE OF THE OHIO CONSUMERS' COUNSEL, CITIZENS' COALITION, OHIO POVERTY LAW CENTER, CITIZEN POWER, SIERRA CLUB OF OHIO, THE NATURAL RESOURCES DEFENSE COUNCIL, AND THE OHIO ENVIRONMENTAL COUNCIL

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I. INTRODUCTION AND STATEMENT OF THE CASE

On June 24, 2008, the Commission issued an Entry that began a process to develop a technical reference manual ("TRM") to "provide predictability and consistency for the benefit of the electric and gas utilities, customers, and the Commission itself."[1] The Entry anticipated "filing of objections to the consultant's draft of the 2010 TRM, followed by a full hearing on the issues raised in the objections, if and to the extent necessary."[2]

Vermont Energy Investment Corporation ("VEIC") was hired as the Commission's consultant, and developed a draft TRM. The Commission Staff was directed to distribute the draft TRM by August 6, 2010, and a workshop was scheduled

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[1] Entry at 3, ¶(5) (June 24, 2008).

[2] Entry at 5, ¶(9) (June 24, 2008).

(and held) on August 10, 2010 to discuss the contents of VEIC's draft.[3] On October 4, 2010, the Commission provided interested parties the opportunity to comment upon the draft TRM.[4]

Energy efficiency can occur on both sides of the meter. The proposed TRM presents reasonable approaches to energy saving techniques, and provides an excellent framework for assisting utilities as well as consumers to quantify and evaluate energy and demand saving opportunities. The TRM required numerous hours of research, analysis, documentation, and review by a dedicated team to become a reality. These Comments support much of the draft TRM, and seek to further develop and elaborate upon the work developed by VEIC.

These Comments are divided into two main parts. The first relates to programs that aim to influence customer behavior to provide verifiable energy and peak demand savings. The TRM should be modified to include additional protocols ("Protocols") that deal with programs directed at influencing behavior.

The second provides recommendations for adjustments to the TRM, largely related to protocols for transmission and distribution ("T&D") projects. R.C. 4928.66(A)(2)(d) permits electric utilities to implement T&D infrastructure improvements that reduce line losses. The TRM appropriately quantifies the line loss savings based on improvement above a baseline.[5] Nearly every T&D project will reduce line losses, but the question that must be addressed by the TRM is whether the line loss

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[3] Entry at 2, ¶(5) (July 29, 2010).

[4] Entry at 2, ¶(6) (October 4, 2010).

[5] TRM at 9 ("the baselines included in the TRM are intended to represent average conditions in Ohio").

reduction would have occurred anyway or is the line loss attributable to an electric utility program. These Comments provide eleven recommendations regarding the TRM that will assist in properly evaluating this question.[6] These recommendations support and further elaborate upon the draft TRM.

II. ARGUMENT

A. Protocols Should be Included in the TRM for Information and Behavioral Norm Programs.

The TRM should be modified to include additional Protocols that deal with programs directed at influencing behavior. A utility must show that its programs had "verified savings" to demonstrate compliance with the energy efficiency standards codified in R.C. 4928.66.[7] Verified savings means an annual reduction in energy usage "directly measured or calculated using reasonable statistical methods consistent with approved measurement and verification guidelines."[8] The TRM is meant to define those measurement and verification guidelines. However, the draft TRM does not contain Protocols related to programs that influence behavior. Additions to the draft TRM are, therefore, appropriate.

Ohio utilities rely on programs that aim to influence customer behavior for a significant portion of their "verified savings." For example, FirstEnergy's Online Home Energy Education Tool "... helps residential and small business customers better understand and manage their energy usage. It provides customers with information on

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[6] This proceeding has not provided an opportunity for expert testimony. However, these Comments are in part based upon the expert advice provided by Kevin J. Mara, P.E. and GDS Associates, Inc.

[7] Ohio Adm. Code 4901:1-39-05(C)(2)(a)(i).

[8] Ohio Adm. Code 4901:1-39-01(Z).

how their energy bill is impacted by choices on control of appliances (including heat and air conditioning) as well as choices on purchases of new appliances."[9] American Electric Power ("AEP") has engaged OPower in offering "[n]eighborhood initiatives that motivate energy conservation through better information and normalized comparative energy use-data."[10] Similarly, Duke Energy Ohio has a pilot program that provides "comparative usage data reports for similar residences in the same geographic area."[11] This important part of utility programs should be addressed in the TRM.

Programs that attempt to influence customer behavior can help reduce energy waste and may raise awareness of other utility program offerings.[12] The impact of these programs is more uncertain than other utility programs that encourage the installation of tangible materials, partly because no verified "installation" occurs with behavioral programs.

In the proposals by AEP, OPower has proposed a method for verifying the energy savings of behavioral programs.[13] The method uses experimental design -- a test group and a control group -- to compare the energy use of those who participate in the program and those who do not. The methodology also includes a Protocol for avoiding double counting of energy savings from behavioral and measure-based programs. Protection

[9] *In re FirstEnergy's Portfolio Plan*, Case No. 09-580-EL-EEC, Application at 4 (July 9, 2009).

[10] *In re AEP's Portfolio Plan*, Case No. 09-1089-EL-POR, Testimony of Jon F. Williams, Exhibit JFW-2, Page 144 of 163 ("Neighborhood initiatives that motivate energy conservation through better information and normalized comparative energy use-data") (prefiled November 12, 2009).

[11] *In re Duke's Portfolio Plan*, Case No. 09-1999-EL-POR, Application at 28 (December 29, 2009).

[12] These programs may, however, not provide long-term savings. When the customer no longer receives feedback, they could revert to old habits.

[13] *Measurement & Verification Protocol for Behavior-Based Efficiency Programs*, OEnergy, attached.

against double counting is important because some of the savings attributed to behavior-based programs could be the result of utility incentives for particular measures.

Behavioral change programs can serve an important role in utility efficiency portfolios. A "reasonable statistical method"[14] for measuring the impact of those programs exists. The Commission should include OPower's proposed Protocol in the TRM.

B. Adjustments Should be Made to the Draft TRM.

The proposed Protocols for quantifying the energy savings provide a consistent and transparent methodology. For the successful evaluation of programs, electric utilities will be required to engage in additional work to provide the data in the format prescribed by the Protocols. However, the methods and data proposed by VEIC are all readily available at electric utilities, and will allow the calculations proposed by the Protocols without undue burden on the electric utilities. The Protocols will likely present the utilities with a different methodology than they have previously used to estimate line losses. But the Protocols should be consistent with the methods used behind the meter, and the Protocols should provide a more accurate method than the "loss factor" method commonly used in the electric industry.[15]

Recommendation 1: The Base Case for Certain T&D Projects Should be Defined.

Appropriate definitions are important to establish reasonable baselines. Section V of the TRM should include a definition of the Base Case in the following T&D

[14] Ohio Adm. Code 4901:1-39-01(Z).

[15] See *The Equivalent Hours Loss Factor Revisited,* Stone & Webster Management Consultants, IEEE Transactions on Power Systems, Vol. 3, No. 4 (November 1988).

Project Protocols:

T&D Loss Reductions – System Reconfiguration Analysis Protocol,[16] and

T&D Loss Reductions – Voltage Conversion Analysis Protocol.[17]

The following language should be added to Section 3 for the above-referenced sections:

> If this project is needed to meet operational criteria such as voltage levels, reliability, or component capacity levels, provide information demonstrating that the assumed base efficiency is in fact standard practice, including:
>
> > Current Industry Practice – Document current industry practice using articles from industry journals, manufacturers' sales data, recent distribution standards from other utilities, and/or similar sources.
> > Applicant Practice – Document the utility's own recent standard practices through purchase records, distribution standards, and similar documents. Provide data on peak forecasts for the substation, supporting the adequacy of the base equipment.

It is necessary to determine what the standard practice would have been without the energy efficient project/program to establish a reasonable baseline.

Utilities provide electric energy within a set bandwidth of delivery voltage[18] to deliver energy reliably. It is standard operating procedure for electric utilities to modify and upgrade their T&D infrastructure to meet the voltage delivery requirements. The need for the upgrade is based on the fact that as the load increases, there is a decrease in the delivery voltage at the end of the line. This is commonly referred to as voltage drop. An electric utility's standard planning policies should include forecasting new load

[16] TRM at 356.

[17] Id. at 360.

[18] ANSI C84.1-2006, American National Standard for Electric Power Systems and Equipment—Voltage Ratings (60 Hertz).

growth and anticipating the need for modification of the infrastructure so as to maintain adequate voltage to the end-use consumer.

The cost of modifications to the T&D infrastructure requires significant capital. In addition, the new infrastructure has a relatively long service life. Thus the new infrastructure is typically designed for future load growth. To allow for this future load growth, a component is installed that has more capacity than is needed for the load in the year it is installed. This is a common practice in planning for the orderly expansion of a power system through the electric industry including Ohio.

The losses associated with most electrical infrastructure components including conductors, transformers, and cables are related to the capacity of the component. Losses are a function of the resistance of the electrical component and the load current passing through the component. Larger capacity electrical components have a lower resistance when compared to smaller capacity electrical components. Therefore, by installing larger capacity components, there will be a reduction in system line losses. Nearly every new T&D project results in a reduction in line loss.

The baseline for T&D projects must be based on the utilities' current standard planning criteria. Specifically, the baseline must be based on projects or programs that the utility would normally make in the foreseeable future to meet peak load or reliability requirements.

The Protocol for System Reconfiguration Analysis and Voltage Conversion Analysis Protocol should include specific language describing the baseline for determining loss savings.

Recommendation 2: The Ending of Efficiency Projects/Programs Should be Defined.

Annual savings due to improved efficiency should be curtailed at the end of the operational life of efficiency projects. Further, annual savings should be curtailed at the end of measured life of the project/program. The TRM provides information regarding the "measure life" that is used for the screening process defined in the Total Resource Cost-Effectiveness ("TRC") test. If the load growth results in the obsolescence of a T&D energy efficiency project, that project's savings should not apply to energy reductions for satisfaction of the requirements under R.C. 4928.66(A)(1)(a).

The definitions contained in the TRM concerning equipment durability states that "measure life is defined to be the life of an energy consuming measure, including its equipment life and measure persistence."[19] For projects behind the meter, the measure life will typically be the equipment life of the installation. For a T&D project, the definition is more complex. The proposed measure life is defined for T&D Protocols in Section 4: Screening Inputs. The definition contains two criteria to consider: equipment life and similar upgrades in the foreseeable future to meet peak load or reliability requirements. There is also a third possibility to consider in the measure life. It is possible and may be likely that the load growth on electrical infrastructure installed by the energy efficient project(s), will cause these components to reach their capacity to deliver energy prior to the end of their equipment life. This could be defined as the operational life of the component.

[19] TRM at 8.

For example, the conductor of a distribution feeder was replaced with a highly efficient conductor to increase system efficiency. Over time and with an increase in loading on the feeder, the new highly efficient conductor is unable to meet peak load requirements. This highly efficient conductor will need to be modified or replaced by a new project. Thus the measure life of the highly efficient conductor is limited to the date it was replaced. This replacement will often occur prior to the end of the service life of the conductor. For the purpose of applying the Protocols contained in the TRM, when the measure life on one efficiency project ends, another new efficiency project begins with the base case being the highly efficient conductor that is being replaced.

The present language alludes to this concept of an operational life of a system component, but it is not specifically addressed. The concern is that energy savings may be attributed to line loss savings for a project or program that is no longer in service or useful in loss reduction.

Recommendation 3: The Use of the Measure Life Should be Limited for Proper Measurement of Loss Savings.

The measure life could be used to exaggerate claims for energy savings. For example, a new substation or new feeder could be built in advance of its need based on capacity limitations. An improvement in system efficiency will result from the construction of the new component (e.g. substation or feeder). The efficiency gains will end at that point in time "[w]here the utility would make this investment in the foreseeable future to meet peak load or reliability requirements, the analysis period should be limited to the period prior to the need date, and reflect the present value of the differences in capital costs."[20] The "foreseeable future to meet peak load requirements" in the above-quoted part of the TRM is ambiguous, and could be used by utilities to show an accelerated construction program with significant energy saving up to the "need date." For large construction projects such as substations and transmission lines, the in-service date is often scheduled in advance of the "need date" to maintain service reliability. However, for the purposes of meeting energy savings targets, the "need date" could be pushed further into the future with no operational risks.

While a measure life is calculated for most if not all of the measures in the TRM, T&D measure equipment lives are particularly susceptible to exaggerated claims for energy efficiency. The following language should be added to resolve ambiguity in Section V of the TRM regarding "Protocols for Transmission & Distribution Projects":

> Notwithstanding, the need date shall not be less than three years from the proposed in service date of the T&D project.

This addition to the TRM helps to address the possibility of exaggerated claims associated with the measure life associated with T&D projects.

Recommendation 4: The Protocol for Capacitors Should be Simplified.

Capacitors are a very cost-effective means of reducing system losses. The application of capacitors has been used to improve the efficiency of T&D systems for many years and their effectiveness is proven. However, like a mass plant replacement project, capacitor utility plant improvements are generally small investments and the determination of loss savings for each capacitor project will not generally be feasible or

[20] See, e.g., id. at 343, 347, 351, 355, and 362.

cost-effective. Therefore, a "deemed value" should be used for incremental annual savings for a capacitor bank. These deemed values can be proposed by the utilities. The deemed value should have as the base case the existing power factor goal of the utility, the proposed power factor goal, hours the capacitor is anticipated to be in service for the year (switched banks), and distance from the substation. The deemed value for the new energy efficiency goals for the capacitors should have two components, peak demand savings and energy savings. The methodology proposed by the utility for the deemed value for the gross loss savings should be consistent with the Protocol formulas provided in the T&D "Loss Reductions – System Reconfiguration Analysis Protocol."[21]

The Protocol for capacitors should include field verification of loss savings by simply verifying the power factor goals for each feeder or substation based on the project definition.

Recommendation 5: Load Duration for Loss Calculations Should be Appropriate.

Many of the proposed formulas in the T&D Protocols use a load duration curve for calculating losses, which is an excellent method to quickly and accurately estimate losses for system components. However, the manner in which electric utilities may apply the load duration curve is a concern. The formula suggests use of the "load-duration curve on the equipment"[22] and requests sources of the load-research data. A duration curve for the system or an "average" load duration curve for a "typical" distribution feeder will inject significant error into the calculation of the losses.

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[21] Id. at 356.

[22] Id. at 341 and 345.

Greater emphasis should be placed on a utility's use of load duration for the equipment, feeder, substation, and transmission line for which the calculation is being made. Data should be readily available for the load duration information at any of these equipment levels. Substitution of system-wide or area load duration curves for site specific data should not be permitted.

Recommendation 6: Upstream Loss Factors Should be Appropriately Applied.

Utilities are permitted to apply "upstream loss factors" for estimating the change in losses on the distribution and transmission system caused by an energy efficiency project.[23] This "upstream loss factor" appears to only apply when the factor is also used for screening customer end-use efficiency measures.

Also, the term "loss factor" can be confusing. This term "loss factor" is used in the T&D calculations to estimate losses based on the system load factor. The loss factor is the subject of many different technical papers that purport to define a more accurate formula.[24] The loss factor in the referenced technical paper is used very differently than is the loss factor proposed in the TRM Protocols. The variable should be changed to "Upstream Factor" rather than "Upstream Loss Factor" to avoid confusion by the parties in applying and reviewing the formulas.

The Upstream Factor recommended by electric utilities should be verified using field data. New metering technology allows for nearly simultaneous readings of meters for a set geographic region. This technology can be used to compare total sales for a

[23] Id. at 354, 358, 362, and 367.

[24] See *The Equivalent Hours Loss Factor Revisited,* Stone & Webster Management Consultants, IEEE Transactions on Power Systems, Vol. 3, No. 4 (November 1988).

substation service area to total incoming energy delivered to the source substation for the same area. The difference of incoming energy and sales represents the losses. The losses as a percent of incoming energy become the ceiling of any Upstream Factor. The percent losses described includes all distribution transformer losses, which should not be included in the Upstream Factor.

Recommendation 7: The Transmission Peak Loss Factor Should be Appropriately Applied.

The Transmission Peak Loss Factor is used in the TRM Protocol to determine upstream transmission loss reduction for a specific substation transformer replacement project. Utilities are permitted to apply a transmission peak loss factor to estimate the change in losses on the distribution and transmission caused by an energy efficiency project.[25] This transmission peak loss factor appears to <u>only</u> apply when the factor is also used for screening customer end-use efficiency measures.

Further, the use of this factor should not be applicable for transmission infrastructure owned by other parties.

Recommendation 8: Protocols for Conservation Voltage Reduction Should be Established.

Conservation voltage reduction ("CVR") is a technique used by many different utilities to help reduce peak demand and to reduce energy use. By reducing the voltage at the substation while still delivering adequate voltage levels, less energy is consumed. The reduction in energy is due to the fact that constant current electrical devices such as incandescent lights and space heaters consume fewer kilowatt-hours when operating at

[25] TRM at 354.

lower voltages. CVR is currently being deployed by Progress Energy and PECO.[26] Progress Energy is using CVR to reduce peak demand by a stated goal of 247 megawatts.

No clear Protocols exist for determining the energy reduction and demand reduction for CVR in the Ohio area. The energy reduction is a function of the type and mix of end-use equipment, and the weather influences on that end-use equipment.

CVR is a cost effective T&D energy efficiency procedure that reduces energy consumption. Some Smart-Grid initiatives network voltage controls in capacitors, voltage regulators, and AMI data to continuously tune a circuit to the optimum delivery voltage. CVR has existed for a long time, but until just recently it was difficult to effectively reduce the voltage without compromising delivery voltage standards. The capital investment to achieve CVR saving is low compared to the potential savings of the program.

Data from Washington State shows a reduction of 1.0 percent in voltage yields and a reduction of 0.7 percent in energy consumption.[27] Many utilities regulate the delivery voltage two to four percent above minimal voltage standards. The TRM should include a test methodology for determining a ratio or formula that links voltage reduction to reduction in energy consumption for the Ohio region. Further, it may be necessary to include a test methodology for determining the relationship between voltage reduction and demand reduction.

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[26] PECO provides electricity to the region that includes Philadelphia.

[27] *Conservation Voltage Reduction at Snohomish County PUD*, IEEE Transaction on Power Systems, Vol. 6, No. 3 (August 1991).

Recommendation 9: "Loss-Driven Retrofit" Should be Defined/Explained.

The TRM references projects that consist of "loss-driven retrofit" of existing connection equipment, but the meaning of "loss-driven retrofit" is unclear.[28] The TRM appears to reference replacing failed equipment with new energy efficient equipment.

The sentences that contain the term "loss-driven retrofit" should each be modified to read: "If this project consists of the *replacement of existing* ____________ *that either failed or was replaced prior to the end of its service life*, describe the existing __________." The italicized words provide the needed definition of "loss-driven retrofit" that should be included, while the blank would be completed with the description of the equipment that is appropriate for the particular Protocol. The definition should clarify the intent of each Protocol that contains the reference.

Recommendation 10: The Use of a Load Duration Curves in All T&D Protocols Should be Specified.

Many of the protocols for T&D projects use the load duration curve for the equipment, transformer, or line being analyzed. In the other protocols,[29] a different modeling system technique is proposed. All protocols can use the site specific load duration curve to determine the annual losses.

The computer modeling software used by electric utilities will provide a load flow (a loss analysis) for a specific loading scenario. This could be the peak load on the feeder or substation or some other hour in the year. However, it is impractical to run a

[28] TRM at 348 and 364.

[29] TRM at 356 (System Reconfiguration Analysis Protocol Voltage Conversion Analysis Protocol) and TRM at 364 (Conductor Analysis Protocol).

simulation for each hour in the year as shown on load duration curve. A reasonable solution is suggested in the "System Reconfiguration Analysis Protocol," which states that the analysis should be based on "N load patterns, such that each hour within the year is reasonably well represented by a load pattern and N is a tractable number of modeling and evaluation."[30] The load duration curve can be represented by four to six load patterns to allow the curve to be input into a computer model to reasonably determine the line losses.

The Protocol described in "System Reconfiguration Analysis Protocol" should be used for the "Voltage Conversion Analysis Protocol" as well as for the "Conductor Analysis Protocol," with one minor change. The change requires the load pattern to represent the load duration curve of the system component(s) being analyzed. As stated earlier, site specific load duration curves should be used rather than average or system-wide load duration curves.

Recommendation 11: Modeling Requirements Should be Adjusted.

The Protocols for some T&D projects define computer simulations with use either constant current or even distributed current along system components.[31] These are sound modeling techniques. However, the "K" factor in the equation proposed (and shown below) is unnecessary.

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[30] Id. at 357.

[31] Id at 356 (System Reconfiguration Analysis Protocol Voltage Conversion Analysis Protocol) and id. at 364 (Conductor Analysis Protocol).

$$loss_{efficient,i} = \Phi \times k \times \sum_t A_{it}^2 \times R_e \div 10^6$$

where

t	= hour
i	= segment number
A_i	= amperage flowing into the segment
R_e	= resistance of the segment in ohms
Φ	= 1.73 for three-phase lines and 1.00 for single-phase lines
k	= 1.0. for segments with constant current
	= $(0.67 \times A_o + 0.33 \times A_i) \div A_i$, for segments with constant change in current per mile
A_o	= amperage flowing out of the segment

The simulation software available today allows the user options for modeling the current flow through a line section when calculating losses as well as voltage drop. These programs use a constant current or even distribution of current (100 percent for A_i and 50 percent for A_0). In either case, the program is making the adjustment that the proposed "K" factor is trying to simulate. Therefore, the "K" factor in the above equation should be eliminated.

III. CONCLUSION

The changes proposed herein will aid in the accuracy and transparency of the calculated loss savings. The Protocols will require additional effort by the electric utilities to collect, model, and analyze energy efficiency projects in greater detail in the early years of such efforts. However, this extra effort is reasonable, and will provide a clear path for meeting energy efficiency and peak demand reduction targets.

Respectfully submitted,

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I hereby certify that a copy of these Comments was served on the persons stated below by regular U.S. Mail, postage prepaid, on this 3rd day of November 2010.

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Measurement & Verification Protocol for Behavior-Based Efficiency Programs

Description of Measure

Behavior-based programs are proven to generate significant, cost-effective energy savings. Through experimental design, energy savings have been rigorously measured and independently evaluated in numerous large-scale pilots across the country. There are a significant number of evaluations supporting the methodology described in the following protocol that have been performed by academics and professional evaluators.[1] This protocol reflects the best practices established through that body of work.

This evaluation protocol describes a method for evaluating behavior-based savings for residential utility customers. The methods specified here allow for rigorous evaluation of behavior-based savings by applying techniques already applied in a number of states, including Ohio. Specifically, the methodology described in this protocol:

- Allows behavioral programs to achieve the definition of verified savings as specified by the Ohio *Green Rules* as "an annual reduction of energy usage or peak reduction from an energy efficiency or peak-demand reduction program directly measured or calculated using reasonable statistical and/or engineering methods consistent with approved measurement and verification guidelines";[2]
- Follows the guidelines for Billing Regression Analysis specified in the IPMVP for whole-facility measurement;[3]
- Is endorsed by the National Action Plan for Energy Efficiency guidelines under the described methodology for "Large Scale Data Analysis";[4]
- Fully accounts for double-counting of savings with current efficiency programs and AMI-enabled conservation; and

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[1] See: Allcott, Hunt, 2009. Social Norms and Energy Conservation. MIT Center for Energy and Environmental Policy Research working paper.

Allcott, Hunt, and Sendhil Mullainathan, 2010. Behavior and Energy Policy. *Science*. Vol. 327

Ayers, Ian, Sophie Raseman, and Alic Shih, 2010. Evidence from Two Large Field Experiments that Peer Comparison Feedback can Reduce Residential Energy Usage. NBER working paper No. 15386.

Levitt, Steven D. and John List, 2008. Field Experiments in Economics: The Past, the Present, and the Future. NBER working paper 14356.

Power System Engineering, 2010. Measurement and Verification Report of OPOWER Energy Efficiency Pilot Program (Connexus Energy)

Summit Blue Consulting, 2009. Impact Evaluation of OPOWER SMUD Pilot Study

[2] Ohio State Rule Code 4901:1-39-01 – 1-39-06

[3] *International Performance Measurement & Verification Protocol (IPMVP); Concepts and Options for Determining Energy and Water Savings: Volume 1.* Section 4.9.4 and Appendix B-2. Efficiency Valuation Organization, September 2009. EVO 10000 – 1:2009

[4] *NAPEE Model Energy Efficiency Program Impact Evaluation Guide.* Section 4.4, p. 4-10. 2007

- Can be executed by utilities in a cost-effective and timely fashion, using existing measurement protocols and software packages.

The types of programs that this protocol will apply to include residential energy efficiency behavioral programs that promote efficient behavior, customer engagement, and individual energy management. Behavior-based programs may include one or more of the following characteristics:

- Normative comparison of a customer's usage against comparable customers in the same geographical area
- Targeted conservation and peak reduction tips based on an analysis of a customer's past usage and individual profile
- Alerts and tips to reduce usage during peak events
- Encouraging participation in other programs in a utility's efficiency portfolio based on previous usage patterns and individual consumer profile

Information from behavioral programs may be delivered to the customer through direct mail, a utility or vendor website, and/or a display in the consumer's home.

Measure Life

While there is evidence that behavior-based program results persist, behavior-based programs only require a single-year measure life, thereby reducing any risk associated with uncertain future performance. No assumptions are made regarding the full "lifetime" savings of behavior-based program beyond the actual measurements. Likewise, any costs associated with the program (including measurement and verification) are attributed to the program in the year they are incurred. There is no amortization of program costs beyond the program length, nor are any future efficiency savings considered part of the behavioral intervention. As a result, this measurement strategy can be considered as a series of single years of actual measurement, being summed for as long as the program is being run and results are being measured.

Definition of Efficient and Baseline Cases

The baseline case is defined first by collecting energy usage information for both the test and control groups to establish a pre-treatment baseline, and then observing energy use among the control group to establish a post-treatment baseline after the program has begun. The efficient case will be determined by measuring the energy savings in the test group – i.e., those customers receiving the treatment – versus the control group.

Calculation of Savings

This protocol may be applied to programs administered by either natural gas or electric utilities and provides a methodology for measuring energy savings for individual utility customers. The protocol occurs in three distinct phases:

1. **Phase 1: Program Setup**. Describes the setup needed to employ experimental design to accurately evaluate the impact of behavior-based programs.

2. **Phase 2: Billing and Survey Analysis.** Outlines the statistical methods required to accurately measure energy savings as well as the data needed to properly attribute savings where there is overlap with another efficiency program.

3. **Phase 3: Reporting and Accounting of Savings.** Provides guidelines for applying survey and billing data to properly report and attribute program savings.

Phase 1: Program Setup

Step 1: Identify target population

Program setup work must be conducted prior to launching the behavior-based program and, while Steps 1-3 are not directly descriptive of the evaluation methodology, these steps are critical to measuring and verifying the resulting savings in an accurate and transparent manner.

Indentifying the universe of participants is the first step in the program setup process. Participants will vary depending on the goal of the implementing utility. For example, a utility could choose to focus on high usage homes, small commercial enterprises, or low-income populations. Any of the following factors could be used to determine potential participants:

- Fuel type (electric and/or natural gas)
- Customer demographics
- Availability and quality of billing or consumption data
- Participation in other efficiency programs
- Presence of specific technologies (AMI, HAN, electric vehicle, customer-owned generation, etc)
- Historical energy consumption
- Other criteria (income level, usage patterns, etc)

Inclusion and exclusion criteria must be applied from the start, before participants are assigned to treatment or control groups. The resulting population of eligible customers must be large enough to yield a statistically significant result as determined by the power analysis outlined in Step 2.

Step 2: Match program size to expected magnitude of impact

Once the potential participant universe has been defined, statistical power analyses must be conducted to determine the sample sizes required to achieve the required level of precision. The sample sizes will depend upon the expected impact of the program, the required level of statistical significance, the desired power for the experiment, and the coefficient of variation in the target variable (consumption, peak demand, etc). For example, a residential program expected to deliver a 10% reduction in energy consumption needs roughly 800 participants in each group (split evenly between the treatment and control groups) to achieve an 80% power.[5] A program expected to deliver 2% savings will need at least 19,600 participants in both treatment and control groups to achieve the same power.[6]

Most behavior-based programs will have heterogeneous treatment effects – that is, the program will work better in some customer segments than others. If the program designer wishes to evaluate the program results for specific population segments, the appropriate power analyses must be conducted at the segment level. To extend the example above, if the program goal was to measure the results across five equally sized demographic segments (such as income), then a program expecting 10% savings would need roughly 5*800 = 4,000 participants, while a program expecting 2% savings will require at least 5*19,600 = 98,000 participants.

Given that behavioral programs can be easily scaled, it is recommended that an enhanced level of statistical precision[7] only possible with large deployments be required. In practical terms this means that for every level of expected impact, there is a minimum number of program participants required in order to achieve the desired statistical precision in the billing analysis described in Step 4. Table 1 below can be used as a guide for minimum program size requirements for different levels of expected demand reduction, ranging from 1% to 10%.[8]

Table 1: Minimum required sample size for expected level of impact

Expected impact	Sample size required for 90% precision	Sample size required for 95% precision
1%	61,826	78,490
2%	15,458	19,624
5%	2,474	3,140
10%	620	786

Step 3: Establish valid test and control groups

After the target population is identified, participants should be randomly assigned to treatment and control groups, rendering them statistically identical. Randomization is the only assignment algorithm guaranteed to ensure internal validity and allow program evaluators to draw causal linkages between the treatment and the measured effect.

Implementation

Once the treatment and control groups have been randomly selected from the target population identified in Step 1, the program is ready to be administered. Note that it is critical that the program is

5 Power analysis, in this case, is used to calculate the minimum sample size required to accept the outcome of the statistical test with a particular level of confidence.

6 Both examples assume an alpha of 0.05 (corresponding to 95% confidence intervals) and a coefficient of variation of 0.5, which is typical for residential programs.

7 It is recommended that the program achieve 90% precision and a power of 0.8, at a minimum.

8 Calculations assume a power of 0.8 and a coefficient of variation of 0.5. Reported sample sizes include participants in both the treatment and control groups

made available only to those customers in the treatment group and not to those in the control. If the control group is contaminated the validity of any measured impact can be called into question.

Adjusting Control Group As Program Expands

Successful programs will often be expanded to non-participants over time. In order to maintain robust measurement, a control group must be maintained. The control group, however, does not need to grow as the treatment group grows; so long as the new participants come from the same population, the original control group remains a valid basis of comparison. There are two situations in which the control group may need to change in order to accommodate an expanded program:

1. **Additional participants differ from the original test group** - If the program is expanded to participants outside the initial target population, the selection process for the program expansion must follow the protocols laid out in Step 1. The expansion will require a new determination of inclusion/exclusion criteria, new power analysis, and a new randomization procedure to assign homes into treatment and control.

2. **Additional participants come from the original control group** – A utility may desire to take homes in the control group and place them in the treatment group. It may do so without jeopardizing the effectiveness of the experimental design so long as the control group remains large enough to continue robust measurement as determined by a power analysis (Step 2).

Billing and Survey Analysis:

Step 4: Perform Statistical Billing Analysis

Performing a billing analysis using properly specified regression models is the preferred approach when evaluating a large-scale, experimentally designed behavior program, as specified by NAPEE.[9] Billing analysis is the preferred methodology when:

1. Both pre and post-treatment billing data are available;
2. Expected program impacts can be expected to be observed in a billing analysis; and
3. The analysis is of a program with larger numbers of participants that are more homogeneous.

Any program that follows the principles laid out in the Program Setup section above should satisfy these criteria to perform a randomized control trial. If the appropriate power calculations have been performed, experimentally designed programs of sufficient sample size can use billing analysis to detect changes in consumption as small as 0.5%.

In order to implement a randomized control trial, the sample of customers eligible to participate in the program must be carefully selected, as outlined in Step 1 above. If participants have been randomly assigned to the treatment and control groups prior to the launch of the behavioral program, there is virtually no risk of selection bias and the results of the regression analysis will have internal validity.

[9] *NAPEE Model Energy Efficiency Program Impact Evaluation Guide.* Section 4.4, p. 4-10. 2007

Several regression techniques can be used for billing analysis. Roughly, all such models should have functional forms similar to:

$$E_{it} = \alpha_i + X_{it}\beta + \delta_1 T_i + \delta_2 P_{it} + \delta_3 T_i P_{it} + \varepsilon_{it}$$

Where

E_{it}	=	Average daily energy consumption for customer *i* in period *t*
α_i	=	Household fixed effects
X_{it}	=	Matrix of time-varying household coefficients, including heating and cooling degree days
T_i	=	Vector of treatment indicator variables, 1 if household *i* is in the treatment group, otherwise 0
P_{it}	=	Matrix of post-treatment indicators, 1 if period *t* is after the program launch for household *i*, otherwise 0
ε_{it}	=	Statistical error term for unexplained variation in observed energy consumption
δ_k	=	Average difference between treatment and control groups in the pre- and post time periods

Functionally, this model compares the average usage of the treatment and control households while adjusting for other factors that may influence energy consumption (household characteristics, weather, etc). Models of this form produce unbiased estimates of the energy savings for a program with homes that were randomly assigned to the treatment group at the outset of the program. The critical coefficients are δ_1, δ_2, and δ_3, which represent the average difference between the test and control groups before the test started (which should be statistically insignificant under randomization), the average difference between the before and after consumption levels (which captures macro effects), and lastly, the average difference between the test and control groups after the start of the program (which is the impact of the program), respectively. This model can also be used to estimate the impact of the program in different population segments by adding various interaction terms.[10]

It should be noted that billing analysis must be carefully performed to be effective. Evaluators must take care to look to current best practices for the most accurate methodologies. Furthermore, evaluators must address issues such as model misspecification, autocorrelation, serial correlation, heteroscedasticity, collinearity, and influential or missing data.

Step 5: Perform Program Participation Survey

The experimental design described so far uses regression analysis to determine the net energy savings resulting from a behavior-based program as measured by the average difference in energy consumption between the treatment and control groups. This measure avoids the need to estimate traditional net-to-gross effects such as free-ridership or spillover. However, additional analysis is required to obtain a true net energy impact.

[10] Adding treatment by post by segment dummies will accomplish the former, while replacing the post variable with time period dummies will accomplish the latter.

Even though some increase in other program participation is attributable to the behavioral program, it is important that these savings be reported separately in order to prevent double counting of benefits in approved energy efficiency portfolios.

There are two types of other programs for which participation rates must be measured: individually tracked incentive programs such as mailed rebates, and so-called "upstream" programs providing subsidies for energy efficiency products, such as CFLs. In the case of the individually tracked programs, the utilities should simply continue to track the participation in these programs on an individual customer basis in both the test and control groups. In the case of "upstream" products, a customer survey must be performed to assess participation levels in both test and control groups. Participation levels for both groups are needed to properly attribute energy savings to the various, contributing energy efficiency programs as describe in Step 6 below.

Step 6: Calculate Savings Attributable to Other Programs

Savings from rebates or "upstream" subsidies must be distinguished to prevent double counting. Thus, the evaluator must first separate these savings from the total savings achieved through a behavioral program. Once the program participation levels are correctly established as described in Step 5 above, this becomes relatively straightforward.

For example, if 100 homes in the control group install efficient furnaces, and 120 homes in the treatment group do the same, the savings from the additional 20 furnaces installed can be easily identified and accounted for by reporting them as part of the behavioral program or as part of the furnace rebate program, but not both.

Figure 2 illustrates an example in which the reports lead to increased participation in a furnace rebate program run by the utility. The savings generated from installations that occur in both groups ("A" and "B" in the figure) cancel each other out and do not contribute to the overall savings measured as a difference in energy use between treatment and control groups. However, the incremental installations that occurred as a result of receiving the behavioral messaging ("C") do show up in the behavioral program's overall savings estimates. The total kWh or therms associated with the incremental installations can be estimated using the deemed savings for each type of installed measure. This process can be repeated across each type of measure offered by the utility.

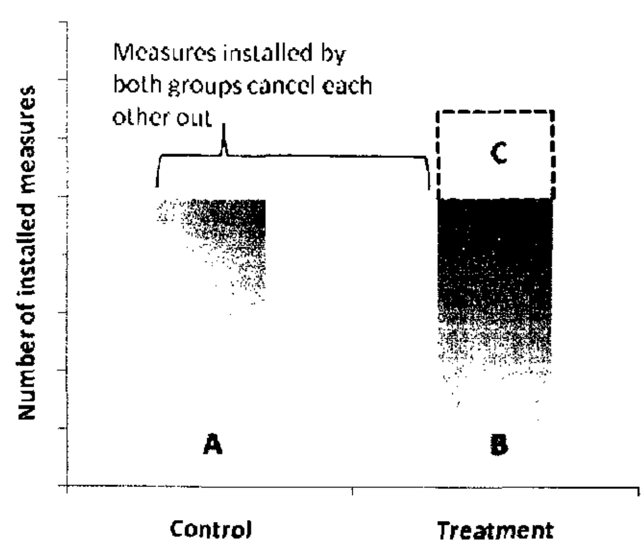

Figure 2: Double-counting mechanics

1. Savings measured as a difference between treatment and control groups do not include measures installed by both groups (areas A + B)

2. The potential for double-counting only exists when the Treatment group installs additional measures (area C)

3. Savings due to incremental measures are easily identified, allowing IOUs to account for them accordingly

A simple example is given in Table 2. The example assumes an energy efficiency portfolio consisting of programs actively promoting three installed measures in addition to the behavioral program: an Energy Star refrigerator incentive, a CFL incentive a program supporting installations of Home Area Networks and in-home displays. Participation rates in each of the three programs for both the treatment and control groups can be determined using the process described in Step 5, with the results listed in Columns 2 and 3. The difference in participation (Column 4) can then be multiplied by the deemed savings for each measure (Column 5) to arrive at the energy savings attributable to the refrigerator, CFL and HAN programs respectively.

Table 2: Example incremental savings calculations

Measure Type (Column 1)	**Treatment group participation** (Column 2)	**Control group participation** (Column 3)	**Incremental participation** (Column 4)	**Deemed Savings** (Column 5)	**Double-counted savings to be accounted for** (Column 6)
ES Refrigerator	1,100 units	1,000 units	100 units	130 kWh	13 MWh
CFL	15,000 bulbs	14,000 bulbs	1,000 bulbs	30 kWh	30 MWh
HAN / IHD	100 devices	50 devices	50 devices	500 kWh	25 MWh
Subtotal					**68 MWh**

Note the because of the experimental approach used for program design and measurement, the potential for double-counting is limited only to the difference in participation between the test and control groups shown in Column 4, not the absolute level of participation shown in Column 2. The IOUs must decide how to report for incremental savings, in this case the 68 MWhs shown in Column 6.

Conduct a Survey to Assess "Upstream" Participation Rates

For energy efficiency programs that are not tracked at the individual customer level, estimates of participation rates must be constructed using other quantitative and qualitative data. Surveys are tools well suited to this task: they can be administered to sample populations from the treatment and control groups without polluting the results of the experiment. Specifically, these surveys should include questions that identify participation in the "upstream" programs of interest, such as CFLs. Because the goal of the survey is to estimate the difference in program participation rates between the treatment and control groups, the survey must be administered to both groups in order for the results to be useful.

Surveys are frequently used in the EM&V process for exactly this purpose; however, they must be carefully designed, administered, and analyzed in order to obtain reliable, unbiased results. For example, customers typically respond to these programs by making small, daily changes to their behavior and inaccurate or leading questions could lead to inconclusive results. A carefully designed survey administered to a substantial number of customers from both the test and control groups will work to avoid such inaccuracies.

Reporting and Accounting of Savings

Step 7: Reporting Savings to the Public Utilities Commission of Ohio ("the Commission")

There are two ways to account for energy savings that were partly achieved as a result of behavioral messaging, and partly due to the financial incentive provided via another energy efficiency program, e.g. a rebate. The first is to subtract the incremental energy savings from the program providing the financial incentive. The second is to subtract the same savings from the total impact estimate of the behavioral program. In the example provided in Table 2 above, this would require reducing the savings claimed for the refrigerator, CFL, and HAN programs by 13 MWh, 30 MWh, and 25 MWh respectively be reported only ones, as part of the behavioral program, or the respective rebate programs, but not both.

Once the Commission has determined the preferred reporting methodology, savings should be attributed to the behavior-based program or other efficiency measure as appropriate. It is important to note that, although there is some overlap between behavior-based programs and other efficiency measures, behavioral programs that utilize experimental design have been shown to achieve greater aggregate energy savings than rebate programs. This is due to the typically high rates for customer engagement typically observed in behavior-based programs. As a result, the level of overlap with other efficiency programs is likely to be only a small portion of the total energy savings reported by a behavioral program.[11]

It is recommended to report program results to the Commission on a regular, annual basis beginning once the program has been deployed for 12 months. These interim results can be easily generated using standard statistical analysis software, and are critical to ensuring ongoing accurate measurement and accounting of savings and thereby ensure cost-effectiveness.

[11] In an analysis done with data from the Sacramento Municipal Utility District (SMUD) Home Energy Reporting program, OPOWER estimated that only 3% of total savings were attributable to financial incentives provided by other SMUD programs, while it was found that approximately 85% of treatment households changed their behavior as a result of the program.