

Massachusetts Program Administrators and the Energy Efficiency Advisory Council

**Estimated Net-To-Gross (NTG) Factors for the
Massachusetts Program Administrators (PAs)
2010 Residential New Construction
Programs, Residential HEHE and Multi-Family
Gas Programs, and Commercial and Industrial
Gas Programs**

July 20, 2011



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July 20, 2011

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Prepared for: Massachusetts Program Administrators
and the Energy Efficiency Advisory Council by Tetra Tech and NMR

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

This report presents net-to-gross ratio (NTGR) recommendations for the Massachusetts Program Administrators (PAs) 2010 Residential New Construction (RNC) programs, commercial and industrial (C&I) programs, and multi-family retrofit and residential High Efficiency Heating and Water Heating (HEHE) programs. The studies were conducted independently and have been assembled into a single report.

For all three studies, Tetra Tech, NMR, and KEMA reviewed secondary literature including program impact evaluations, utility filings, and market effects studies to develop our recommendations. Given the short time frame allotted for this work, we focused the search for information on a limited number of readily available sources.

1.2 RESULTS

Table 1–1 summarizes the NTGR recommendations by program types. When Spillover is noted as a finding, the intention is that the Program Administrators will add this number to the previously-determined Net to Gross Ratio for these measures.

Table 1-1. Recommended Net-to-Gross Ratios by Program Types

Program Type	Recommended NTGR
Residential New Construction	1.00
Commercial and Industrial Gas	
Custom	0.96
Prescriptive	0.83
Residential HEHE and Multi-family	
Boiler controls—HEHE	NTGR 1.0 (Residential)
Boilers—HEHE	Spillover: 0.14 (Residential)
Furnace/ECM furnace—HEHE	Spillover: 0.19 (Residential)
Insulation	NTGR 0.8 (Multifamily)
Programmable thermostats	NTGR 0.88 (Multifamily) 0.42 (Residential)
Miscellaneous Water heating equipment	NTGR 0.63 (Residential)
Water saving devices	NTGR 0.77 (Multifamily)
Windows	NTGR 0.8 (Combined MF & Res)

1.3 ORGANIZATION OF THIS REPORT

Chapter 2 presents the study methodology and NTGR recommendations for the 2010 Residential New Construction (RNC) programs. Chapter 3 presents the methodology and NTGR recommendations for the 2010 C&I gas programs, and Chapter 4 presents this same information for the multi-family retrofit and residential HEHE gas programs.



2. RESIDENTIAL NEW CONSTRUCTION

2.1 METHODOLOGY

In order to develop a range of possible NTG estimates, NMR reviewed the following RNC impact evaluations: *California Residential New Construction Programs Impact Evaluation*,¹ *California Residential New Construction (Single-Family Home) Market Effects Study*,² and *New York ENERGY STAR Labeled Homes Program Market Characterization, Market Assessment and Causality Evaluation*.³

This memorandum has the following sections:

- Summary
- Background
- Program Descriptions
- Methodologies
- Net-to-Gross Ratios
- Conclusions

2.2 SUMMARY

As shown in Table 2–1, the New York ENERGY STAR[®] Labeled Homes (NYESLH) study found significant savings due to market effects. In California, there were even more significant net savings, exceeding gross program savings by a factor of three for electric, a factor of six for gas, and a factor of five for gas and electric combined. However, the net savings estimates for market effects in California were subsumed in net savings estimates derived and claimed for the Codes and Standards (C&S) Program.⁴ The C&S evaluation was more general in its coverage; the contribution of the market effects study was to identify the *mechanisms* by which a subset of the savings was achieved.

The CA Residential New Construction (RNC) studies spent significant time and resources developing a baseline for residential new construction in California that was used to develop estimates of energy savings in non-participant homes. The CA RNC market effects study developed estimates of the impact of the IOU programs through the use of two Delphi panels. In contrast, the NYESLH study relied on self-reported information from builders (including non-participating builders) to determine spillover in non-participating homes. While this approach may be adequate in assessing participant spillover, it has the potential to overlook larger market effects.

¹ KEMA, Cadmus, Itron, NMR (2010) *Residential New Construction (RNC) Programs. Impact Evaluation—Volume I*. Submitted February 8th, 2010.

² KEMA, NMR, Itron and Cadmus (2010) *Phase II Report Residential New Construction (Single-Family Home) Market Effects Study*. Submitted December 6th, 2010.

³ Quantec and Summit Blue (2006) *New York ENERGY STAR Labeled Homes Program Market Characterization, Market Assessment and Causality Evaluation*. Submitted May 2006

⁴ The Cadmus Group, Inc. (2010). *Results of Analysis of Market Effects of Utility Programs on Codes and Standards Development (REVISED)*. San Francisco: California Public Utilities Commission.

**Table 2-1. Net-to-Gross Ratios**

	Net-to-Gross Ratios
CA RNC—Combined Gas and Electric	6.25
CA RNC—Electric Only	4.12
CA RNC—Gas Only	7.10
NYESLH	1.17

However, there are key differences between the California RNC programs and the Massachusetts program that would lead one to expect a lower NTG ratio in Massachusetts—in particular, lower savings from market effects. Specifically, the California programs have much more extensive training for builders, subcontractors, HERS raters, Title 24 consultants, and code officials—and the evaluation identified the training elements of the programs as being most responsible for market effects. The training appears to be the major driver of the high California NTG ratio. The New York program too, while less than that of California, has had more extensive training than Massachusetts.

A key difference between Massachusetts and both California and New York for purposes of developing a NTG is that the California market effects evaluation focused solely on single family homes, and the New York evaluation focused on one- to four-family homes. More than one-half the units participating in the Massachusetts program, in contrast, are in buildings with five or more units. Many of those, moreover, are low-income buildings, some of them required to meet ENERGY STAR standards and hence likely free riders.

On one hand, given the Massachusetts program's focus on changing building practices, it seems reasonable to assume that it has affected practices in nonparticipating homes and thus has generated spillover. On the other hand, the state mandate for many low-income units to be built to ENERGY STAR standards, coupled with their qualification for program participation, virtually assures a substantial number of free riders in the program. NMR therefore recommends that, until the PAs are able to develop a program-specific NTG ratio, they adopt a conservative ratio of 1.0.

2.3 BACKGROUND

Residential new construction programs in Massachusetts began in 1991 with the Energy-Crafted Homes program and transitioned to the ENERGY STAR[®] Homes program in April 1998. In 2007 the program's name was changed to Massachusetts New Homes with ENERGY STAR.

In a Memorandum of Agreement (MOA) dated April 15, 2011, the PAs and the Massachusetts Department of Public Utilities, among other issues, discussed the application of net-to-gross (NTG) ratios for reported savings in the PAs' individual annual reports. The MOA states the following:

In the Program Administrators' individual 2010 Annual Reports, the electric Program Administrators will determine and apply net-to-gross ratios for at least eighty percent (80%) of 2011 projected annual savings (at a statewide level) in the residential (not including low-income) sector and at least eighty percent (80%) of 2011 projected annual savings (at a statewide level) in the non-residential sector. Such determinations will be made by means of completed net-to-gross studies or impact evaluations which include net-to-gross factors. Where studies or evaluation results are not complete, savings and net-to-gross ratios shall be reported using the best available information (determined after



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collaborative discussion, and referring to the best-available preliminary results, research, and comparable data from other jurisdictions, as applicable and if any, and/or market information and intelligence).

The MOA also states the following:

The gas Program Administrators will utilize and apply all available net-to gross ratios from completed net-to-gross studies or impact evaluations which include net-to-gross factors in their 2010 Annual Reports, provided that such studies/evaluations are completed by an advance date mutually agreed to by the Program Administrators and the EM&V consultants. Where studies or evaluation results are not complete, for 2010 Annual Reports, savings and net-to gross ratios shall be reported using the best available information (determined after collaborative discussion, and referring to the best-available preliminary results, research, and comparable data from other jurisdictions, as applicable and if any, and/or market information and intelligence).

In keeping with this direction, in order to assist the PAs in Massachusetts in identifying an appropriate NTG ratio to use for their 2010 RNC filings, NMR reviewed available evaluation studies from other jurisdictions to determine if any comparable data existed. After reviewing several studies of RNC programs throughout the US, NMR found two studies, one in California and one in New York, that had sufficiently explored the issues of free-ridership, spillover, and market effects to serve as a basis for estimating a NTG factor in Massachusetts. These are discussed in the following sections.

2.4 PROGRAM DESCRIPTIONS

This section includes brief program descriptions for the CA RNC programs and the NYESLH program.

2.4.1 CA RNC

The California investor-owned utilities (IOUs)—Pacific Gas and Electric (PG&E), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE), and Southern California Gas (SCG)—have been operating energy-efficiency programs for many years. The most recent iteration of the IOU programs was implemented in the 2006-2008 time period and included a variety of RNC programs, including:

- PG&E: Residential new Construction Program
- SDG&E: Advanced Home Program
- SCG: Advanced Home Program
- SCE: CA New Homes Program

While the scope and focus of each of the above programs varies by IOU, each of the above programs served the residential new construction market and offered incentives for whole house and prescriptive measures. One notable difference is that PG&E's program focused primarily on single-family buildings with multifamily efforts handled through a separate program. The other three programs included single-family and multifamily components within the same program.

The programs provide support to encourage high-performance building design that exceeds the 2005 Title 24 energy efficiency requirements by 15% or more, while also aiming to increase the adoption and



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installation of individual high efficiency measures, such as efficient heating, cooling, lighting, and appliances in residential new construction.

While each of the programs includes a whole-house goal and incentive, the number and type of prescriptive measures vary by each utility. The following describes some key differences between the programs.

a. *PG&E: Residential New Construction Program*

This program offers builders financial incentives for energy-efficiency measures. Builders can choose to individually add measures to homes through a prescriptive option or take a whole house approach and upgrade to the California ENERGY STAR New Homes program.

Distinctive features:

- Whole-house incentive for homes built 15% above the 2005 Title 24 Standards and qualified as an ENERGY STAR new home
- Prescriptive incentives including: energy efficient dish washers, clothes washers, central natural gas furnaces, tankless water heaters, and cool roofs.

b. *SDG&E and SCG: Advanced Homes Programs⁵*

This program offers a comprehensive (whole-house) approach to residential new construction and focuses on sustainable design, construction, and energy efficiency. The program utilizes a combination of education, design assistance, and financial support to achieve its goals.

Distinctive features:

- California ENERGY STAR Homes program—homes must meet the ENERGY STAR criteria
- High-rise multifamily program—overall efficiency increased by 15% or more compared to Title 24
- High-performing new homes program with two tiers. Tier 1—15% above Title 24, Tier 2—35% above Title 24

c. *SCE: CA New Homes Program*

This program awards a limited number of incentives to builders whose homes exceed Title 24 code. The program also offers training opportunities, technical support and marketing to help homebuilders build more efficient homes.

Distinctive features:

- Incentives for homes built 15% above Title 24 code
- Additional incentives for homes built 20% or 35% above Title 24 code
- Prescriptive incentives for measures, including appliances and lighting

⁵ Due to high volume the program was temporarily shut down and then re-opened. When the program was re-opened it only offered whole-house incentives for buildings exceeding Title 24 by 15%.



d. The Broader RNC Program Portfolio

The above California programs, which more or less parallel the Massachusetts program, are part of a broader portfolio of program activities designed to increase the adoption of energy-efficient equipment and practices in the single-family and multifamily building industry and include the following:

- Incentives for meeting efficiency criteria;
- Program Plan Check;⁶
- Research & development on new technologies and practices;
- The Codes and Standards Enhancement (CASE) Initiative Project to address energy-efficiency opportunities through development of new and updated appliance (Title 20) and building (Title 24) standards;
- Training of builders and other market actors in new technologies and practices;
- Training (by PG&E only) for building code officials on how to inspect homes for purposes of code enforcement;
- Requirements for HERS ratings to verify proper installation and specified equipment are required for a home to achieve program-specified efficiency levels; and
- Advertising and outreach to increase consumer awareness of efficiency and associated benefits.

2.4.2 NYESLH

Launched in 2000, the New York ENERGY STAR Labeled Homes (NYESLH) program is a modified version of the national U.S. Environmental Protection Agency's (EPA) ENERGY STAR Labeled Homes program. The program marketing and advertising tools are designed to attract home buyers and real estate professionals and encourage participation from builders.

The program provides the following support for builders and Home Energy Rating System (HERS) raters:

- Marketing
- Technical assistance
- Training support
- Financial incentives

Qualifying homes must be built by a participating builder, have a qualified ventilation system, include electrical measures that produce annual electricity savings of at least 450 kWh compared to standard

⁶ Program Plan Check is a process in which IOU staff reviews participating builders' plans and Title 24 compliance documentation to ensure accurate modeling. If significant modeling errors are discovered, Program Plan Check staff members utilize CEC-approved Title 24 compliance software to correctly model the home. The revised model and revised compliance margins are then provided to the builder and energy consultant. This feedback mechanism is intended to both ensure that applications meet program requirements and to educate energy consultants on proper modeling techniques.



measures, and attain a HERS rating of 86⁷ or higher (30% more efficient than homes built to Model Energy Code).

Table 2–2 compares ENERGY STAR homes activity in New York and Massachusetts. Considering the relative size of the two states, the volume of the Massachusetts program is considerably greater.

Table 2-2. Comparison of Program Indicators in New York and Massachusetts as of April 2011⁸

Type of Homes	New York	Massachusetts
ENERGY STAR qualified homes built to date	21,122	19,666
ENERGY STAR qualified homes built 2011 to date	76	610
ENERGY STAR qualified homes built in 2010	2,789	2,407
ENERGY STAR for Homes Partners	1,098	226

2.5 METHODOLOGIES AND NTG RATIOS

This section presents brief summaries of the methodologies employed in each of the studies and resulting NTG Ratios. The information presented is not meant to be comprehensive but instead to provide an overview of the methodologies. For additional details consult the individual evaluation reports.

2.5.1 CA RNC

The RNC evaluations consisted of three main components:

- RNC programs evaluation
- RNC single-family baseline study
- RNC market effects study

The RNC program evaluation and the single-family baseline study both relied on on-site surveys and end-use metering. The on-sites were used to adjust or build models for each of the homes visited. These models were then used to estimate the gross program savings. The baseline homes were used to estimate naturally occurring savings. The study included metering at a total of 162 sites—131 non-participant sites (sampled from new hook-up data) and 31 participant sites. The evaluation team metered Air Conditioning usage at 131 non-participant sites, water heating usage at 50 sites, and heating usage from at 84 sites.⁹ The study also included on-site surveys at 300 non-participant sites and 2 participant sites.¹⁰

⁷ It was 86 in 2006, the period covered by the study, and now is 84. Also, New York uses an expanded HERS score instead of the HERS index used in Massachusetts and most everywhere else. A lower number on the index is better than a higher number. In contrast, with New York’s scoring system, a higher number is better than a lower number. The expanded score is: $80 + (100 - \text{HERS Index})/5$.

⁸ http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showStateResults&s_code=NY

⁹ Not all sites had AC units. Sites with no AC units were included as ‘metered’ but the annual usage was assumed to be zero.

¹⁰ According to the evaluation report, because participant homes were modeled as part of program participation there was no need to visit additional participant sites to develop models.



After all data collection was completed, the evaluation team developed models and employed algorithms to calculate gross and naturally occurring savings for single-family whole-house measures and single-family prescriptive measures. The relative precisions for the meter-to-model ratios varied from +/-70% to +/- 18% at 90% level of confidence.

2.5.2 Difference of Differences

Comparing the non-participant baseline and the participant gross savings, the CA RNC evaluation team was able to calculate net savings using a Difference of Differences approach. Net savings were expressed in savings-per-square-foot and calculated separately for each climate region. The net savings-per-square-foot was then applied to the corresponding square footage of homes contained in the tracking database to obtain net program savings. Net-to-gross ratios were calculated by dividing these net savings by the ex-post gross savings. It should be noted that these savings do not include the impact of market effects as those savings were addressed in a separate study, discussed next.

2.5.3 Market Effects

The market effects study was performed in two phases. Phase I was largely qualitative and was designed to ascertain if there was sufficient evidence of market effects and whether those effects could be linked to IOU program activity. Phase II took a more quantitative approach. This phase began by quantifying the energy savings caused by the market effects, relying on on-site assessments conducted as part of the baseline study. Once gross savings were determined the CA RNC team set out to determine what impact the IOU programs had on the detected market effects. The CA RNC team relied on two Delphi panels: a panel of Title-24 consultants and a separate panel of RNC experts. The Delphi panelists were asked to assign attribution scores to IOU programs and non-IOU factors and to identify elements of the IOU programs most responsible for savings.

Activities undertaken by the CA RNC to understand market effects included:

- Estimating code compliance for non-program homes
- Estimating gross energy savings among non-program homes
- Estimating net savings from market effects
- Assessing the sustainability and persistence of market effects

2.5.4 Resulting NTG Ratio—CA RNC

As shown in Table 2–3, market effects account for the majority of energy savings attributable to the California RNC programs. The California RNC evaluations result in a NTG of 4.12 for electric savings and 7.10 for natural gas savings. When electric savings and natural gas savings are converted to BTU savings, the combined electric and gas NTG ratio is 6.25.

**Table 2-3. CA RNC—Savings Estimates and Net-to-Gross Ratios**

Savings and Market Effects	MWh	Therms	BTUs ¹¹
Gross Savings: No Market Effects	3,631	313,432	43,753
Net Savings: No Market Effects	3,711	165,728	29,246
Net Market Effects ¹²	11,252	2,060,000	244,531
Total Net Savings	14,963	2,225,728	273,778
NTG without Market Effects (Net savings / Gross Savings)	1.02	0.53	0.67
Overall NTG (Net savings + Market Effects) / Gross Savings	4.12	7.10	6.25

2.5.5 Market Effects in Relation to Codes and Standards

There was also a separate Codes and Standards (C&S) evaluation conducted in California.¹³ The savings identified in this study were broader than and included those identified in the market effects study. Further, the IOUs had already claimed the savings identified in the C&S evaluation, so there were no further savings to be claimed as a result of the market effects study. As the market effects report states:

The RNC market effects (ME) study measured savings in homes exceeding the 2005 code relative to homes just meeting the code and in homes just meeting the 2005 code relative to homes not meeting the code. The Codes and Standards (C & S) Program evaluation measured savings in all homes using the 2001 code as baseline. Therefore, all gross savings in the RNC ME study are a strict subset of and should have been counted in the C & S Program evaluation's gross standard savings.

However, the report goes on to say:

It is important to point out that while it is likely that there is overlap in savings with the C & S Programs, the market effects research helps program administrators understand how and why the savings were achieved and where they should consider concentrating their efforts in future program cycles.

Hence the market effects study goes beyond the C&S evaluation by identifying the *program elements* by which net savings were achieved. Many of these program elements—including the training that is responsible for much of the net savings—are part of a broad suite of programs, including some

¹¹ Sum of MWh and Therms in equivalent BTUs.

¹² Net market effects include savings due to above-code homes compared to code-compliant homes and savings in code-compliant homes compared to below-code homes as attributed to the 2006-08 IOU programs by the Delphi panel.

¹³ The Cadmus Group, Inc.. (2010). *Results of Analysis of Market Effects of Utility Programs on Codes and Standards Development (REVISED)*. San Francisco: California Public Utilities Commission.



specifically targeting savings from codes and standards, which are much more extensive than is the case with the Massachusetts RNC program.

2.5.6 NYESLH

The NTG ratio for the NYESLH program consisted of two components: free-ridership and spillover. The NYESLH evaluation included extensive survey and analysis work to develop NTG estimates for the program. The evaluation drew on information collected through a variety of surveys and interviews to determine free-ridership and spillover factors. For free-ridership, the NYESLH relied on builder self-reported data and captured participant spillover and non-participant spillover through interviews with market actors.

a. Free-Ridership

Participating builders were asked direct questions to estimate their partial free-ridership rate; indirect qualitative questions were used as consistency checks to verify builder estimates of their own free-ridership levels. Builders were asked to estimate their lower bound, upper bound, and best estimate of the percentage of ENERGY STAR labeled homes they would have constructed in the absence of the program. Builders were also asked a series of questions related to specific equipment efficiency levels they would have installed in the absence of the program.

Based on builders' responses, the NYESLH evaluation team estimated that the overall free-ridership in the program was 29.7%.

b. Spillover

To estimate spillover, the NYESLH evaluation estimated program savings beyond the measures installed through the program at participating sites. For the evaluation, NYESLH defined spillover as "a combination of several factors that may influence non-reported actions to be taken at the participating home (inside spillover), at other non-participating homes by the builder (outside spillover), or by non-participating builders (non-participant spillover)."

The spillover analysis included interviews with the following market actors:

- 78 interviews with NYESLH new home purchasers (Purchasers)
- 71 interviews with participating builders
- 61 interviews with non-participating builders

During the interviews, purchasers were asked if they had installed any additional energy-efficiency measures in their homes since purchasing it. Participating builders were asked about homes that were not submitted through the program but that could qualify for the program and about the percentage of their non-program homes that included measures similar to their program homes. Non-participating builders, who were aware of the NYESLH program, including previous participating builders, were asked about homes that could qualify for the program but were not submitted through the program. All interviewees were also asked a series of questions to determine the extent to which the program had influenced their decisions to install energy-efficient measures.

According to the NYESLH evaluation, inside spillover (1.0%), outside spillover (9.0%), and non-participant spillover (36.4%) combined account for total spillover value of 46.4%. Forty percent of the non-participant spillover was attributed to builders who had never participated in the NYESLH program and sixty percent was attributed to builders who had previously participated in the program.



c. *Resulting NTG Ratio—NYESLH*

In addition to the point estimate NTG of 1.17 presented in the NYESLH evaluation, the evaluation team also presented a range of NTG ratios based on relative precision. With a 90% confidence interval, the range of NTG estimates was 0.99 to 1.34.

Table 2-4. NYESLH—Savings Estimates and Net-to-Gross Ratios¹⁴

Savings Absent Market Effects	NYESLH	
	MWh	Therms
Gross Savings	5,261	377,951
Net Savings	6,155	442,203
Overall NTG	1.17	1.17
Free-ridership	0.297	0.297
Spillover	0.464	0.464

2.6 CONCLUSIONS

While the California and New York studies offer widely different NTG ratio estimates, they both found that RNC programs have significant market effects, resulting in NTG ratios greater than one, which fits the market transformational goals of the programs. That the CA RNC studies found significantly higher levels of market effects may largely be due to the more extensive range of programs and program activities, including a greater level of training. California also devoted a considerable level of effort to developing and examining a baseline of RNC efficiency trends, and establishing a link between those trends and the RNC programs. Through these efforts the California evaluation team found significant, quantifiable, energy savings in non-participant homes that were attributable to the market effects of a broad suite of RNC programs operated by the California Investor Owned Utilities (IOU). However, it is important to note that the evaluation found that these gross savings overlapped with the gross savings from another evaluation (the Codes and Standards evaluation). Due to this overlap, while these market effects savings were found they were not specifically credited to the corresponding RNC programs. Moreover, some of the program activities identified as responsible for net savings in the market effects study, such as much of the training, were components of a C&S program that has no parallel in Massachusetts.

It is clear from both the CA RNC studies and the NYESLH evaluation that market effects have the potential to add substantial energy savings to RNC programs. In fact, the CA RNC studies found that the IOU programs resulted in substantially more savings from market effects than from direct program participation. While market effects included in the NYESLH evaluation were substantially less, the evaluation did find a high level of program spillover— 46.4%, 40% of which was attributable to builders who had never participated in the program. Indeed, the impact of market effects led to NTG ratios significantly greater than one for the CA RNC programs and the NYESLH program. This finding supports that the programs are achieving their market transformation goals.

¹⁴ The NTG ratio presented in the 2006 evaluation is a blended NTG ratio based on the weighted average of the NTG ratios estimated in the previous MCAC analysis and the current (2006) analysis. This was done because of changes made to the formula used to calculate the NTG ratio, partly due to changes in how spillover was determined.



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However, the scale of market effects found in California is significantly greater compared to those found in New York. This is likely due in large part to due to the more extensive range of programs and program activities, including a greater level of training. In particular, the California programs have much more extensive training for builders, subcontractors, HERS raters, Title 24 consultants, and code officials—and the evaluation identified the training elements of the programs as being most responsible for market effects. The New York program too, while less than that of California, has had more extensive training than Massachusetts.

Another key difference between Massachusetts and both California and New York for purposes of developing a NTG is that the California market effects evaluation focused solely on single family homes, and the New York evaluation focused on one- to four-family homes. More than one- half the units participating in the Massachusetts program, in contrast, are in buildings with five or more units. Many of those, moreover, are low-income buildings, some of them required to meet ENERGY STAR standards and hence likely free riders.

On one hand, given the Massachusetts program's focus on changing building practices, it seems reasonable to assume that it has affected practices in nonparticipating homes and thus has generated spillover. On the other hand, the state mandate for many low-income units to be built to ENERGY STAR standards, coupled with their qualification for program participation, virtually assures a substantial number of free riders in the program. NMR therefore recommends that, until the PAs are able to develop a program-specific NTG ratio, they adopt a conservative ratio of 1.0.



3. COMMERCIAL AND INDUSTRIAL GAS PROGRAMS

3.1 INTRODUCTION

The objective of this chapter is to provide recommended net-to-gross ratios (NTGR) for use in the upcoming gas filings by the Massachusetts Program Administrators for their custom and prescriptive commercial and Industrial (C&I) gas programs.

3.2 METHODOLOGY

Tetra Tech and KEMA conducted a literature review over a two week period beginning May 25, 2011. Our search criteria were restricted to C&I gas program evaluations and explored net savings adjustments for free-ridership and spillover. We reviewed each source of information and summarized the findings¹⁵ as follows: (1) whether the rate is negotiated or based on study results, (2) whether the measure group is prescriptive or custom, and (3) whether the program is new construction or retrofit. In addition, we maintained a source information library of the impact evaluation reports and utility DSM filings referenced.

We reviewed the following in-house and Internet-based information sources:

- Previous Tetra Tech and KEMA in-house gas program impact evaluations
- Email exchange with program staff
- The California Measurement Advisory Council (CALMAC) searchable database (<http://www.calmac.org/search.asp>)
- Consortium for Energy Efficiency (CEE) evaluation/research clearinghouse database (<http://www.cee1.org/search/search.php>)
- Evaluations and DSM filings on state/utility websites
- California Public Utilities Commission Database for Energy Efficient Resources (DEER) (<http://www.deeresources.com>)

3.3 RESULTS

Overall, we reviewed 96 C&I gas NTGRs. Table 3–1 summarizes our overall findings organized by the inclusion of spillover and whether the NTGR is negotiated or study-based.

¹⁵ The accompanying Excel workbook, “MA C&I NTGR Gas Programs Table.xls” provides detailed findings by program and measure type.



Table 3-1. Negotiated vs. Study-Based NTGRs by Program Type

Category	Overall			Negotiated			Study-Based		
	Number of NTGR Inputs	Reviewed NTGR range	Avg. NTGR	Number of NTGR Inputs	Reviewed NTGR range	Avg. NTGR	Number of NTGR Inputs	Reviewed NTGR range	Avg. NTGR
NTGR Inputs Which Include Spillover									
Prescriptive	4	0.80 - 0.89	0.87	2	0.89 - 0.89	0.89	2	0.80 - 0.89	0.84
Custom	2	0.94 - 0.94	0.94	2	0.94 - 0.94	0.94			
Both (Pre & Cust)	44	0.55 - 1.10	0.87	34	0.61 - 1.10	0.91	10	0.55 - 1.10	0.73
Total	50	0.55 - 1.10	0.87	38	0.61 - 1.10	0.91	12	0.55 - 1.10	0.75
NTGR Inputs Which Do Not Include Spillover									
Prescriptive	11	0.36 - 1.00	0.67				11	0.36 - 1.00	0.7
Custom	10	0.43 - 1.15	0.88				10	0.43 - 1.15	0.88
Both (Pre & Cust)	25	0.00 - 1.09	0.57	1	0.90 - 0.90	0.90	24	0.00 - 1.09	0.56
Total	46	0.00-1.15	0.67	1	0.90-0.90	0.90	45	0.00-1.15	0.66

There are three consistent high level patterns evident in our findings:

- On average, study-based NTGRs across all measure groups including spillover are about 15 percent lower than negotiated NTGRs. The average negotiated NTGR is 0.91, while the study based NTGR is 0.75.
- On average, the study-based findings show custom program NTGRs are between seven and twenty percent higher than prescriptive program NTGRs.
- For study-based findings on average, spillover accounts for a nine percent NTGR increase (0.66 to 0.75). We used this spillover difference in deriving our recommendations.

In addition to the summarized findings in Table 3-1, we also reviewed NTGR values which include spillover across whether or not the program is new construction or retrofit. Comparison of this group was inconclusive.

We present summarized findings at a measure group level in Table 3–2, which combines study-based and negotiated NTGRs by prescriptive, custom, and both prescriptive and custom (not broken out).



Table 3-2. Custom vs. Prescriptive NTGRs by Measure Group

Measure Category	Custom			Prescriptive			Programs that include both Prescriptive and Custom		
	Number of NTGR Inputs	Reviewed NTGR range	Avg. NTGR	Number of NTGR Inputs	Reviewed NTGR range	Avg. NTGR	Number of NTGR Inputs	Reviewed NTGR range	Avg. NTGR
NTGR Inputs Which Include Spillover									
Combined				1	0.80 - 0.80	0.80	12	0.55 - 0.90	0.82
HVAC	1	0.94 - 0.94	0.94	1	0.89 - 0.89	0.89	10	0.83 - 1.00	0.91
Process							9	0.68 - 0.90	0.86
Hot Water	1	0.94 - 0.94	0.94	2	0.88 - 0.89	0.89	9	0.61 - 1.10	0.89
Building Envelope							4	0.90 - 0.90	0.90
Total	2	0.94-0.94	0.94	4	0.80-0.89	0.87	44	0.55-1.10	0.87
NTGR Inputs Which Do Not Include Spillover									
Combined	6	0.43 - 0.96	0.76	7	0.50 - 1.00	0.64	9	0.00 - 1.09	0.54
HVAC	1	1.01 - 1.01	1.01	1	0.99 - 0.99	0.99	7	0.37 - 0.92	0.63
Process				2	0.85 - 0.85	0.85	5	0.52 - 0.79	0.6
Hot Water	1	1.00 - 1.00	1.00	1	0.52 - 0.52	0.52			
Building Envelope	2	1.06 - 1.15	1.10				4	0.52 - 0.52	0.52
Total	10	0.43-1.15	0.88	11	0.36-1.00	0.70	25	0.00-1.09	0.57

Based on our literature review of C&I gas NTGRs, Table 3–3 summarizes our recommended values for custom and prescriptive NTGRs, with a brief rationale for each recommendation. These recommendations were derived from the detailed findings across all literature reviewed and detailed in Table 3–1 and Table 3–2.

Table 3-3. NTGR Recommendations by Custom and Prescriptive Programs

Measure Group	Recommended NTGR	Brief Rationale for Recommendation
Custom	0.96	We took the average of two figures: (1) the average of two NTGRs which included spillover (0.94); and (2) the average of ten NTGRs which did not include spillover, adding the overall 0.09 study-based spillover difference estimate (0.97).difference (0.97)
Prescriptive	0.83	We also averaged two figures: (1) the average of four NTGRs which included spillover (0.87); and (2) the average of eleven NTGRs which did not include spillover, adding the overall 0.09 study-based spillover difference (0.79).

3.4 CONSIDERATIONS FOR FUTURE ASSESSMENTS

Given the short timeframe, the literature review and NTGR analysis is not fully comprehensive and did not review of the quality of the studies undertaken. In addition, the study would benefit from more details on the programs that are being compared beyond just having similar measure categories. The level of free-ridership and spillover are affected by the maturity of the programs compared to Massachusetts' program, program design and delivery, marketing strategies, rebate levels, local energy costs, whether measures are custom or prescriptive, and whether the program is new construction or retrofit, among many others factors. With that said,



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our review did unveil consistent patterns and mean values for several measure groups which we believe are reasonable to form the basis of our recommendations. Tetra Tech's upcoming C&I participant gas free-ridership study (beginning later this June) will produce free-ridership and spillover findings which will provide detailed results specific to each C&I Massachusetts gas program.



4. RESIDENTIAL HEHE AND MULTI-FAMILY PROGRAMS

4.1 INTRODUCTION

The objective of this chapter is to recommend a net-to-gross ratio (NTGR) for use in the upcoming gas filings by the Massachusetts Program Administrators for their multi-family retrofit and residential High Efficiency Heating and Water Heating (HEHE) programs.

4.2 METHODOLOGY

Given the short time frame allotted for this work, NMR focused its search for information on a limited number of readily available, easily searched sources. These were:

- Previous gas program evaluations conducted by NMR, Tetra Tech, and KEMA
- The CEE Market Assessment and Program Evaluation Clearinghouse
- Two deemed savings databases: that of the Northwest Regional Technical Forum, and the Database for Energy Efficient Resources (DEER) prepared for the California Energy Commission and the California Public Utilities Commission
- The following state/local databases of evaluation studies: CALMAC, Northwest Energy Efficiency Alliance, Energy Trust of Oregon, WI Focus on Energy and Energy Center of Wisconsin, NYSERDA
- IEPEC, ACEEE Summer Study in Buildings, and AESP proceedings

Per the clarifications to the scope of work received by email from Monica Cohen, Gail Azulay, and Kim Crossman, we focused our literature search on finding measure-specific NTGRs that included spillover for residential and multi-family gas retrofit programs. We found very few gas-only program reports that went down to the measure level, but we did find a number of program reports that addressed both gas and electric NTGR at the individual measure level. Since few reports explicitly included spillover in the NTGR, we have provided the information broken down by NTGRs that include spillover and those that do not.

Of the sixty documents and two deemed savings databases we reviewed for this project, we found a total of 17 reports and one database that provided NTGR (or for which NTGR could be calculated) at the measure level for measures affecting gas usage. Of these, seven studies included spillover in the NTGR. Not all the studies addressed the same measures, or broke down measures in the same way. Of the studies that calculated spillover, with one exception the spillover was one of the following: (1) for the first year of the program or of equipment operation, (2) annualized or (3) no details were given regarding assumptions about the duration of spillover. The exception was a study that offered spillover two ways: both first year and over the expected lifecycle of the equipment. None of the reports was clear about whether spillover was cumulative over the life of a program.

4.3 RESULTS

Table 4–1 below summarizes the NTGR ranges we found for each measure, provides recommendations for NTGR including spillover, and includes the rationale for each recommendation. Recommendations are given only for measures with sufficient information on which to base a recommendation. The recommendations take into account the duration of spillover and the relative cost of the measure. An Excel file with detailed results by study for each measure is also attached. The information by study is split between two worksheets, one for studies with NTGR including spillover and one for those excluding spillover. The details by study include publication information, program (residential HEHE or MF retrofit), NTGR, whether NTGR is study-based or negotiated, spillover value and duration (where provided), and notes.



We have revised Table 4–1 since releasing the first version on June 16. Revisions are as follows:

1. We have broken out information on the program (MF, Res HEHE) for the source of each the NTGR and spillover ranges. Unless otherwise noted, the studies on which the tables are based are of market rate rebate programs.
2. The table makes clear the applicability of each recommendation for each program type (multifamily or residential HEHE).
3. We have added ranges from a study that was not included earlier because it was released to us just as we completed the first version of this memo. The new study included new NTGR for residential boilers, furnaces, programmable thermostats and water heating equipment.
4. We ensured that LI studies were not taken into account in any recommendation unless specifically noted.

4.4 CONSIDERATIONS FOR FUTURE ASSESSMENTS

The maturity of the program and the duration of spillover—cumulative versus annualized or for a particular year—are important considerations in calculating NTGR. Ideally both would commonly be included in evaluation reports, and would explicitly be taken into account in developing NTGR recommendations. Given both the limited time available for this work and the paucity of this kind of information in the reports, we were unable to take this information into account across all the NTGRs assessed. MA programs and the energy efficiency industry would benefit from more systematic inclusion of information on program maturity and the duration of spillover in future evaluation reports. In the future, the Massachusetts Gas Program Administrators and the Energy Efficiency Advisory Council may want to consider requiring this information to be included in studies of NTG for Massachusetts programs, and that these variables be taken into consideration whenever possible in future recommendations of NTGR.



Table 4-1 Revised Summary of NTG by Measure for Measures Affecting Gas Usage

Measure Category	With Spillover Included in NTGR		Without Spillover Included in NTGR		Recommended NTGR <i>or</i> Recommended Spillover	Rationale for Recommendation
	Reviewed NTGR range*	Spillover	Reviewed NTGR range*	Spillover (calculated but not included in NTGR)		
Air sealing	MF: no studies Res: no studies		MF: no studies Res: 0.77 (1 study)		NA	No spillover estimate available. Insufficient information to make a recommendation (only one study with this measure).
Boiler controls—HEHE	MF LI: 1.11 (one study)	0.11	MF: 0.80-0.83 (2 studies)		NTGR 1.0 (Residential)	The recommended NTGR considers the level of free ridership in the LI MF estimate without spillover and the spillover in the reviewed market-rate MF estimates with spillover. In the absence of a market rate estimate of spillover for residential programs, based on research in the MF sector we recommend using 1.0 for this measure.
Boilers—HEHE		Res: 0.12-0.148 (for "furnaces, boilers, and combination heating systems," <i>not</i> for boilers alone—two studies)			Spillover: 0.14 (Residential)	Unable to locate a study that broke out spillover or NTGR for res boilers. Spillover recommendation is based on two residential studies that provided estimates for <i>furnaces and boilers combined into one category</i> . Recommendation is the average of the estimates ($[(.12+.13)/2+ .15]/2$). (One of the studies provided slightly different spillover estimates for the two study years; NMR used the average from this study.)



Measure Category	With Spillover Included in NTGR		Without Spillover Included in NTGR		Recommended NTGR <i>or</i> Recommended Spillover	Rationale for Recommendation
	Reviewed NTGR range*	Spillover	Reviewed NTGR range*	Spillover (calculated but not included in NTGR)		
Furnace/ECM furnace—HEHE		Res Participant: 0 Res Non-participant: 0.12 (one study)		Res Participant: 0.015 Res Non-Participant: 0.25 (one study)	Spillover: 0.19 (Residential)	Spillover is based on the two residential studies that provided separate calculations of spillover. It is the sum of the average of the participant and non-participant spillover values from each of these studies $([0+0.015]/2+[0.12+0.25]/2)$.
Insulation	MF: 0.81 (one study) Res: 0.80 (one study)	Participant: 0.03 Non-participant: 0.22	Res: 0.62 -0.70 (2 studies) MF: 0.79 (one study)	Res Participant: 0.049 Res Non-participant: 0.25	NTGR 0.8 (Multifamily)	NTGR w spillover based on 2 studies, one each MF & res; spillover adoptions identified within 2 year window. NTGR without spillover based on 2 studies ; spillover estimated for 2 of these studies.
Programmable thermostats	MF: no studies Res: no studies		MF: 0.88 (1 study) Res: 0.20-0.49 (2 studies)	MF: no studies Res Participant: 0.016 (1 study) Res Non-participant: 0.06 (1 study)	NTGR 0.88 (Multifamily) 0.42 (Residential)	One study for MF and 2 for residential, in CA & MI. Spillover estimated for CA but not included in NTGR. While we generally would not recommend a NTGR based on only one study conducted outside Massachusetts, and we have been asked to recommend at NTGR only when spillover has been addressed California studies are generally rigorous, and programmable thermostats account for a lot of savings in Massachusetts; we therefore make an exception here. The recommended MF NTGR (0.88) is simply the estimate from California; it is relatively high even without spillover. The recommended res NTGR (0.42) is the average of the



Measure Category	With Spillover Included in NTGR		Without Spillover Included in NTGR		Recommended NTGR <i>or</i> Recommended Spillover	Rationale for Recommendation
	Reviewed NTGR range*	Spillover	Reviewed NTGR range*	Spillover (calculated but not included in NTGR)		
						without spillover estimate from California and Michigan (.35), plus the participant and non-participant spillover from California (.016+.06).
Miscellaneous Water heating equipment	MF: 0.24 - 0.45 (one study) Res: No studies		Res: 0.13 - 0.58 (3 studies) MF: No studies	Res Participant: 0.039 Res Non-participant: 0.17	NTGR 0.63 (Residential)	Recommended Res NTGR ratio is the average of the reviewed without spillover estimates (0.42), plus the spillover (0.04+0.17). Insufficient information for a MF recommendation (one study).
Water saving devices	MF: 0.58 - 0.96 (2 studies) Res: no studies	MF: 0 (1 study)	MF: 0.68 - 0.69 (1 study) Res: no studies		NTGR 0.77 (Multifamily)	NTGR w spillover based on 2 MF studies. NTGR without spillover based on 1 MF study. Recommended NTGR is the midpoint between the two reviewed estimates w spillover.
Windows	Res: 0.80 (one study) MF: 0.85 (one study)	Res Participant: 0.016 Res Non-participant: 0.06	MF: 0.47 (one study)	Res Participant: 0.015 Res Non-participant: 0.08	NTGR 0.8 (Combined MF & Res)	NTGR w spillover based on 1 res & 1 MF study, both OR. NTGR without spillover based on 1 res study. The recommended NTRG ratio is the low end of the two reviewed estimates w spillover, considering the low spillover estimated but not included in the NTGR in the other studies.

* Where free-ridership was offered without a NTGR, we calculated NTGR by subtracting free-ridership from 1.

* Unless otherwise noted, recommendations exclude from consideration low-income programs and measures that were not rebated.