FILED WITH
Executive Secretary

December 24, 2015

IOWA UTILITIES BOARD

STATE OF IOWA
DEPARTMENT OF COMMERCE
BEFORE THE IOWA UTILITIES BOARD

IN RE: INTERSTATE POWER AND LIGHT COMPANY	DOCKET NO. EEP-2012-0001
MIDAMERICAN ENERGY COMPANY	DOCKET NO. EEP-2012-0002
BLACK HILLS/IOWA GAS UTILITY, LLC, d/b/a BLACK HILLS ENERGY	DOCKET NO. EEP-2013-0001

ERRATA TO FINAL REPORT

The Office of Consumer Advocate ("OCA"), a division of the Iowa Department of Justice submits this Errata to the final report on net-to-gross policy filed in the above captioned dockets on November 25, 2015. The original filing inadvertently omitted Appendix B, which is attached to this filing.

Respectfully submitted,

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Consumer Advocate

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OFFICE OF CONSUMER ADVOCATE

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ENERGY

Iowa Utility Association and the Oversight Committee

Net-to-Gross Report: Methods and State Policies Discussion

January 7, 2015

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DISPUTES & INVESTIGATIONS • ECONOMICS • FINANCIAL ADVISORY • MANAGEMENT CONSULTING

Agenda

1 NTG Decision Making Context

2 NTG Policy Landscape

3 NTG Methodologies

4 Wrap-up and Next Steps

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NTG Decision Making Context

What is Net-to-Gross (NTG)?

» Net Savings is a measure of the change in energy use attributable to a particular EE program. This may take into account factors such as free ridership, spillover and program-induced market effects.

» Gross Savings is a measure of changes in energy consumption resulting from program-related actions taken by EE program participants -- regardless of why they took the actions.

» Net-to-Gross (NTG) Ratio is the ratio of these two measures.

» Net Savings as the Goal – the NTG ratio is usually not viewed as an end goal, but as an intermediate calculation used to estimate net savings for a portfolio (or program).

- The NTG ratio is dimensionless
- It is artifact of one evaluation method that typically estimates gross savings first; and then, uses an adjustment factor (the NTG ratio) to get to net savings.
- The concept of moving from initial gross savings estimates to net estimates (often by addition and subtraction) is the general method.

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Re-Assessing Net Savings (and NTG)

Use of net savings to ensure alignment with current policies

» Appropriately using and estimating net savings has been issue all the way back to the 1980s.

- Methods used today are often a re-discovery of methods that had been used in previously in evaluation.

» States are re-examining the use of net savings estimates due to:

- New types of EE programs are comprising larger parts of EE portfolios (e.g., HERs, market transformation, and behavioral programs.
- New methods of evaluation have been and are being developed.
- A focus on different aspects of the program design and delivery process.
- Carbon issues are driving increased interest in EE in some jurisdictions.
- New regulatory policies are being used that incorporate both gross and net savings values in different contexts *(cost recovery, incentives and targets).*
- Changes in the way gross savings is being used and estimated.
- A view that net savings is an appropriate way to measure the return on investment in EE efforts.

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Re-Assessing Net Savings (and NTG) - Continued

Use of net savings to ensure alignment with current policies - continued

- Free ridership, spillover and induced market changes are considerations in measuring net savings.
- Free Ridership refers to program participants who completed the EE measure but would have taken the same actions (or some of the actions) even in the absence of the program.
- EXAMPLE:
  - A utility EE program pays rebates for customers to install Energy Star air conditioners.
  - But, some of these customers were planning to install one anyway;
  - For them, the rebate program didn't change behavior, and yet they still receive the rebate and the program is credited with the savings.
- Because EE evaluation is trying to measure the effect attributable to the program, not counting free ridership may overstate program effectiveness

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Re-Assessing Net Savings (and NTG) - Continued

Use of net savings to ensure alignment with current policies - continued

- Spillover refers to additional reductions in energy consumption due to the program, but not directly part of program participation.
- Spillover represents savings attributable to the program, but are not counted in the program tracking system or program accounting. It simply is untracked savings.
- EXAMPLE:
  - A utility EE program offers rebates for energy efficiency equipment/appliances.
  - Saving energy on equipment results in some customers thinking about other investments in EE such as EE windows and weatherization measures.
  - These actions lower energy use even farther, but are not counted in the program tracking system even though they are attributable to the program.
- Because the goal of estimating program savings is to measure the effect the program had on energy use, not counting spillover may understate program effectiveness.

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Net Savings in a Decision-Making Context

Assessing investments in EE

» The determination of net savings has been an issue in EE programs funded both publically or through utility/customer resources.

» The most direct contribution of net savings research may be in providing decision-makers with information they need to make good EE investments.

- A focus on the return from the EE investment, with return being defined as the savings attributable to that investment (i.e., net savings).
- Savings that would have happened even if the program had not been offered are not viewed as a return on that EE investment.

» Program goals, scale, funding sources, and the specific audience for the evaluation effort can influence:

- evaluation methods used,
- the aspects of the evaluation that are emphasized,
- the depth of analysis, and
- the manner in which the results are presented.

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Universality of the Net Savings (or Impact) Estimation Issue

All investment decisions face the same net savings issue.

- Issues in estimating net savings are not unique to EE evaluation.
- Regardless of the type of investment, once made, it is difficult to assess "net impacts," i.e., what would have happened if that that investment had not been made.
- This is the essence of evaluation: "What impacts are attributable to a specific a decision?"
- To address net impacts a baseline is needed that represents what would have happened in the absence of the investment.
- This baseline is also called the counterfactual scenario, and is required of any evaluation of a public policy, or a public/private investment.

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The Universality of the Net Savings Estimation Problem

All evaluations of policies need to examine changes attributable to that policy.

» The broader literature on evaluation reveals parallels in EE evaluation of and evaluations of private or the public sector policies.

» Examples include:

- Healthcare: What would the health effects have been without an investment in water fluoridation?
- Tax subsidies for economic development: Would the project—or a variant of the project—have proceeded without a subsidy?
- Education subsidies: What would happen if school lunch programs were not subsidized or if low-interest loans for higher education were not offered?
- Military expenditures: What would have happened without an investment in a specific military program or technology?

» Evaluators across fields grapple with how to appropriately approximate the counterfactual scenario to determine impacts that are attributable to the investment being analyzed.

» An extensive literature from these diverse applications forms the basis for much of what we do in EE evaluation work.

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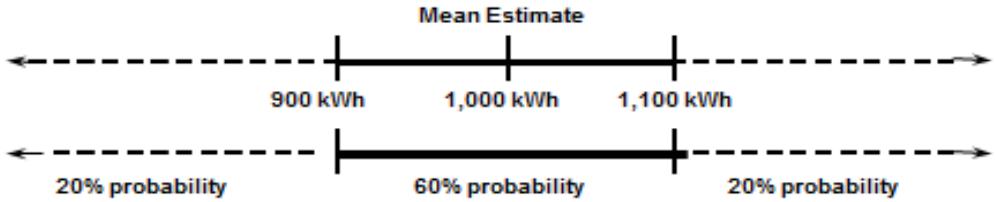
Uncertainty in Net Savings Estimation

Do estimation methods estimates that are accurate?

» There are several embedded questions:

1. What choice do we have if we want to know the impacts of a program – shouldn't we be using the best available information in decision making even if it is uncertain.
2. Is the uncertainty in estimating EE impacts really that much greater than the uncertainty in other business and policy decisions, including investments in other resources?
3. How accurate is accurate enough?
   - Would the use of a 60% confidence interval ever make sense?



   - *OR:* This same confidence interval shows that there is an 80% probability that actual impacts exceed 900 kWh or 90% of the estimated mean savings.

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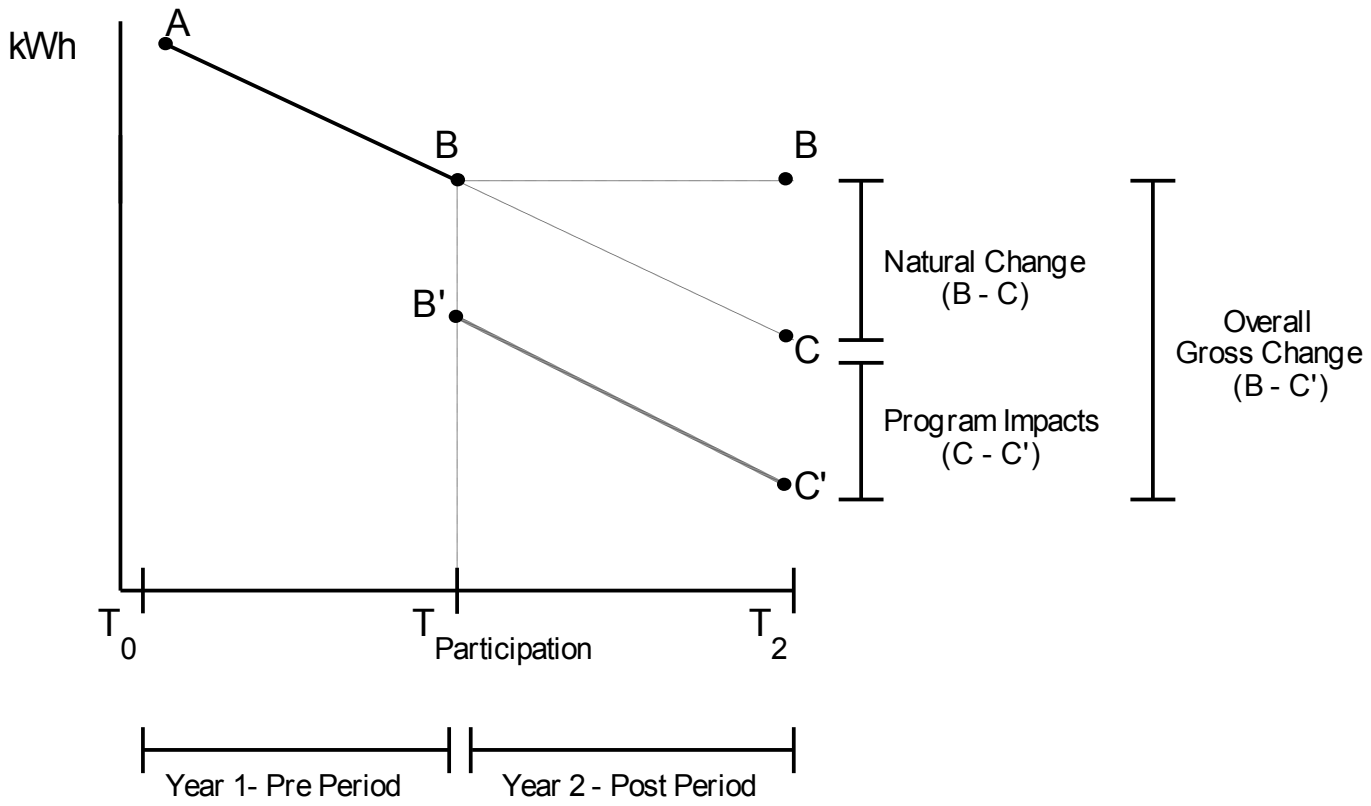
Relationship of Gross Impacts to Net Impacts

A standard scenario with gross set using the pre-participation energy use.



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The Need for and Appropriate Baseline

Example using a sample of non-participants a control group for the baseline

- Many of the estimation issues associated with evaluation occur because the baseline is not a (or is argued to not be) perfect approximation of what participants would have done had the program not been offered.
- Three of these are: 1) self selection, 2) free riders and 3) spillover.
- All three issues can stem from the same source — the view that the baseline is inexact.
- A perfect comparison baseline group would solve all three problems

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Estimation Issues and their Link to the BASELINE Used.

Consider baseline issues from the perspective of a non-participant control group

» Self-Selection

- Arises when a program is voluntary and participants select themselves into the program.
- Issue: The very fact that some consumers selected themselves into the program suggests systematic differences between program participants and nonparticipants.
- Self-selection is an issue in impact estimation

AND

- Self-selection is an issue in many if not most data collection efforts across impact, process and market evaluation in DSM and also in the assessment of most every business initiative.
- Consider a business problem such as down-sizing where some employees can select an early retirement package – might self-selection be important to address in designing this business initiative?

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Free Riders and the Link to the Baseline

Consider baseline issues from the perspective of a non-participant control group

» Free Riders

- This is an estimation issue when the actions of the comparison/control group do not accurately reflect the actions that would have been undertaken by participants in the absence of the program.
- Specifically, the assumption is that program participants would have undertaken more conservation actions than are observed in a general nonparticipant comparison group.
- In this context, free riders might be viewed as a subset of the self-selection problem as a perfect baseline would control for both free-ridership and self-selection.

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Spillover as a Baseline Issue

Consider baseline issues from the perspective of a non-participant control group

- Nonparticipant Spillover (similar to market effects)
  - This is an issue when the energy consumption of the comparison group is not indicative of what the participant group would have used.
  - In this case, the problem can be viewed as a *contaminated* comparison group, i.e., the behavior of the comparison group has been affected by the existence of the program.
  - This is not a self-selection issue.
- Note: There can also be participant spillover.
- How these are treated in a comprehensive evaluation framework does vary.

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Back To Basics – Definitions and What is to be Estimated

Common Definitions

» Equation 1. Net Savings Including Free Ridership, Spillover, and Market Effects

– Net Savings = Gross Savings – FR + SO + ME not already captured by SO

Where:

- FR = free ridership savings
- SO = spillover savings
- ME = market effects savings not already captured by SO

» The use of a net-to-gross (NTG) ratio expresses free ridership, spillover, and market effects ratios to gross savings.

» Equation 2. Net-to-Gross Ratio

– NTG Ratio = 1 – FR ratio + SO ratio + ME ratio (where the denominator in each ratio is the gross savings)

– Net Savings = NTG Ratio * Gross Savings

NOTE: When using ratios the decision whether they should be multiplied or averaged to get the right value may not be straightforward given some current net-to-gross constructs.

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Defining Market Effects

Closer look at market effects …

» ***Market Effects*** refer to changes in the structure of a market or the behavior of market actors reflecting an increase in energy efficiency products, services or practices, that is caused by the program.

- Example:
  - A utility EE program provides agricultural incentives for installing efficient dairy farming equipment.
  - Result -- the number of companies that specialize in selling and installing energy efficient dairy farm equipment grows.
  - This is a program induced market effect -- expanding the energy efficient dairy equipment market within the utility service territory.

» Because savings is trying to measure the effect the program had on overall savings, not accounting for market effects may understate program effectiveness.

» Bottom Line—free ridership, spillover and market effects are factors that are candidates for inclusion in estimate of net savings. But, factors such as equity, clarity, and reasonableness need to be considered.

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Attainable Precision as a Policy Issue

Assessing Confidence and Precision

- Achievable precision is crucially dependent upon the assumed magnitude of impacts (i.e., effect size).
- It is easier to obtain higher levels of precision when program impacts are large.
- This implies that it may not be reasonable to pick one set of confidence/precision levels and apply them to "most" programs.
- Programs with large savings will be able to achieve higher precision levels at lower evaluation costs.
- In addition, within a single program and even a single technology type:
  - Different segments may best use different calculation methods due to limits on attainable precision.
  - Stratification of participants by appropriate evaluation method can reduce evaluation costs *and* enhance precision.

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Accuracy – Distorting EE Evaluation Information

Distorting Evaluation Information – using surveys as an example.

» <u>There is no such thing as a 90/10 survey.</u>

» IN FACT -- Each question in a survey will have different accuracy depending upon the variance of the characteristics being measured

» For example, a recent survey of 218 participants had the following accuracy for three different questions (at a 90% level of confidence)

- Do you have an air conditioner (yes/no):
  Mean = .91 s.d. = 0.28 precision of +/-3.5%
- What is your income ($/year):
  Mean = 95,798 s.d. = 72,008 implies precision of +/-8.4%
- What is your expected monthly savings from the program ($):
  Mean = 11.61 s.d. = 14.98 implies precision of +/-14.4%

» EE evaluation has driven advances in survey design to attain better confidence and precision.

- Use of algorithms to assess NTG factors;
- But some of these algorithms have had unintended consequences.

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Emphasis on Conventional Confidence and Precision Targets

Appropriate policy choices for the EE effort and information needed.

» Cost-of-service and PURPA type load research more or less established 90% confidence levels and plus or minus 10% tolerances (90-10) as a standard for those uses back in the 1980s.

» Does this work for *EE* evaluations?

- Load research generally looks at the entire customer load – 100% effect size.
- EE often looks at effect sizes that are 2% to 10% of a customers load.
- The effect size is very different which affects the sample sizes and choice of methods as well as what is a reasonable confidence and precision target.
- There are choices to be made in selecting appropriate target confidence and precision levels and they depend on what stakeholders really want to know.
- For example, one-tailed tests are becoming more common if a focus is on whether the EE programs save at least a target amount of energy.

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Inconsistent Policies on Confidence and Precision Targets

Example using regression analyses

- In a regression equation used to forecast energy use, an estimated coefficient and a t-value are standard outputs with a t-value of 2.0 being considered "good."
- The purpose of the t-test is to determine whether the regression coefficient is significantly different from 0, *not whether it is plus or minus 10% from the estimate.*
- A t-value of 2.0 results in a confidence interval of 95% with a precision level of +/- 100%.
- A t-value of 16.4 is needed to produce 90% confidence and 10% precision.

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The policy context of confidence and precision

Appropriate confidence and precision levels will depend on the methods available for use in the evaluation and the question(s) being asked. As examples:

» Work on a C/I retro-fit program in Ontario targeted 90% confidence +/- 15% precision on large customer projects.

– Program in effect for a number of years and relatively accurate engineering estimates in the tracking system.

» PJM indicates that "DLC programs for residential AC usually get the highest levels of precision and confidence." For these programs, the PJM is setting a target (i.e., designed to achieve) of 90% +/- 20%.

» The ISO New England states that:

"Sampling shall meet a statistical accuracy and precision of no less than 80% confidence level and 10% relative precision …" for both permanent kW reductions from EE programs and callable load reductions.

» The decision should be based on what can be attained cost-effectively, and what won't distort the information needed for good decision making.

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NTG Decision Making Context

What methods are available for measuring Net Savings?

- Deemed or Stipulated NTG Ratios
- Randomized Control Trials
- Quasi-Experimental Methods
- Survey-Based Approaches
- Common Practice Baseline Methods
- Market Sales Data Analyses
- Top-Down Macroeconomic Models
- Historical Tracing Methods
- Structured Expert Judgment Approaches

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NTG Decision Making Context

With a number of research options, how to decide which methods to use?

- There is no one-size-fits-all answer to this question—the best method depends on many factors including:
  - purpose of study,
  - policy implications that might result from the study (study value),
  - cost considerations,
  - data availability,
  - program type,
  - retrospective vs prospective approaches, and
  - the evolution of net savings estimation methodology and practices.
- Navigant's role is to provide Iowa stakeholders with an understanding of the approaches, and more importantly, to provide a framework for the decision making.
- The framework involves a decision-based benefit-cost analysis of different research options.
  - The approach uses a value-of-information approach that is based on assuming one value of estimated program savings is correct, but in truth another value is correct.

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Benefit-Cost Decision Framework

- There are some cases where the cost of the research out weighs the benefits that are produced by the information produced.
- This depends on:
  1. The reliability of current estimates (if they exist).
  2. The ability of research to produce "better" estimates.
  3. The value of the better estimates – do they influence decisions AND have value that outweighs the cost of the research (e.g., could influence EE targets, expenditures on EE, and policy levers such as incentives).
  4. How frequently do estimates need to be updated based on this value.
- The information needed for this framework comes from literature reviews, experience with applied methods, and results from actual research.
- Benefit-cost scenarios are developed using a initial range of plausible values; then, a "loss function" is developed:
  - The cost of assuming one value is correct when another value is in fact correct.
  - The tangible benefits of better, more accurate information.
  - These scenarios provide information for stakeholders to assess research alternatives taking into account the costs and likely benefits of the research.

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Some Current Issues

Recently developing issues

» All "modern" evaluations use leveraged approaches and need a good (or great) program tracking system as a starting point.

- It should contain information on participants, what was installed, what was taken out, and the date (for home energy reports – the dates of reports are needed, and customer usage information)
- An initial estimate of gross savings based on practical engineering estimates.
- The standard process is to draw a sample from participants and develop a realization rate to adjust the initial gross savings estimates to improve accuracy.
- Accuracy in evaluation is critically dependent on the completeness and quality of the tracking system, and the final estimates in the tracking system provide for the accounting system used to present final savings numbers.

» Gross savings estimation methods are now incorporating more factors that in the past might have been net factors complicating the NTG by changing the denominator.

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One Example of Leveraging Information in an Evaluation – Simplified

One view of evaluation is that it is an audit of the tracking system, i.e., an audit of the booked savings for each participant.

Tracking System Estimates of Gross Energy Savings for all Participants (**Z**)

1 - savings
.
.
.
.
.
.
.
.
.
5,000 - savings

Verified Gross Energy Savings from Infield information (**Y**)

1.
.
.
.
.
.
.
800.

Estimated Free Riders (**X**)

1.
.
.
.
.
50.

Calibrated Net Savings

$$\overline{Y} - \overline{X} = net\ savings$$

A Realization Rate Factor (**Y**/**Z**) converts initial tracking system estimates into verified estimates (**Y**)

Appropriate sampling and stratification would be used – representative samples are critical

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Agenda

1. NTG Decision Making Context
2. NTG Policy Landscape
3. NTG Methodologies
4. Wrap-up and Next Steps

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NTG Policy Landscape

Examined policies from 50 states plus DC

- Sources
  - ACEEE NTG Report
  - Our own knowledge/experience/research
- Direct outreach to confirm findings
  - Confirmation still in process: findings are still draft
- Based on most recent policies
- Prepared case studies of selected states
- Next Step: compare NTG policies to other DSM policies

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NTG Policy Landscape

Key NTG policy issues

» Most basic: Gross vs. Net?

– May be gross but also allow net savings for planning

» A little more complex…

– Fixed or researched net?

– Allowance for spillover?

– Allowance for market effects?

– NTG protocols

» A lot more complex…

– Prospective vs. retrospective applications

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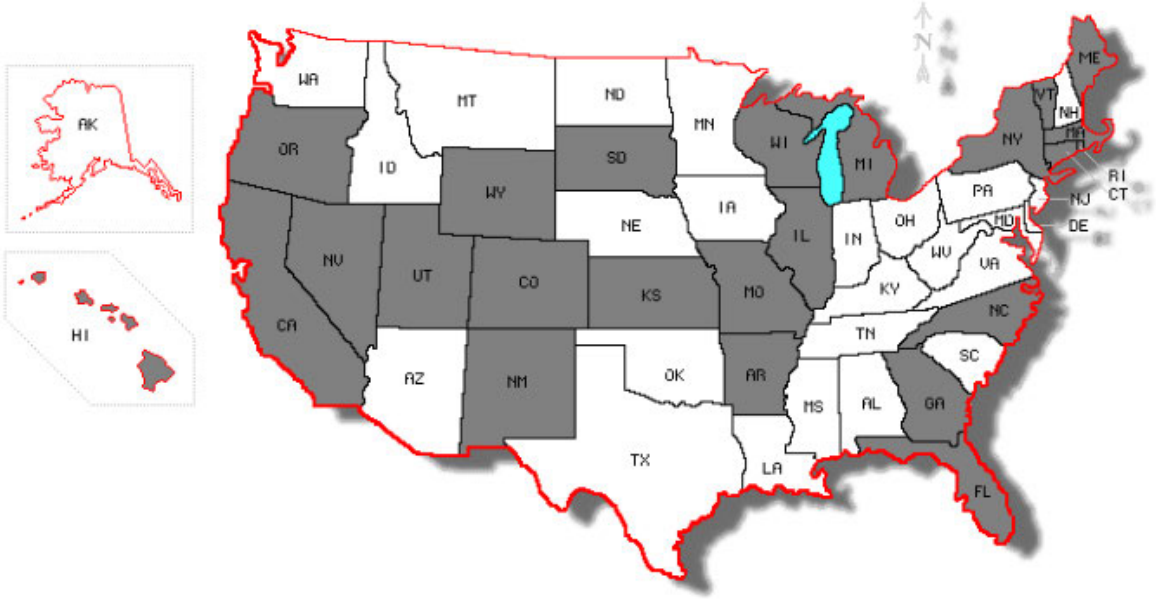
NTG Policy Landscape

Gross vs. Net

» 24 jurisdictions (47%) use net savings

– Many states with gross do still allow – and sometime require – net savings estimates for planning purposes, and for cost recovery



= Net Savings

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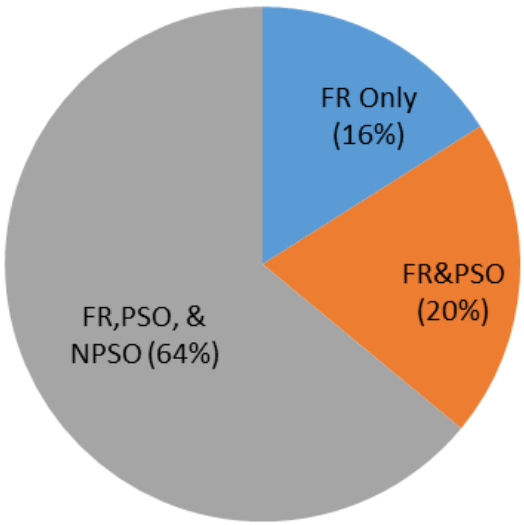
NTG Policy Landscape

Net policies

- Three states (12% of those that use net) assume a fixed NTG factor across all measures/programs
  - Hawaii uses 0.7
  - Michigan uses 0.9 but 0.82 for CFLs
  - New York uses 0.9
- Most states with net savings (n=24) allow freeridership, participant spillover (PS), and non-participant spillover (NPSO) when calculating NTG



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NTG Policy Landscape

Use of common batteries/algorithms

- Emerging practice
- Goal: mitigate differences in NTG estimates due to different methodologies
  - EM&V contractors may have different methods/approaches
- Initially developed in CA and MA
  - But not always followed
- Now being introduced in PA, IL, and AR
  - Challenge of "one size fits all"

Pennsylvania Act 129
Statewide Evaluation Team

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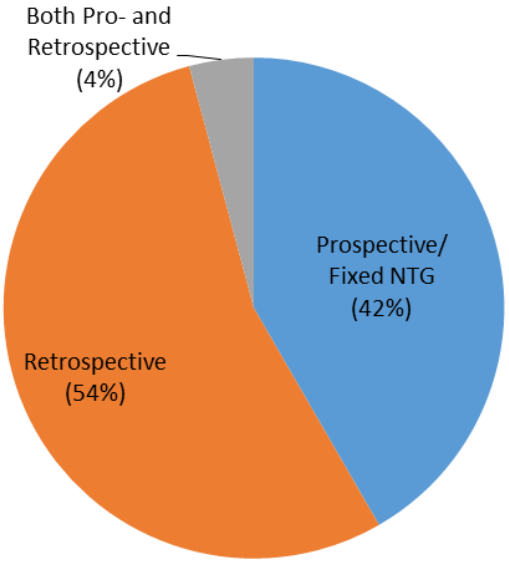
NTG Policy Landscape

Net application: Retrospective vs. Prospective

- Definitions
  - ***Retrospective***: values get applied to year researched
  - ***Prospective***: values get applied in future years
    - NTG in current year is a fixed, negotiated value
- Focused on final claimed savings



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NTG Policy Landscape

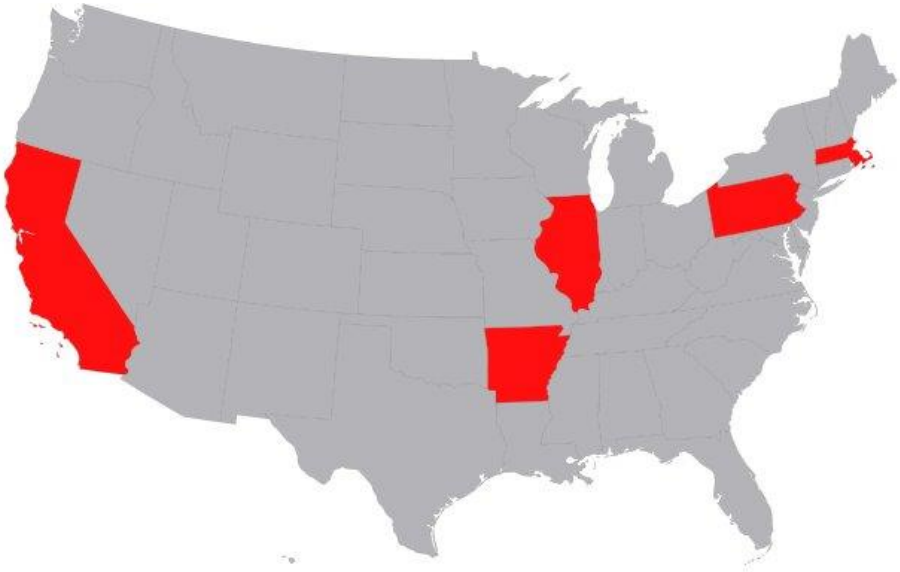
Case studies

» Mix of geography and program maturity

» Allow longitudinal analysis

» States selected

- Massachusetts
- California
- Illinois
- Pennsylvania
- Arkansas



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NTG Policy Landscape

Case Study: Massachusetts

- Over 20+ years of active DSM
- ACEEE top EE state past 4 years
- Long history of comprehensive NTG research
  - NTG recommended methods developed in 2010-2011
- Regulatory framework
  - Aggressive EE goals, lost revenue recovery, bonuses
- NTG framework
  - NTG had always been retrospective until recently
  - For 2013-2015 NTG is fixed based on DSM plan
  - All current NTG research feeds into 2016-2018 plan

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NTG Policy Landscape

Case Study: California

- Over 20+ years of active DSM
- ACEEE Top 5 EE state
- Long history of comprehensive NTG research
  - NTG recommended methods developed in 2008-2009
- Regulatory framework
  - Aggressive EE goals, bonuses (penalties eliminated in 2013)
- NTG framework
  - Only recently allowed spillover to be counted (fixed at 5%)
  - Assume portfolio "net of FR" of 80% for goal setting
  - Ex post for custom and measures with high uncertainty
    - Ex ante for the remaining measures

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NTG Policy Landscape

Case Study: Illinois

- Seven years of active electric DSM (4 yrs gas)
- Ranked 11th on ACEEE EE scorecard
- Regulatory framework
  - Mandated EE goals, lost revenue recovery, bonuses
- NTG framework
  - Until recently NTG was fully retrospective
  - With most recent three-year plans NTG is fixed annually
    - Finalized TRM process, three months prior to program year
    - Requirement to develop statewide methodologies

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NTG Policy Landscape

Case Study: Pennsylvania

- Five years of active electric DSM
- Ranked 20th on ACEEE EE scorecard
- Regulatory framework
  - Mandated EE goals, no lost revenue, penalty only
- NTG framework
  - Gross savings use for goal compliance
  - NTG required for planning purposes
  - DSM plans need to include net savings cost-effectiveness analysis

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NTG Policy Landscape

Case Study: Arkansas

- Four years of active electric DSM
- ACEEE "most improved" state in 2014
- Regulatory framework
  - Mandated EE goals, lost revenue recovery, bonuses
- NTG framework
  - Deemed NTG of 0.8 (0.6 for CFLs) for first DSM year
  - Then researched, fully retrospective NTG
  - Statewide NTG methods planned for 2015

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Agenda

1. NTG Decision Making Context
2. NTG Policy Landscape
3. NTG Methodologies
4. Wrap-up and Next Steps

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NTG Methodologies

A detailed look at specific methodologies…

- We've established the context for choosing an appropriate net savings estimation method based on program, situation, benefits, and costs.
- We've described the current policy landscape and changes in savings estimation by key states.
- A detailed understanding of specific methodologies will help utilities make the final choice of method based on a given situation.

- *Deemed or Stipulated NTG Ratios*
- *Randomized Control Trials*
- *Quasi-Experimental Methods*
- *Survey-Based Approaches*
- *Common Practice Baseline Methods*
- *Market Sales Data Analyses*
- *Top-Down Macroeconomic Models*
- *Historical Tracing Methods*
- *Structured Expert Judgment Approaches*

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NTG Methods » Deemed or Stipulated Approaches

Deemed or stipulated approaches rely on ex ante assumptions

- Deemed NTG ratios are predetermined values that do not rely on a calculation-based approach.
- These values are often based on previous NTG research conducted in the jurisdiction or elsewhere using one of the other savings estimation methods.
- Deemed values are commonly used when the expense of implementing other methods cannot be justified, or if the uncertainty of the results of other methods is judged too great.
- Recent research finds that 14% of jurisdictions in the US and Canada with ratepayer-funded EE programs use a deemed approach to net savings for C&I programs.

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NTG Methods » Deemed or Stipulated Approaches

Deemed values does not necessarily mean NTG = 1.0

» Some states set portfolio-wide deemed levels

- Iowa sets deemed NTG at 1.0 for all programs
- Michigan sets deemed NTG as 0.9 for most programs
- Arkansas sets deemed NTG as 0.8 for all programs
- Some states set deemed levels on a measure-by-measure or program-by-program basis

» Other states, such as Massachusetts, continue rigorous NTG research on specific measures and programs while setting deemed levels for EE plans.

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NTG Methods » Deemed or Stipulated Approaches

High-level summary of deemed NTG pros and cons

Pros	• This approach can reduce contentious after-implementation adjustments to estimated program savings because agreed-upon net savings factors are developed in advance of program implementation.
Cons	• An incorrect estimate can be deemed • It is not based on program-specific information • The evaluator cannot assign sample-based statistical precision to the estimate • Developing deemed savings net values at the measure and technology levels can be time consuming and expensive • The process for developing deemed net savings can be contentious

Source: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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NTG Methods » Randomized Control Trials

The RCT method and net savings calculation options

» Basic design

- Based on random assignment, study population defined first, then randomly assigned to treatment or control
- Eliminates influence of observable differences between groups
- May be used with opt-in or opt-out style programs
- If properly designed, produces results with high internal and external validity

» RCTs most common in residential behavior-based programs because:

- Program provides customers with information only
- Can be implemented for large number of consumers at one time providing for the needed large sample sizes.
- Allows for advanced planning needed for RCT implementation

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NTG Methods » Randomized Control Trials

The RCT method and net savings calculation options

» While certain residential programs lend themselves to RCT design and highly rigorous results, they often provide only small savings.

» RCTs more difficult for programs with larger savings at sites and C&I programs -- program characteristics don't lend themselves to RCT design and the customers are more heterogeneous.

» In general, the RCT approach relies on a regression framework to estimate net savings

- Post-only regression comparing treatment vs. control consumption
- Post-only regression comparing treatment vs. control consumption including lagged consumption
- Difference-in-differences (DiD) approach
- Linear fixed-effects regression (LFER) approach
- Last three options provide more safety checks for possibility of self-selection bias in treatment groups and trends over time

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NTG Methods » Randomized Control Trials

Example of RCT net savings estimation: Opower Home Energy Reports (HER)

» HER and similar programs are designed to generate energy savings by providing residential customers with feedback information on customer energy use and energy conservation.

» HERs are reports that give provide consumers various types of information, including:

- how their recent energy use compares to their energy use in the past
- tips on how to reduce energy consumption, which may be tailored to the customer's circumstances
- information on how their energy use compares to that of neighbors with similar homes

» Since the expected savings from these programs are "small" at 1-3%, Opower has designed the program as an RCT with (tens of) thousands of customers in treatment and control groups to measure/validate savings

- Idea - small effects may require large sample sizes in order to generate a statistically significant estimate of savings

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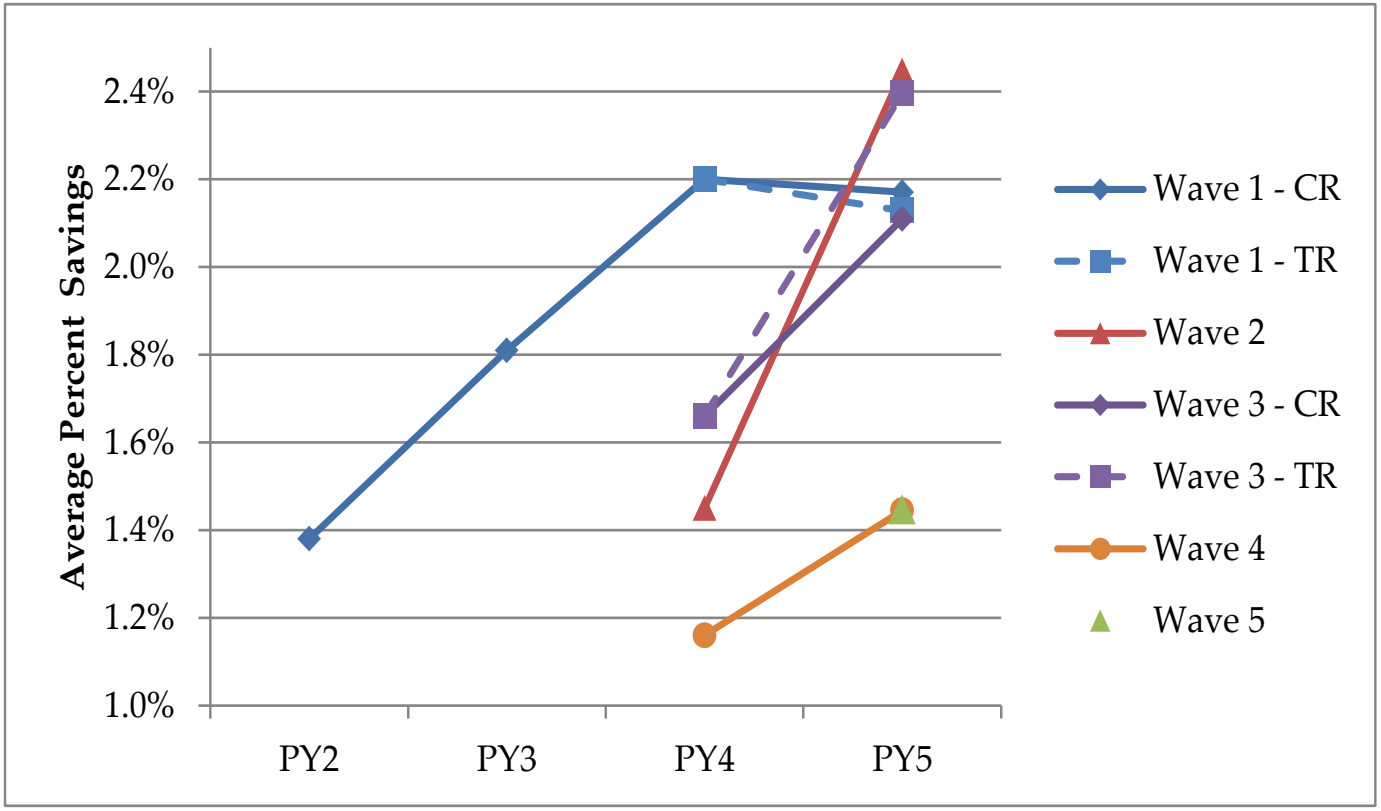
NTG Methods » Randomized Control Trials

Opower Net Savings Example: Commonwealth Edison



Source: "Home Energy Reports ProgramPY5 Evaluation Report," Prepared by Navigant for Commonwealth Edison, January, 2014.

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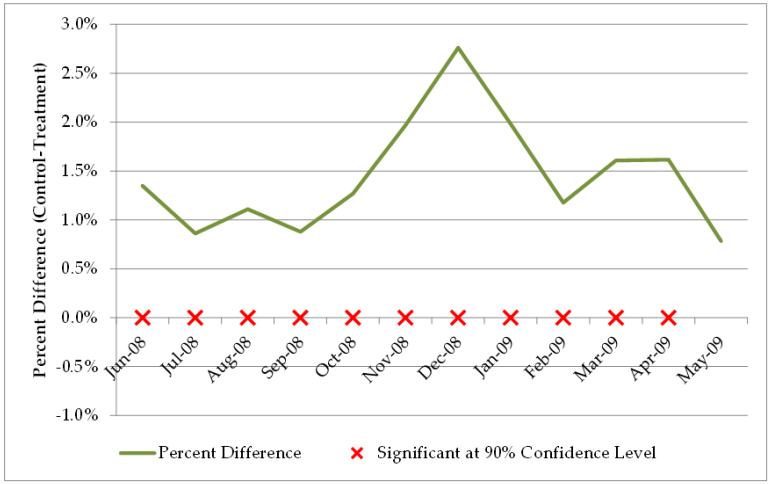
NTG Methods » Randomized Control Trials

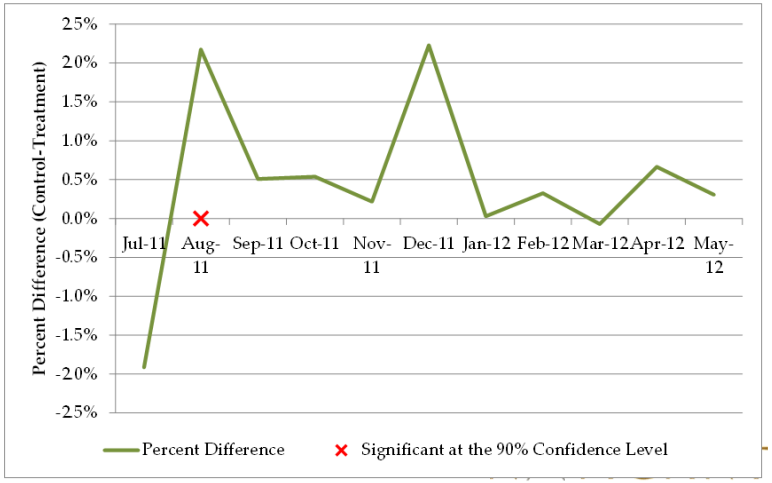
RCT Robustness checks and implementation issues: is the assignment of customers to treatment and control groups truly random?



» Testing for RCT validity is necessary to assure treatment and control assignment truly random

» Yet, testing is often excluded from the evaluation!

» Ignoring this can lower NTG evaluation costs, but risks the possibility of conducting the analysis and reporting biased or spurious results



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NTG Methods » Randomized Control Trials

High-level summary of RCT pros and cons

Pros	• Random assignment reduces and limits bias in estimates. Increases reliability and validity. • Controls for free riders and participant spillover. • Widely accepted in natural and social sciences as the gold standard of research designs.
Cons	• Bias can result if random assignment occurs among volunteers or if the program drop-out rate differs by key characteristics. • Does not address nonparticipant spillover. • Equity/ethical concerns about assigning some ratepayers to a control group and not allowing them to participate in the program for a period of time. • Generally not applicable to programs that involve large investments in measures and services. • Participants in some C&I programs may be relatively unique and with few control group candidates. • Needs to be planned as part of program implementation to allow for appropriate randomization of program participants and control group.

Source: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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NTG Methods » Quasi-Experimental Designs

Quasi-experimental methods most relevant to net savings estimation

- » Matching Methods
- » Regression Discontinuity Designs (RDD)
- » Random Encouragement Designs (RED)

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NTG Methods » Quasi-Experimental Designs

Why are matching methods used?

- Analysis of program data rarely begins with treatment and comparison groups that look the same (in absence of an RCT).
- Matching methods help to create a better comparison group by limiting comparison group to only observations that are a close match to treatment observations in terms of observable characteristics.
- Increases validity of comparison.
- Tries to approximate random assignment after the fact
- *Use of matching methods is becoming more popular as methods for matching become more rigorous.*

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NTG Methods » Quasi-Experimental Designs

What is Matching?

» **Technical definition:** Matching methods are non-parametric regression methods for pre-processing data to equate or balance the distribution of covariates in the treatment and comparison groups.

» **Layman definition:** Matching methods create better comparison groups by retaining only comparison observations that are a close match (in terms of observable characteristics) for treatment observations.

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How do matching methods work?

» **There are 4 key steps to matching methods:**

1. Define closeness: the distance measure used to determine whether an observation is a good match for another
2. Implement a matching method appropriate to measure closeness of observations (i.e..—nearest neighbor, propensity score, etc.)
3. Implement a test to assess the quality of the resulting matched samples (i.e..—how close a match have you generated?)
4. Use the matched control group created in steps 1-3 for comparison with the treatment group to estimate savings (typically done using a regression model)

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What are we matching on?

- Until relatively recently, matching was limited to observable population characteristics such as square-footage, annual kWh energy consumption, household income and demographic characteristics, etc.
- Most matching has been done for residential programs to this point.
- Matching is in its infancy with respect to commercial programs.
- Recently, sophistication of matching has grown such that we are now seeing highly refined matching methods using AMI data
  - In other words, we are able to match based on actual load profiles of customer energy consumption using hourly data
  - Use of highly detailed energy data for matching necessitates special protocols for how to manage large volumes of data for matching

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Matching Method Energy Usage Data Considerations

Annual Usage
Dataset: All Potential Matches

Monthly Usage
Dataset: Top 25% of Annual Matches

Daily Usage
Dataset: Top 10-25% of Monthly Matches

Hourly Usage
Dataset: Top 10-25% of Daily Matches

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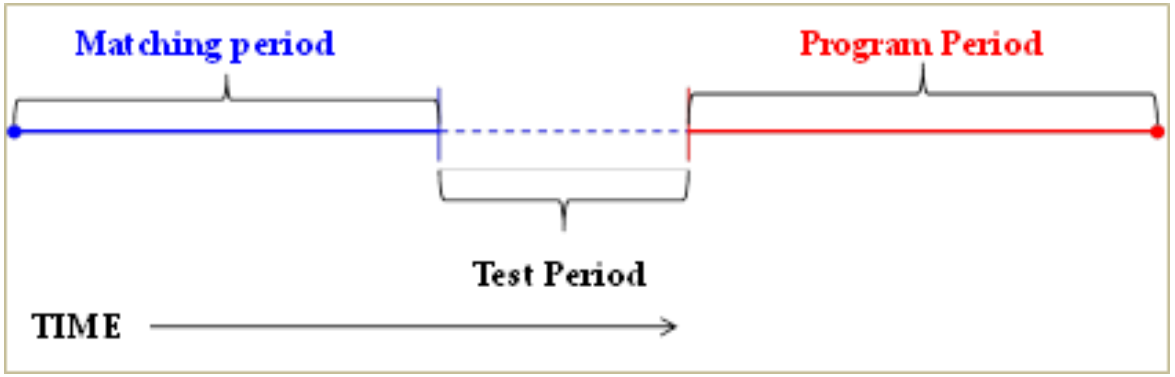
Testing for appropriate matches

» Letting t_k denote the month of program enrollment by customer k, researchers matched on energy use over the 12-month period t_k-16 to t_k-5. As a test, they compared average energy use for participants and their matches in the four month test window, t_k-4 to t_k-1, to validate the match.



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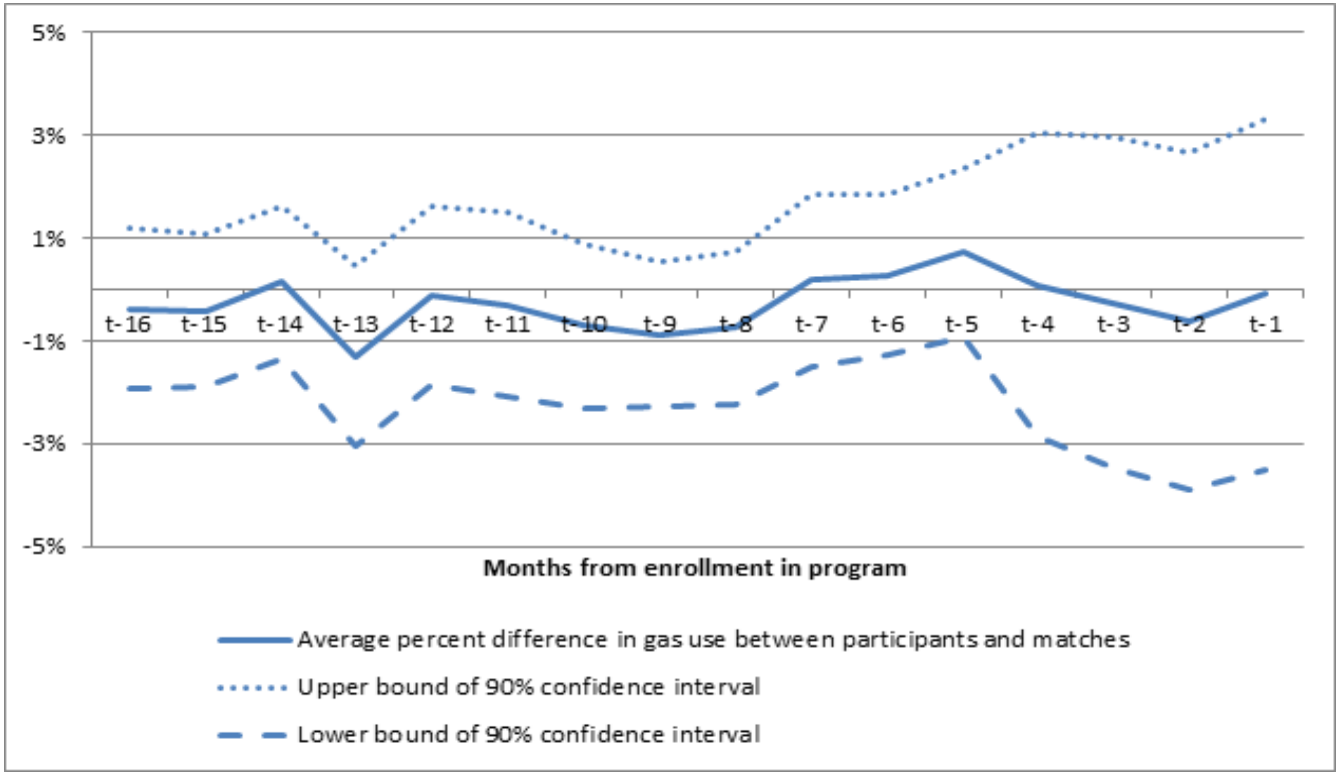
Matching produced a comparison group very similar to the treatment group in terms of energy usage. In this example for gas residential customers, the average difference between Treatment and Control is <1%.



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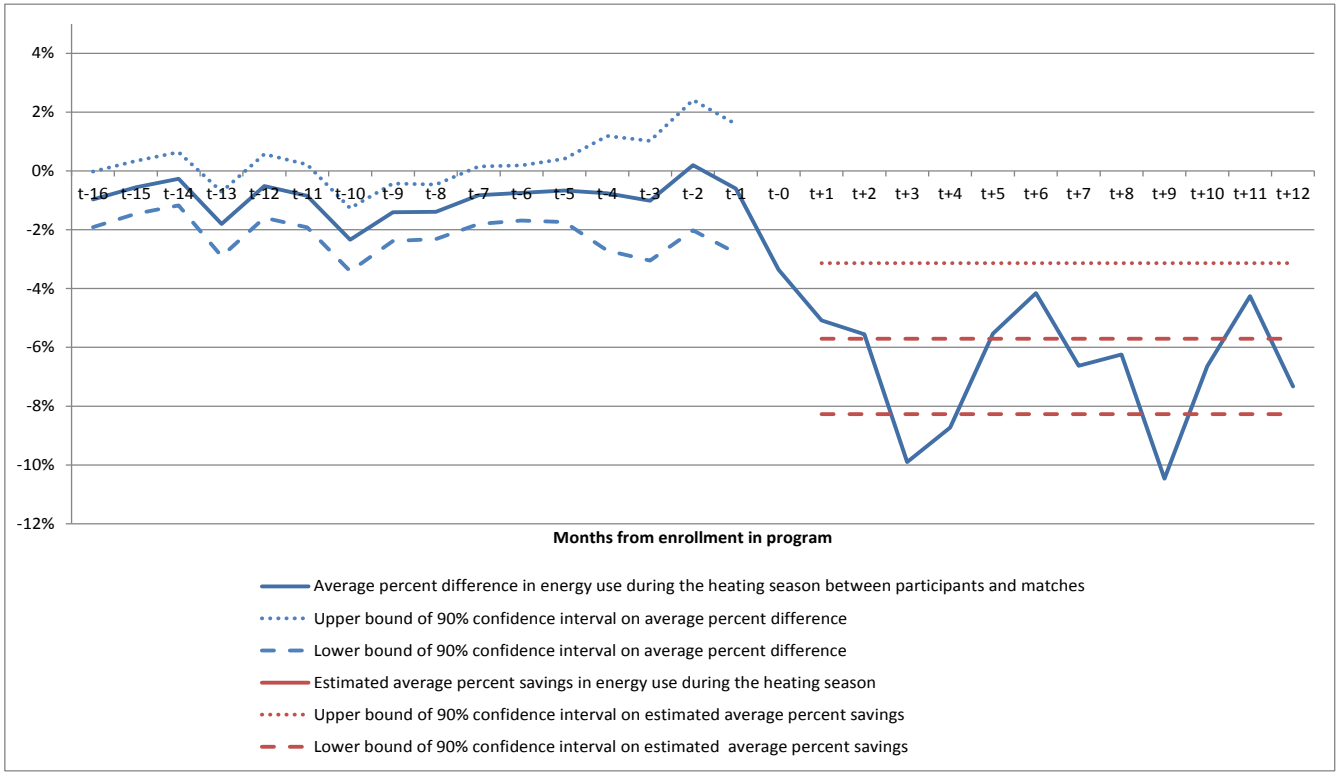
Regression results clearly show large program impact—5% reduction in gas use



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NTG Methods » Quasi-Experimental Designs

High-level summary of matching pros and cons

Pros	• Matching methods are not costly to implement, do not take advance-planning, and can provide high-resolution results. • This approach attempts to approximate random assignment to control and treatment groups after-the-fact. • Matching methods can be used in tandem with other methods such as surveys to increase resolution of results and validate the baseline comparison.
Cons	• Matching methods can reduce, but not eliminate, self-selection bias. • They do not take non-participant spillover into account. • Requires “big data” computer analytics capability.

Sources:

The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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NTG Methods » Quasi-Experimental Designs

Quasi-experimental methods most relevant to net savings estimation

- » Matching Methods
- » Regression Discontinuity Designs (RDD)
- » Random Encouragement Designs (RED)

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NTG Methods » Quasi-Experimental Designs

Why are Regression Discontinuity Designs (RDDs) used?

- As with Matching methods, RDDs are a means of approximating the randomness created using an RCT when an RCT is not feasible
- The goal of a well-designed RDD is to create a comparison group similar enough to the treatment group that it approximates the random assignment to treatment and control seen in an RCT
- A better comparison group yields a more rigorous estimate of net savings

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NTG Methods » Quasi-Experimental Designs

What is Regression Discontinuity Design (RDD)?

» **Technical definition:** RDD methods leverage spatial or numerical discontinuities stemming from arbitrary assignment rules, which cause discontinuous shifts in otherwise continuous functions underlying the relationship between the dependent and independent variable, in order to isolate more exogenous variation to estimate treatment effects.

» **Layman definition:** Arbitrary cutoffs for program participation create opportunities to identify good comparison groups by focusing on a narrow window of observations around the cutoff point—the idea is the customers just to one side or other of the cutoff are nearly identical, except that those to one side got to participate in the program, and those to the other did not.

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Variants of RDD methods

- Regression Discontinuity Designs
  - Numerical Discontinuity
  - Geographic Discontinuity

Numerical discontinuity methods use some existing numerical assignment rule such as minimum square footage to provide cutoff between treatment and comparison groups

Geographic discontinuity methods use some existing spatial assignment rule such as a utility territory boundary to provide cutoff between treatment and comparison groups

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How do RDD methods work?

» There are 4 key steps to RDD methods

1. Identify a discontinuity source: find an arbitrary assignment cutoff rule to leverage (e.g., minimum square-footage for program participation, or a utility territory boundary)

2. Define desired level of closeness to boundary (i.e., how narrow a window of observations around the boundary will be used)

3. Implement a test to assess the quality of the resulting comparison groups based on observable characteristics (i.e., how similar are your treatment and comparison groups?)

4. Use the control group created in steps 1-3 for comparison with the treatment group to estimate savings (typically done using a regression models)

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Example—Utilizing an arbitrary geographic boundary discontinuity

- Say we want to estimate savings from an EE "whole building retrofit" program for C&I customers
- This program was available in utility X but not in neighboring utility Y
- To implement an RDD approach, we decide on an arbitrarily close distance from the shared utility boundary, and only use observations in our study that fall within this narrow buffer zone surrounding the boundary (e.g.—a 5 mile corridor on either side)
- *Basic idea: buildings just to one side or the other side of the utility boundary line should be statistically similar. Thus buildings in that narrow strip around the boundary in utility Y should be good comparisons for the treatment group*
- As with matching, a test is performed to assess similarity of the treatment and control groups, and regression analysis is used to estimate net savings

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Pros and Cons to RDD methods

Pros	• If well designed, has the potential to create treatment and comparison groups that approximate random assignment (as in an RCT) • Is a good option when RCT is infeasible • Is low-cost option, provided data available
Cons	• Often hard to find appropriate sources of discontinuity • May be difficult to obtain similar data for observations on both sides of the discontinuity • Especially using geographic discontinuity, may require data coordination with neighboring utility

Sources:

The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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NTG Methods » Quasi-Experimental Designs

Quasi-experimental methods most relevant to net savings estimation

» Matching Methods

» Regression Discontinuity Designs (RDD)

» Random Encouragement Designs (RED)

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Why are Random Encouragement Designs (REDs) used?

- As with Matching methods, REDs are an means of approximating the randomness created using an RCT when an RCT is not feasible
- The goal of an RED is to create randomness in whether or not customers receive extra encouragement to conserve energy, in an effort to approximate the randomness of an RCT
- REDs help to lessen the self-selection bias in evaluation of opt-in program impacts

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NTG Methods » Quasi-Experimental Designs

What is a Random Encouragement Design (RED)?

» **Technical Explanation**—Department of Energy (2010) describes RED as a method in which "researchers indirectly manipulate program participation using an encouragement 'instrument' so as to generate the exogenous variation in program participation that is so essential for causal inference. This exogenous variation can then be used to identify the effect of the program on those households whose participation was contingent upon the encouragement."

» **Layman Explanation**

- REDs are most commonly used in opt-in program situations
- Randomly selects customers to receive extra encouragement or incentives participate in the program
- Rather than randomizing program participation (as in RCT), REDs randomize the ***likelihood of participation*** by providing some customers with extra incentives to participate
- Allows for estimation of program effect and extra encouragement effect
- Helps reduce self-selection bias problem with opt-in program impact evaluation

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NTG Methods » Quasi-Experimental Designs

Research findings on Random Encouragement Designs

» Fowlie and Wolfram (2009) identify best situations for RED use:

- Randomization of access or mandatory participation is not practical or desirable
- There is no need to ration services (demand not in excess of supply)
- Effects of both the program and extra encouragement/outreach are of interest to policy makers

» Diamond and Haninmueller (2007) and McKinzie (2009) find RED methods allow both the effects of the program and the extra encouragement to be estimated when the RED is well designed and implemented

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NTG Methods » Quasi-Experimental Designs

Design and implementation issues with REDs

» As with RDD and other quasi-experimental designs, practical issues in implementation and design must be carefully considered

- Sample sizes for RED typically exceed those for RCT
- Avoids problem of excluding participation by certain customer segments—all have opportunity to participate
- However, extra encouragement groups must demonstrate higher participation than non, in order to show validity of results— can be a challenge to successful use of RED method
- Downside to RED is that it is relatively new method with small literature/research results—not many examples to show effectiveness and successful results

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Example of difficulties in RED designs: Rhode Island RED estimation of gas savings

» In the case of programs with small savings (small program effect size), it is especially hard to implement RED designs. RI's recent study on gas savings from a behavioral program shows large difference in net savings results using matching vs. RED method

	Dual Fuel - Gas - RED	Dual Fuel - Gas - Matching
Treatment Period	June 2013 - May 2014	June 2013 - May 2014
First Rewards Enrollment Date	15-Apr-13	15-Apr-13
Total Evaluated Participants	45,745	2,466
Baseline Usage (average daily therms)	2.4269	2.6435
Incremental Net Savings (therms)	-0.0529	0.0115
Incremental Net Pilot Savings (% per HH)	-2.23%	0.43%
90% Confidence Interval Lower Bound	-6.66%	-0.12%
90% Confidence Interval Upper Bound	1.85%	0.98%
Total Net Savings	-43,377	8,345

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NTG Methods » Quasi-Experimental Methods

Summary—Pros and cons of quasi-experimental designs

Pros	• Limits bias if a matched comparison group can be identified regarding the actions that influence energy use. • Unlike RCT, can be applied after program implementation • Increases reliability and validity • Controls for free riders and participant spillover • Widely accepted in natural and social sciences when random assignments cannot be used.
Cons	• May be difficult to identify a matched comparison group if there are unobservable variables that affect energy use. • Does not address nonparticipant spillover • Some C&I programs may have unique participants and few control group candidates.

Source: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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NTG Methods » Survey-Based Approaches

Why Are Survey-Based Approaches Used?

- Programs are usually designed to affect participant or trade ally behaviors (hence-forth just "participants'). In principal, no one ought to know better than the participant or trade ally how the program affected their knowledge and behavior. Through surveys, evaluators attempt to directly measure the program effects.
- Surveys can be customized to address the various ways the program attempts to influence participant knowledge and behavior.
- Surveys can measure program effects in a timely manner, without waiting for evidence from energy use data.
- Surveys can be scaled to meet precision requirements.
- Surveys can tell not just whether a program is having an effect on participants but why and how.
- Not susceptible (or perhaps less susceptible) to some of the confounding variables that might hinder other analyses, e.g., business cycles, weather.
- Commonly used, well vetted.

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NTG Methods » Survey-Based Approaches

What Is A Survey-Based Approach?

- Respondents are surveyed and asked questions that address the impact of the program on their behavior and knowledge from a variety of perspectives.
- Responses are fed into an algorithm to calculate free ridership and spillover.
- In concept: “Would you have installed that equipment if the program had not helped you?” Yes=free rider, No=not a free rider.
- In reality: Questions asked from a variety of perspectives to overcome potential biases and get at “The Truth”.

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NTG Methods » Survey-Based Approaches

How Do Surveys Work?

- Target: Participants, market actors (e.g., trade allies), non-participants
  - "Enhanced" approach uses participants and market actors together.
- Method
  - Telephone, internet, paper, in-person
  - Typically interviewed by evaluators. Occasionally via forms that are handed out as part of the participation process.
- Survey Design
  - Approach program influence from a variety of perspectives
  - Some will be more salient than others
  - Consistency checks
- Algorithm combines answers from multiple questions to calculate participant-level free ridership.
  - Can be calculated at the project or measure level.
  - Weighted by savings

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NTG Methods » Survey-Based Approaches

Example - Illinois Business Programs

Concepts Tested

» Program and Non-Program Factors

- Importance of various program (e.g., incentive, technical assistance) and non-program factors (e.g., standard practice, company policy), in the decision
- Score = Maximum score for any program factor

» Program Influence Score

- Allocate 100 points between program and non-program factors as a group

» No Program Score

- Without the program, what is the likelihood…?
- Without the program, when would you have…?
- Score is likelihood adjusted for time.

Algorithm: Average the three scores

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NTG Methods » Survey-Based Approaches

Design and Implementation Issues

Survey and Algorithm Design Is Critical

- Survey Design
  - Question wording, skip logic, and algorithm choices are critical for accurate results.
  - The industry has established best practices. Some practitioners vary from those practices and produce results that are suspect.
- Design the algorithm before fielding the survey to ensure the survey supports the analysis.
- Compare result with intuition in the design phase using manufactured data
- Watch the math – e.g., multiplying factors can produce nonsensical results
- Pre-test and make sure respondents interpret questions just like the evaluators.
- Sensitivity Tests – test variations on the algorithm to determine whether the results are overly sensitive to algorithm assumptions. Report the range of results, not just the point estimate.
- Cross-check result with user-provided responses to validate the algorithm.

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NTG Methods » Survey-Based Approaches

Design and Implementation Issues

Surveys and samples must be designed to mitigate bias

» Analyst Bias
- Interpret responses
- Arbitrary decisions in designing the algorithm

» Sample Bias
- Non-respondent bias
- Extrapolate from the sample to the population – do not measure the population
- High precision does not guarantee unbiased result.

» Respondent Bias
- Social desirability
- Participants internalize the action, rationalize past decisions
- Do not know how the program influenced others who influenced them.
- Cannot know what they would have done if not for…
- Forget more as time goes by

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NTG Methods » Survey-Based Approaches

Summary—Pros and cons of survey-based approaches

Pros	• Provides information to explain why the NTG value is what it is. • Flexible approach that allows the evaluator to tailor questions to the program design and implementation methods • Can provide useful information to support process and impact evaluations (for example, source of awareness, satisfaction, and demographics) • Can yield estimates of free ridership and spillover without the need for a nonparticipant control group
Cons	• Potential biases related to respondents' giving "socially desirable" answers • Consumers' inability to know what they would have done in a hypothetical alternative situation, especially in current program designs that use multiple methods to influence behavior • The tendency of respondents to rationalize past choices. • Potential arbitrariness of scoring methods based on evaluator judgment that translate responses into free rider estimates. • Consumers may fail to recognize the influence the program may have had on other parties who influenced their decisions (for example, program may have influenced contractor practices, which in turn impacted the participant) • Participant surveys capture only a subset of market effects.

Source: The Uniform Methods Project: methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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NTG Methods » Common Practice Baseline Approaches

Definition and Practical Issues

» Defined as:

– Common practice baselines are estimates of what a typical consumer would have done at the time of the project implementation. Essentially, what is "commonly done" becomes the basis for baseline energy consumption (SEE Action, 2012b, p.7-2).55, 56

» This baseline includes a "consideration of what typically would have been done in the absence of the efficiency action" (SEE Action 2012b).

» This approach is under development in several jurisdictions and will certainly evolve in its application.

» In general, it is based on using available information to develop an *ex ante* estimate of net savings, with no (or limited) adjustments based on *ex post* data and analysis.

» There are appealing qualities, but the tradeoffs need to be clarified, both in terms of potential biases and the real costs associated with this approach.

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Common Practice Baselines

Method Rationale

» A key advantage claimed for the common practice baseline approach is that it avoids double counting of free riders in the two-step evaluation approach:

1. Gross savings is estimated using methods other than in situ practice (e.g., Technical Resource Manuals – TRMs); and,
2. An NTG ratio (or other adjustment) is applied to the ex post gross savings—can double count at least some free

» The argument is that the estimated claimed (ex ante) gross savings may be closer to net savings than the estimates of net savings calculated by adjusting the gross savings estimates by free ridership and spillover.

» One issue is the growing use of Technical Resource Manuals (TRMs) to develop estimates used in tracking systems.

– TRMs may use different baselines that include some net factors and baseline concepts may not be consistent across measures even in the same TRM.

» Some net factors may already be contained in the process used to produce the gross savings estimates and there may not be as significant a need to readjust the savings to account for free riders.

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Common Practice Baselines

Areas of Emphasis

» This Common Practice Baseline approach emphasizes the need to:

1. Understand the derivation of gross estimates as part of the EE evaluation process, and
2. To explicitly set out the assumed counterfactual scenario in the net savings method used.

» Taking these two steps avoids above can be argued to avoid double counting that results in higher-than-appropriate free ridership estimates, and lower than appropriate net savings estimates.

» Gross impact estimates might be based on any of the following:

1. The energy use of the equipment that was replaced during a retrofit;
2. The energy use of standard-efficiency technology that likely would have been installed by the consumer; or
3. The energy use of the equipment required by codes and standards (assuming stringent enforcement of the codes and standards).

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Common Practice Baselines

Case for Common Practice Baselines

The case made for the use of a common practice baseline appears to stem from two arguments:

1. The definition of gross savings may include factors that are more appropriately viewed as components of net savings.
   - Additional adjustments are not needed to these original estimates.
   - This is essentially an *ex ante* estimate of net savings using current practice as the baseline with net savings estimated (in advance) as the reduction in energy use resulting from the change to more efficient technologies.
2. Less clear is the argument that program evaluations that report net savings may do so inconsistently.
   - Unfortunately, the components of the net savings calculation differ between jurisdictions, and are often based on what the jurisdiction's stakeholders view as appropriate and measurable.
   - Although spillover is widely recognized and can be significant, a number of jurisdictions resist estimating spillover values and including them in the net savings calculations. Market effects values have faced similar challenges. ***But, it is not clear how the Common Practice Baseline resolves this.***

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Common Practice Baselines

Key Issues

1. The estimation of the common practice baseline can pose considerable challenges and be expensive.
   - Do you develop a common practice baseline for every measure from low flow shower heads, to different types of motors and VSDs, to commercial lighting and HVAC? If yes, this can be a significant task.
   - Represents a snap shot in time and has to be updated.
2. A significant concern is that self-selection bias.
   - An EE program that allows consumers to select themselves into the program may attract consumers among the common practice baseline who would have taken the high-efficiency actions anyway.
   - If an EE program attracted only consumers who were predisposed to install the high-efficiency equipment promoted by the program, net savings could be overestimated by not fully accounting for all free ridership.
   - Additionally, to the extent that the program results in nonparticipant spillover, it is not clear how the common practice baseline approach would capture those savings.

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Common Practice Baselines

A third case for Common Practice Baselines -- Prior EE impacts

» Another point made is that previous EE programs have affected the markets for EE equipment through spillover and market effects. This results in current common practice baselines that are more efficient than they would have been if these past EE programs were not offered.

» The bottom line for assessing the common practice baseline approach is the same process that is used in all other methods:

1. Understand the construction of the baseline used in the evaluation; and
2. Analyze the implications of this baseline against an appropriate counterfactual scenario for that program.

» Based on this standard approach, decisions can be made about the net savings estimation method that is most appropriate for the evaluation of an EE program.

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Common Practice Baselines

Summary—Pros and cons of the common practice baseline approach

Pros	• Can help to avoid double counting free ridership in circumstances where gross impacts incorporate some net savings factors • Can be used in upstream and market transformation programs • Can be applied market-wide
Cons	• Self-selection bias is not addressed and methods for addressing self-selection are not readily apparent • Does not capture nonparticipant spillover • Common practice baselines for measures and technologies will change over time and require updating • Determining average market practice has accuracy challenges • Approach has been applied in the Pacific Northwest, along with other net savings estimation methods, but is relatively new and still evolving as a general net savings estimation method

Source: The Uniform Methods Project: methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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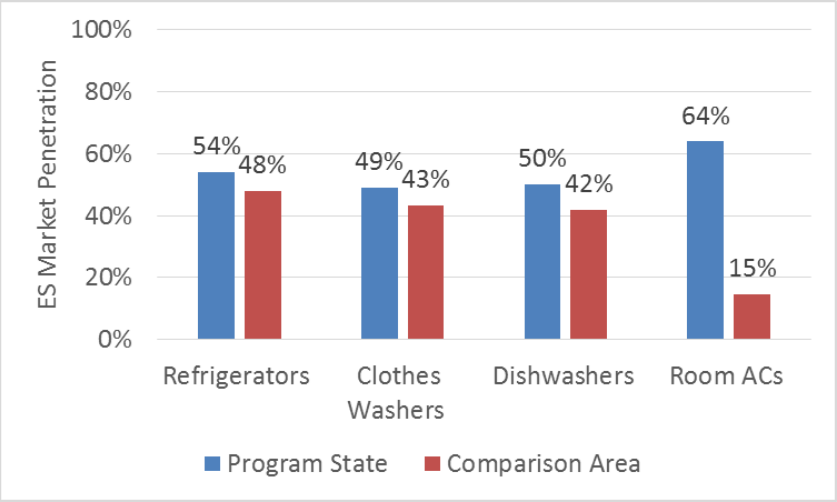
NTG Methods » Market Sales Data Approaches

Market sales data analyses approaches

- » Compare sales of energy efficient measures in treatment area to a comparison area
  - – Best to have cross-sectional, plus time series (pre/post)
  - – Regression analysis is the tool often used as it can allow for the inclusion of variables that can make the areas more comparable.
- » Comparison areas represent the "no program" counterfactual
- » Difference in sales is due to the program



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NTG Methods » Market Sales Data Approaches

Market sales data analyses approaches

Three factors to consider for selecting this method:

1. Does an appropriate comparison area exist?
2. Are the market data available and complete?
3. Does the program support large number of homogenous measures?

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NTG Methods » Market Sales Data Approaches

Summary—Pros and cons of market sales data analyses

Pros	• Can estimate the total net effect of a program • Uses information on actual consumer behavior • Addresses trends in an entire market • Most appropriate for programs that promote a large number of homogeneous measures and have substantial influence upstream
Cons	• There may be a low availability and quality of sales and shipment data in the area of interest and in an appropriate comparison area(s) • Data may be expensive to acquire and/or may have gaps that can be misleading • May be difficult to determine the appropriateness of a comparison area

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NTG Methods » Top-Down/Macroeconomic Approaches

Introduction to Top-Down / Macroeconomic modeling approaches

» Differences between two approaches:

- Bottom-up approaches using program level and participant data
- Top-down approaches in this context use aggregated for all programs across a data set of a large number of geographic cross sections (e.g., state, province, service territory, other cross-sectional area)

» Controversy in regulatory proceedings:

- Claims have made that bottom-up approaches over estimates DSM program impacts due to not fully accounting for free riders.
- The initiative stems from a recent paper (Rivers and Jaccard – 2011) that concludes that:

  "Demand-side management expenditures have had a minimal impact on electricity demand" with estimated savings being considerable less than those estimated by utilities using program-level estimation approaches.

  "In sum, all of the models that were estimated suggest that demand side management expenditures have had minimal impact on electricity demand."

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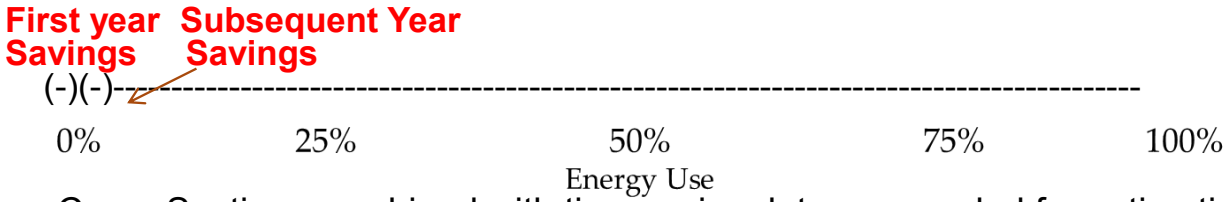
NTG Methods » Top-Down/Macroeconomic Approaches

Initial perspective on data requirements for Top-Down / Macroeconomic modeling

» The effect size is small thereby requiring a large data platform and well-specified model to identify energy savings from DSM investments.



» Cross-Sections combined with time-series data are needed for estimation – sample sizes of 160 have been near the borderline number, with many applications have over 2,000 observations.

- Each cross section must have accurate data necessary for estimating the relationship – including the lag structure.
- Accurate allocation to each cross section includes:
  - Total Energy Use for that cross-section
  - Expenditures on energy efficiency within that cross-section (EE investment).
  - Other explanatory variables (income, economic activity, energy prices, etc.)
- In addition, variation in key variables is needed across the cross-sectional data set.

» Contrast these cross-sectional requirements to how the industry treats RCT sample sizes (hundreds vs. thousands)

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NTG Methods » Top-Down/Macroeconomic Approaches

Example study: Rivers and Jaccard (2011)

We are focusing on this model as it was a point of contention in a DSM portfolio review at a utility.

1. Observations on 10 Canadian provinces for 16 years for a total of 160 observations (roughly – some dropped due to data problems)
2. Dependent variable is the natural log (LN) of energy use per capita for a province in year "t"
3. The model is a partial adjustment model where the lagged value (i.e., the value in "t-1" is included as a dependent value.
4. The model is a "fixed-effects model" where a unique intercept is estimated for each province.
5. This aggregation avoids many of the estimation issues in bottom-up approaches as you are looking directly at the end result; specifically, there is no need to explicitly estimate NTG factors.
6. Market effects might be included in the savings estimates depending on the length of time period analyzed and lag structure.

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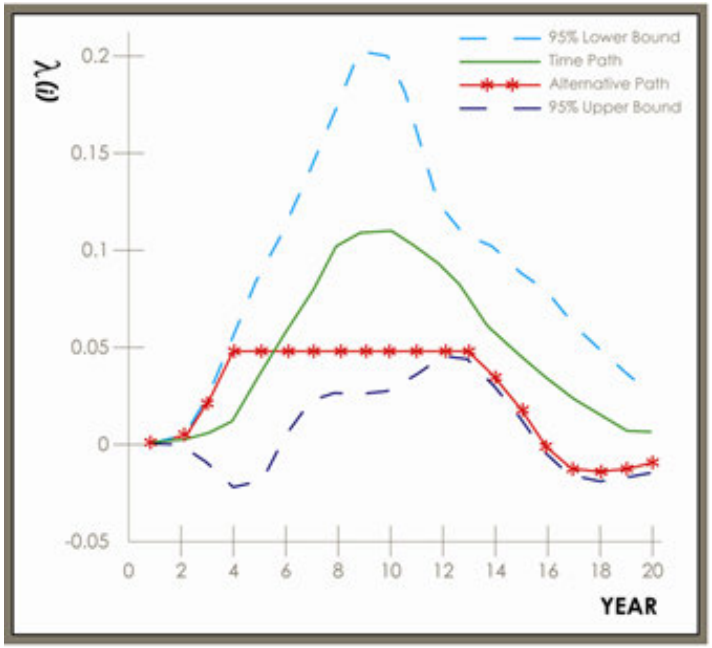
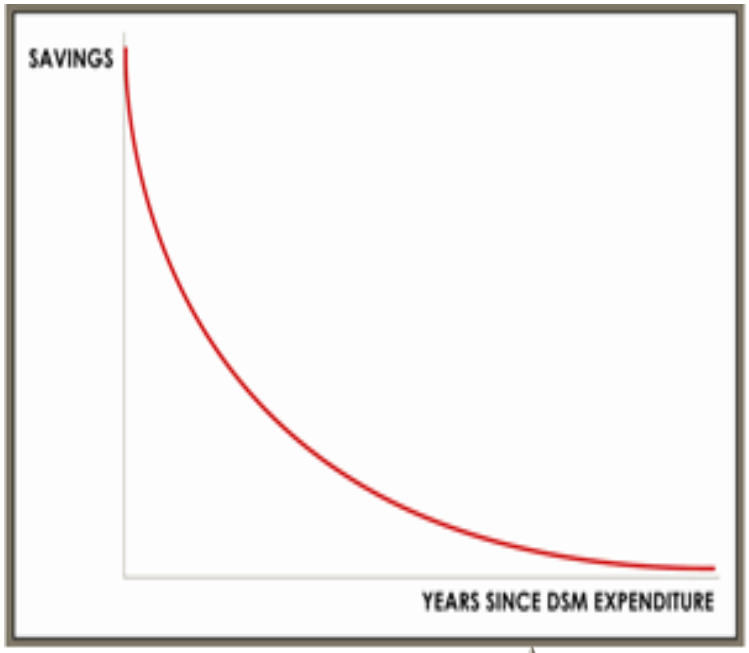
NTG Methods » Top-Down/Macroeconomic Approaches

Example study: Rivers and Jaccard (2011) and a key issue – the timing of DSM impacts

- **First graph** shows a non-linear relationship between DSM expenditures and when impacts occur – the peak at about 8 years out (see Arimura et al., 2011)
- **Second graph** illustrates the "enforced" time trend of the partial adjustment model chosen by Rivers and Jaccard (2011) – to the extent this time path does not match the actual relationship between impacts and expenditures, the ability of the model to appropriately estimate this relationship will reduced.





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NTG Methods » Top-Down/Macroeconomic Approaches

Example study: Rivers and Jaccard (2011) and a key issue – the timing of DSM impacts: interpreting the plots

» Two important messages from the plots:

- DSM spending has a long-lasting demand effect. The plots suggest that the aggregate demand effect in year 15 is still statistically different from zero at the 5 percent confidence level.
- This contrasts with the modeling assumptions used in previous top-down studies constraining DSM spending to impacts within the first few years.
- Many DSM programs promote long-lasting energy-efficient investments by customers (including residential, commercial and industrial users).
- Market effects need time to develop – important implication for one of the benefits claimed for top down methods.

» Electricity demand reductions may occur over a number of years after the initial expenditure takes place.

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NTG Methods » Top-Down/Macroeconomic Approaches

Example study: Rivers and Jaccard (2011) and a key issue – the timing of DSM impacts – re-estimation by Navigant

» The same data set was used in the re-estimation.

» Changes included:

1. A more flexible relationship between the timing of DSM expenditures and when the impacts take place.
2. Province-level fixed effects were accounted for by using variables that take the difference between LN MWh at "t" and LN MWh at time "t-1", following other specifications in the literature.
3. A dummy variable for annual fixed effects is incorporated.

» RESULTS:

- Rather than the finding that: "Demand-side management expenditures have had a minimal impact on electricity demand" with estimated savings being considerably less than those estimated by utilities using program-level estimation approaches.
- The re-estimation produced estimates consistent with the bottom up approaches used by the utility (in this case BC Hydro).
- The small number of observations result in large confidence intervals.
- NOTE: Top-Down approaches require large data sets which may be difficult to obtain.

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NTG Methods » Top-Down/Macroeconomic Approaches

Example study: state of California Top-Down net savings analysis (Demand Research LLC, 2013)

» Aggregate statewide estimates of energy savings across all three sectors was forecasted with reasonable confidence and precision.

» Looking at the results at one level of disaggregation lower (at the sector level results) shows a high degree of variability. For example:

- The estimated industrial energy savings (all three utilities combined) were much higher than the utilities' ex ante values, about 276% higher
- The commercial sector kWh savings estimates (all three IOUs combined) were much lower than the utilities' ex ante estimates (about 27% of the ex ante savings).
- The residential sector savings estimates from the estimated Top-Down MCM model for PG&E (345%) and SDG&E (275%) were substantially higher than the utilities' ex ante values (SCE was not estimated).

» When these sector-level results are aggregated up to a statewide number, the wide discrepancies at the sector level tend to offset each other.

» It is important to recognize that this was a pilot effort and views will differ on the overall robustness of findings at the sector and statewide levels.

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NTG Methods » Top-Down/Macroeconomic Approaches

Further thoughts: both Top-Down and Bottom-Up approaches have strengths and weaknesses

» Policy makers are more experienced interpreting Bottom-Up approaches, and econometric Top-Down approaches have not yet been fully vetted from a State policy perspective.

» Developing an accurate data base with an appropriately large number of cross-sections is very difficult at a state or utility service territory level.

» They address different important questions:

- Top-Down econometric methods address the average effects of DSM expenditures at an aggregated cross-sectional level.
- Bottom-Up methods can address issues relating to a utility or other DSM program provider portfolio, sector and program level analyses.

» Both methods are valuable, but appropriate context and interpretation are needed such that results are not over-extended to the detriment of DSM resource decisions.

» If only one method were to be selected, the bottom-up method would seem to be most appropriate given the information it can provide by program – savings, process, design, and economics.

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NTG Methods » Top-Down/Macroeconomic Approaches

Summary—Pros and cons of Top-Down Approaches

Pros	• Estimates net effects of all programs cumulatively • No need to adjust for free ridership, spillover, or market effects at the aggregate level
Cons	• Methods are not fully developed at the state or regional levels • Relies on high-quality energy consumption data and on data regarding EE efforts within each cross-section analyzed • Cannot provide savings at the measure, technology, or program level • Does not provide information on how to improve program design and implementation processes

Source: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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NTG Methods » Historical Tracing Approaches

What is Historical Tracing?

- Historical tracing involves reconstructing the events (such as the launch of a product or the passage of legislation) that led to the outcome of interest.
- An example of this would be developing a "weight of evidence" conclusion regarding the specific influence or role of the program in question on the outcome.
- Although this qualitative analysis method has rarely been applied to energy-efficiency programs, it is well suited to an attribution analysis of major events, such as adoption of various tax polices or codes & standards
- It is also well suited to attribution given multiple, overlapping energy-efficiency programs and policies.

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NTG Methods » Historical Tracing Approaches

Historical tracing relies on logical devices typically found in historical studies, journalism, and legal arguments (Rosenberg and Hoefgen 2009).

- Compiling, comparing, and weighing the merits of narratives of the same set of events provided by individuals who have different points of view and interests in the outcome
- Compiling detailed chronological narratives of the events in question to validate hypotheses regarding patterns of influence
- Positing a number of alternative causal hypotheses and examining their consistency with the narrative fact pattern
- Assessing the consistency of the observed fact pattern with linkages predicted by the program logic model
- Using information from a wide range of sources (including public and private documents, personal interviews, and surveys) to inform historical tracing analyses

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NTG Methods » Historical Tracing Approaches

Forward and backward Historical Tracing

» The historical tracing method traces chronologically a series of interrelated events

- Going forward from the research point of interest to downstream outcomes, or
- Working backward from an outcome along a path that is expected to lead to precursor events

» Forward tracing: If all likely paths are followed, forward tracing can capture a relatively comprehensive view of project or program effects. Because the path leads from a program event, the connection to the event is assured.

» Backward tracing: usually focuses on a single outcome of importance and follows the trail back through developments that seem to have been critical to reaching the identified outcome. These developments may or may not link back to the research program of interest

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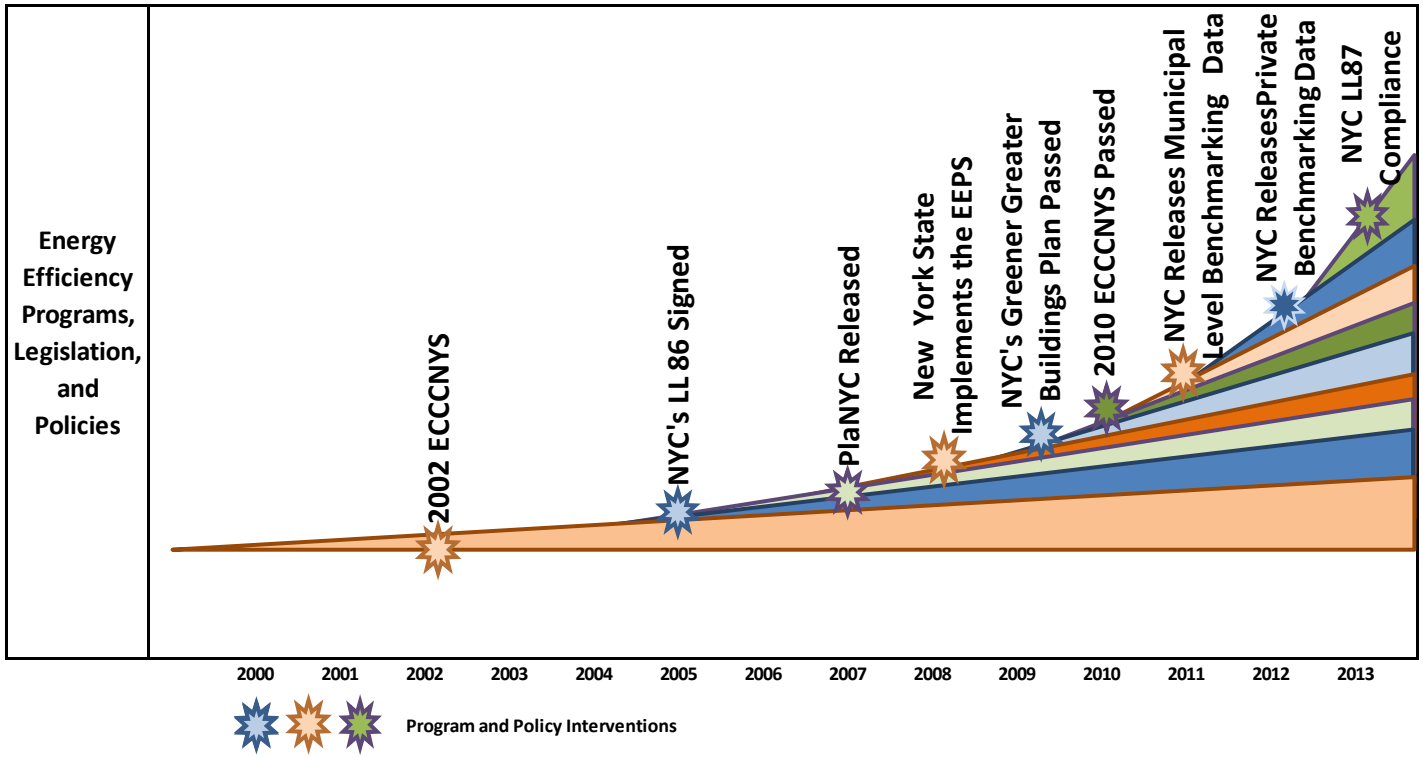
NTG Methods » Historical Tracing Approaches

Example: Historical Tracing of Energy Efficiency Policy and Program Influences in the NYC Commercial/Multifamily Market (2000-2014)



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NTG Methods » Historical Tracing Approaches

Summary—Pros and cons of historical tracing approaches

Pros	• Draws from multiple information sources • Can be used at a market level for upstream EE programs • Can be useful for making a persuasive case for attribution and provide evidence to support a statistically derived net savings estimate
Cons	• It can be difficult to translate the influence factors into estimates of impacts without additional modeling • The evaluator cannot calculate sample-based statistical confidence and precision levels for the estimate

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NTG Methods » Structured Expert Judgment Approaches

What are the structured expert judgment approaches?

- Structured expert judgment approaches involve assembling a panel of experts who have a good working knowledge of the technology, infrastructure systems, markets, and political environments.
- This approach is one alternative for addressing market effects in different end-use markets.
- The experts are asked to estimate baseline market share for a measure or behavior. In some cases, they are also asked to forecast market share with and without the program in place.
- Structured expert judgment processes use a variety of specific techniques to ensure that the panel of experts specify and take into account key known facts about the program, the technologies supported, and the development of other influences over time.

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NTG Methods » Structured Expert Judgment Approaches

Delphi panels

» The Delphi process is the most widely known and used structured expert judgment technique:

1. Each panelist is asked to make a judgment on the topic—based on the provided information and on his or her experience—and submit the information to the evaluators.
2. The evaluators compile the information from the panelists and return it to the panelists for another review.
3. The panelists are asked whether they stand by their original judgments or whether the assessments of their peers have caused them to alter their judgments.
4. Additional iterations as appropriate and within budget.

» At least two rounds of judgment are required for a true Delphi approach, although more rounds can be used

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NTG Methods » Structured Expert Judgment Approaches

Delphi processes and key issues

» There are various ways to implement the Delphi panel:

- Mail / email, which must allow several days or weeks for the iterative process to work itself out
- Virtual / webinar based panels
- Real-time in person panels, which combines the Delphi with a focus group-like process
- Combinations of these

» Choice of process is less important than making sure these key issues are addressed before embarking on this approach

- Getting the "right" group of experts on the panel
- Establishing the panel's objectives: reach consensus, or provide a realistic range/likelihood of alternative outcomes?
- Is maintaining anonymity among panelists important

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NTG Methods » Structured Expert Judgment Approaches

Example 1: Residential New Construction Delphi Panel (Hoefgen et al. 2011).

- Two Delphi panels of consultants and building industry experts received detailed data pertaining to code compliance, compliance margins, and estimates of annual energy savings in non-program homes
- Panelists were asked to:
  - Estimate the proportion of the electricity and natural gas savings attributable to the IOU programs (spillover) and other factors (non-IOU residential new construction programs, the economy/housing market, energy prices, and climate change).
  - Estimate the percentage of net savings in nonprogram homes attributable to different IOU program elements (builder trainings, incentives, and design assistance).
  - Assess the extent to which the market effects were likely to persist in the absence or reduction of the IOU programs.
  - Estimate the percentage of homes that would have been below code in the absence of the IOUs' programs and other factors, and estimate the compliance margin of the below-code homes in the absence of each factor.
- Each panelist completed two rounds of detailed surveys
- In the second round, they were provided a comparison with other panelists' responses and logic and allowed to change their answers

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NTG Methods » Structured Expert Judgment Approaches

Example 2: Delphi Panel for Statewide CFL NTGR (Navigant, Cadmus and NMR, 2014).

- A Delphi panel of industry experts reviewed results of seven CFL NTGR studies conducted in Michigan between 2009 and 2013 as well as market data and information on program history
- The Delphi panel consisted of manufacturers and retailers, program administrators, evaluators and consultants, as well as government/regulatory and advocacy experts.
- Panelists were asked to:
  - Estimate a statewide CFL NTGR for 2009-2013, or an individual NTGR for Consumer's Energy and DTE Energy if justified.
  - Estimate a statewide CFL NTGR for 2014-2015.
- Each panelist completed two rounds of detailed surveys.
- In the second round, they were provided a comparison with other panelists' responses and logic and allowed to change their answers.
- The research resulted in the Michigan Energy Optimization Collaborative adopting a revised deemed NTGR for CFLs of 0.89 for 2009-2013 and 0.82 for 2014-2015.

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NTG Methods » Structured Expert Judgment Approaches

Summary—Pros and cons of structured expert judgment approaches

Pros	• The resulting estimate is the independent, professional judgment of a group of technology and/or market experts • It is a useful approach for programs with diverse and complex end uses or practices • It is a useful tool for consolidating results from multiple methods to develop a consensus estimate • Panel members can provide levels of confidence and procedures using appropriate elicitation methods
Cons	• The approach relies on high-quality data to inform the panel, leading to reasonable estimates of net savings • Sampling-based calculation of confidence and precision are not available

Source: The Uniform Methods Project: methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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New Method Focused on Up-Stream Lighting Programs

Price Elasticity Analyses for Upstream Lighting – Appendix to UMP study.

» Upstream lighting has been one of the most difficult programs to evaluate due to the nature of the programs
  – Participants are not well identified
  – Tracking where CFLs go once bought at a retailer has been difficult.

» Standard approaches include:
  – Store intercepts to survey customers
  – Surveys of retailers
  – Industry panels and Delphi Methods.

» A new approach is regression based and uses data on weekly sales of CFLs by retailer regressed against price and program variables.

» The impact of the CFL buy-downs is examined using the relationship of sales to price which provides additional information. Potential issues:
  1. There may be little variation in price across retailers
  2. The market price is not in the data set so extrapolation to sales that would have occurred at higher prices is a bit speculative
  3. Results may be dependent on model specification -- not sure about the quality of the information yet but experience is being gained.

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NTG Methods Summary

Categorizing applicability of methods

- The following chart, taken from the Uniform Methods Project (UMP) published by the National Renewable Energy Laboratory (NREL) in 2014, helps categorize applicability of different methods by data availability, cost and other considerations
- This chart is a starting place for considering applicability of methods—later in our presentation, we will go into greater depth on each method individually
- Again, information in this chart emphasizes that the right method is highly dependent on the context of the study

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NTG Methods Summary

Net Savings Method	Surveyed Group	Applicability				Typical Cost or Complexity	Special Requirements
		Custom Measures	Measures With Few, Diverse Participants	Large Numbers of Similar Participants	Measures With Substantial Upstream Influence Invisible to Consumers		
RCTs using DiD	None necessary, but could be conducted to help validate the baseline as an appropriate counterfactual scenario	Poor	Poor	Good	Poor	Low	Random assignment of participants and controls
Quasi-experimental design	None necessary but could be conducted to validate or develop better baselines	Poor	Poor	Good	Poor	Low	Matched nonparticipant comparison group
Regression models—Billing data analyses with control variables and Linear Fixed Effects Regression (LFER)	Participating consumers and comparison group consumers	Poor	Poor	Good if there is a valid comparison group	Good if there is a valid comparison group	Low	Need control variables that influence energy use across participants and nonparticipants
Survey based—participants, nonparticipants, and market actors	Participating end users	Good	Good	Good	Poor unless combined with retailer or contractor surveys	Medium	Counterfactual baseline based on survey responses
	Participating and nonparticipating end users	Poor	Poor	Good	Poor unless combined with retailer or contractor surveys	Medium-High	Nonparticipants must be representative of participants
	Retail store managers and contractors	Good	Good	Medium	Good	Medium	
Survey based - qualitative sales and	Retail store managers and	Poor	Poor	Good	Good	Low	

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NTG Methods Summary

Net Savings Method	Surveyed Group	Applicability				Typical Cost or Complexity	Special Requirements
		Custom Measures	Measures With Few, Diverse Participants	Large Numbers of Similar Participants	Measures With Substantial Upstream Influence Invisible to Consumers		
counterfactual scenario	contractors						
Structured expert judgment	Experts	Depends on quality of input methods				Low	
Market sales data (cross-sectional studies)	None	Poor	Poor	Good	Good	Low if data are available; high or not possible if data must be developed	Defined market segment
	Manufacturers and regional buyers and distributors	Poor	Poor	Good	Good	Low	
	Retail store managers and contractors	Good	Good	Medium	Good	Medium	
Common practice baseline	Participating and Nonparticipating end-user surveys or market sales data are used	Poor	Poor	Good	Good	Medium to high	Defined market segment
Top-down methods for regional application	None	Requires data on aggregate energy consumption and information on EE effort (expenditures or related program variable) for a large number of cross-sectional observations over a period of time				Depends on the cost of compiling the initial dataset	Aggregate data available on geographic cross-sections

Source: The Uniform Methods Project: methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 17: Estimating Net Savings: Common Practices, Daniel M. Violette & Pamela Rathbun, 2014.

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Agenda

1. NTG Decision Making Context
2. NTG Policy Landscape
3. NTG Methodologies
4. Wrap-up and Next Steps

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