Giving Credit Where Credit is Due: Assessing Attribution and Savings from a Building Energy Code Compliance Enhancement Program

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ABSTRACT

Energy code compliance enhancement programs play a critical role in fostering energy-efficient building practices and improving code compliance rates. The recent proliferation of code compliance enhancement programs has helped promote energy-saving building practices among a wide spectrum of new construction stakeholders. Understanding the influence of such programs on building practices is important to justify continued engagement from energy-efficiency program administrators. However, the influence can be hard to measure as this kind of program indirectly affects building energy efficiency. This paper summarizes findings from an evaluation of the efforts of Massachusetts' statewide building energy code enhancement program. The evaluation assessed the influence of the program on the commercial new construction sector and estimated related savings stemming from improved compliance rates. The evaluation used an innovative approach for assessing program attribution and estimating related savings. The results offer important insights for program administrators in other jurisdictions interested in assessing attribution of energy code enhancement programs, and for policymakers responsible for reviewing such assessments. This paper builds upon and contributes to the growing body of research focused on code compliance efforts that affect the commercial sector.

Introduction

Since 2014, the Massachusetts Program Administrators (PAs) have funded the Code Compliance Support Initiative (CCSI), a code enhancement effort designed to improve the energy code compliance rates of residential and commercial[1] buildings, thereby achieving greater electric and gas savings statewide. The CCSI offers training and technical assistance to help building professionals and code officials[2] stay abreast of changes to building energy codes as they occur, understand how to apply such changes to their work, and learn to better enforce the energy code to achieve greater compliance. The classroom and in-field trainings, which range from one to four hours in length, are rooted in building science principles and best practices. The CCSI offers technical assistance to code officials and building professionals through the their implementation contractor via statewide circuit riders. These individuals provide phone and email support to answer general energy code questions and provide code interpretations. The CCSI also uses statewide circuit riders, who provide outreach services, education, and support in the field through plan and specification review and on-site observations. In 2018, the Massachusetts PAs and the Energy Efficiency Advisory Council (EEAC) consultants contracted with NMR

[1] This market segment is referred to as both the non-residential and commercial market in this paper.
[2] Building professionals include builders, contractors, design professionals, energy-efficiency consultants, project managers, engineering service providers, among others. Code officials include individuals involved in building code enforcement, such as building commissioners, building inspectors, and plans reviewers.

and Cadmus (referred to as “the team”) to estimate the savings attributable to the commercial portion of the CCSI for the 2019-2021 program period. This evaluation only accounts for the influence of the CCSI and related savings for true new construction (e.g., new commercial buildings constructed from the ground up). Although code enhancement activities may affect renovation projects that trigger building energy code requirements, there was insufficient data regarding retrofit activity (from the PAs and other sources) to accurately estimate these related savings.

Methodology

This evaluation used a Delphi panel approach to estimate savings attributable to the CCSI from code compliance enhancement efforts. The Delphi method is a group communication process, or forecasting method, that relies on panels of experts to develop an estimate or group judgment on a topic or issue. It is an interactive process that involves at least two rounds of questions or interviews with panels. The Delphi technique is based on the principle that structured responses from experts will be more accurate than unstructured responses from individuals.

The overall process for this evaluation involved several major steps and relied on multiple sources of information (Figure 1). The main steps for this process were to (1) identify factors affecting code compliance and supply them to a panel of experts (Delphi panel) to assess attribution, (2) convene the Delphi panel to estimate code compliance with and without the CCSI, (3) calculate gross technical potential (GTP) savings, and (4) estimate net savings from the CCSI (by multiplying CCSI attribution derived in Step 2 by GTP savings derived in Step 3).

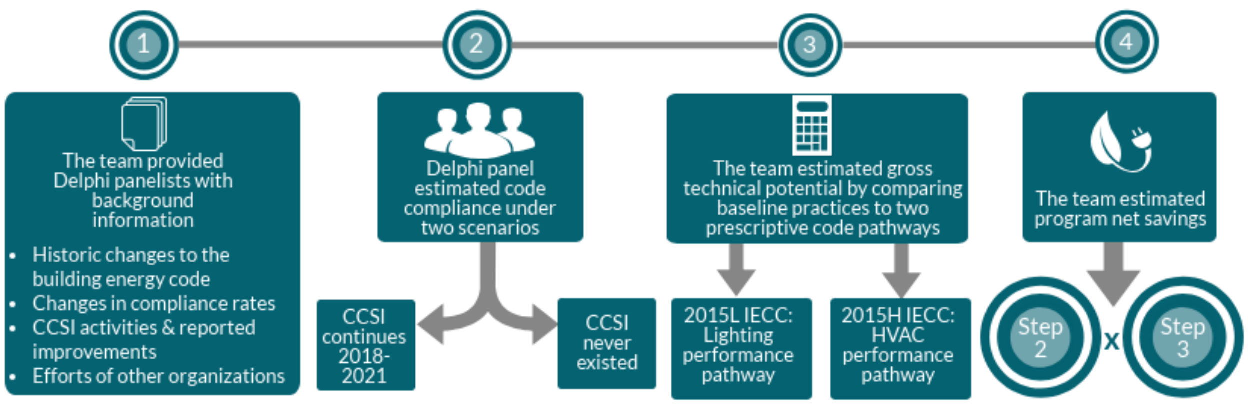

Figure 1. Evaluation Approach

The sources of data and information the team relied on to derive an attribution estimate and project related energy savings for the CCSI were established several years ago. One key source for the evaluation was the series of statewide commercial code compliance baseline studies that occurred between 2012 and 2018 (DNV KEMA, Energy & Resource Solutions, and APPRISE 2012; DNV GL, Energy & Resource Solutions, and APPRISE 2015; DNV GL Energy & Resource Solutions, and APPRISE 2018). The team also relied on related modeling results from the New Buildings Institute (NBI) that estimated the GTP from code compliance enhancement. The Massachusetts PAs and EEAC have funded these efforts to measure commercial new construction compliance rates, collect information on trends and common practices within the industry, and identify opportunities to improve code support activities. The team also reviewed CCSI training materials and drew upon results from multiple formal evaluations of the CCSI. These ongoing evaluations help to assess the CCSI’s influence on attendees’ professional practice.

The overall approach for this evaluation followed the guidelines from a 2015 report: *Recommended Methods for Assessing Market Effects of Non-Residential New Construction Programs*

(Tetra Tech and NMR Group, Inc. 2015). The objective of the report was to outline appropriate methods for evaluating market effects resulting from Massachusetts' Non-Residential New Construction program. The report includes proposed methods for establishing qualitative evidence of the program's effects on the market, quantifying the market effects, and estimating net savings. The report identified several other PA-sponsored programs and initiatives that may affect the commercial new construction market, in addition to the CCSI. The report specifically recommended using a Delphi panel to estimate the CCSI savings attribution (analogous to a net-to-gross [NTG] ratio) and called for the panel to estimate the efforts of the PA program on building practices, rather than energy use, net savings, or NTG.

Analysis and Results

The process of assessing the proportion of savings attributable to the CCSI involved multiple steps and relied on primary and secondary sources of data. These steps and related data sources are described below. The evaluation report provides more detail on the overall process and related findings (NMR Group, Inc. and Cadmus 2018).

Step 1: Identify Factors Affecting Code Compliance

To help Delphi panelists estimate code compliance rates with and without the CCSI, the team provided panelists with a *situation memo* that summarized background information about commercial building energy codes in Massachusetts, including an overall timeline of events, code compliance rates before and after the CCSI was implemented, CCSI trainings and their influence on participants (as estimated from participant surveys), code enhancement efforts of other organizations, and other relevant information about the CCSI. Together, this information helped Delphi panelists estimate the effects of the CCSI on code compliance rates, or program attribution. Key highlights from the situation memo are presented below. As noted previously, the full evaluation report offers greater detail on the information presented to the Delphi panelists (Ibid.).

Program Background and Timeline. As noted above, the CCSI was established in 2014, and training on the commercial code starting in November of that year. At the time, the 2012 International Energy Conservation Code (IECC) was in place. The situation memo for Delphi panelists included a timeline of CCSI trainings within the context of recent building energy codes in Massachusetts (IECC code cycles and Massachusetts' Stretch Code[3]). The timeline, shown in Figure 2, also indicated the timing of three separate statewide commercial code compliance baseline studies. Because the baseline studies rely on building permit dates, the timeline indicates our best estimates of when the buildings included in these studies completed construction. Although the CCSI commercial training started four months after the 2012 IECC went into effect and the attribution assessment period fell under the 2015 IECC, this timeline was important for providing historical context to better understand the increases in efficiency required by the code over time.

[3] The Stretch Code is an optional appendix to the Massachusetts state building energy code, which offers greater efficiency than is required by the base energy code.

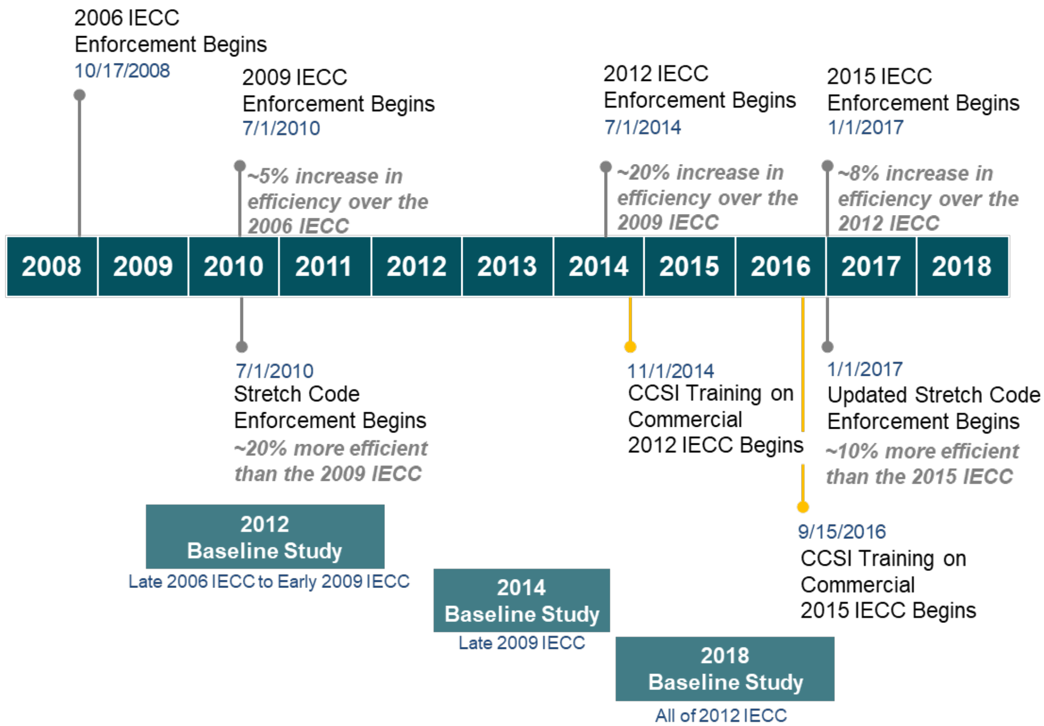

Figure 2. Timeline of Events

Changes to the Building Energy Code. As Figure 2 shows, increases in the stringency of the Massachusetts commercial energy code and Stretch Code have varied over time. The 2009 IECC increased the energy-efficiency requirement by approximately 5% over the 2006 IECC, with each subsequent code mandating greater energy efficiency than its predecessor. The 2012 IECC increased the requirement by roughly 20% over the 2009 IECC, and the 2015 IECC increased the requirement by about 8% over the 2012 IECC.

In addition, the proportion of jurisdictions enforcing the Massachusetts Stretch Code, instead of the state base code, has increased substantially over time. The first edition of the Stretch Code went into effect in July 2010, the same time the 2009 IECC became effective as the state's base energy code. This Stretch Code was roughly equivalent to the 2012 IECC and stayed in effect unchanged when the 2012 IECC went into effect as the state's base energy code. Both the base energy code and the Stretch Code were updated in 2017, with the updated Stretch Code requiring buildings to be about 10% more efficient than the 2015 IECC. As of September 2017, 70% of the state population resided in the 207 jurisdictions that had adopted the Stretch Code.[4]

Changes in Code Compliance Rates. Three commercial code compliance baseline studies, funded by the Massachusetts PAs and EEAC in 2012, 2014, and 2018, found that code compliance rates have varied over time as the code has changed (DNV KEMA, Energy & Resource Solutions, and APPRISE 2012; DNV GL, Energy & Resource Solutions, and APPRISE, 2015; DNV GL, Energy & Resource Solutions, and APPRISE 2018). The three studies included buildings permitted under three different code cycles, and the 2014 and 2018 studies used two different methodologies for calculating compliance rates: the Department of Energy and Pacific Northwest National Laboratory (DOE/PNNL) approach and the Massachusetts

[4] As of November 27, 2018, 250 municipalities in Massachusetts have adopted the Stretch Code. This evaluation occurred before this date.

Commercial and Industrial Evaluation Contract team (MA-CIEC) approach.[5] While the team presented Delphi panelists with the results based on both methods to show a longer period of data, the team also instructed panelists to focus on and estimate compliance based on the MA-CIEC method as it more accurately reflected energy consumption and savings opportunities.

Table 1 shows weighted compliance results from the baseline studies and the applicable code. The team presented the Delphi panel results from the first two baseline studies to illustrate past compliance rates and likely impacts of code changes on building practices, although these results were not influenced by the CCSI. The 2018 baseline study is the only compliance study that has occurred since the start of the CCSI. While it is possible that some of the buildings included in the 2018 study were influenced by the CCSI, the extent of that influence is uncertain considering the timing of the trainings and the lag time between commercial new construction design, permit, and completion dates.

Table 1. Compliance Trends

Study Year	Calendar Year	Applicable Code (Cycle Timing)	Site Count	DOE/PNNL Approach		MA-CIEC Approach
2012	2009-2010	2006 IECC (Late)	48	82%	82% combined	NA
	2011-2012	2009 IECC (Early)	27	76%		NA
2014	2013-2014	2009 IECC (Late)	50	85%		94%
2018	2015-2016	2012 IECC (All)	39	88%		94%

In addition to overall compliance rates, the team shared compliance rates by measure category (lighting, HVAC, and building envelope) as additional points of reference. The results were mixed but revealed relatively high compliance overall. Figure 3 displays unweighted measure-level and weighted overall compliance rates. The compliance results for the 2012 IECC show improved compliance rates for lighting and HVAC measures compared to previous rates under the 2006 and 2009 IECC. Compliance rates for building envelope measures only improved slightly using the DOE/PNNL method (79% to 80%) and dropped slightly using the MA-CIEC method (from 95% to 91%). As noted in Figure 2, the increase in efficiency between the 2006 IECC and the 2009 IECC was not as significant as the increase in efficiency between the 2009 and 2012 IECC.

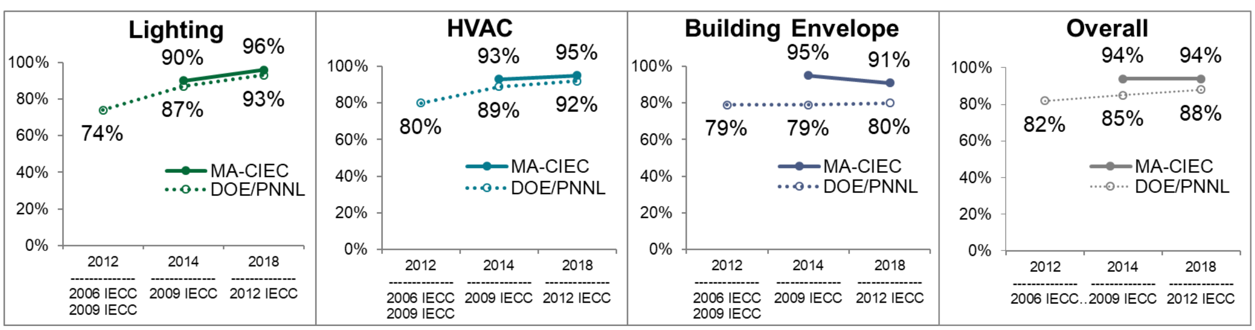

Figure 3. Compliance Rates by Measure Category and Overall

[5] The DOE/PNNL method weighs each provision of the energy code according to the relative energy impact of its compliance or non-compliance. This approach is compatible with compliance rates in other jurisdictions and provides consistency with results from previous years. The MA-CIEC method, used in the 2014 and 2018 studies, accounts for partial compliance with energy code provisions and trade-offs within the building envelope that are permitted by the energy code. Unlike the MA-CIEC method, evidence indicates that the DOE/PNNL method does not correlate well with actual impacts on energy usage.

CCSI Training and Support Services, Participants, and Reported Improvements. Between November 2014 and October 2017, the CCSI sponsored 52 public and private classroom training sessions covering the 2012 and 2015 IECC, with stretch code topics discussed in the courses where appropriate. The training sessions focused on three main areas of the energy code: envelope provisions and building science (EBS); mechanical provisions (MP), including HVAC equipment and system requirements; and lighting, lighting controls, and electric provisions (LLC).

A total of 1,089 unique attendees participated in the 2012 and 2015 IECC commercial energy code trainings. For both code years, most attendees were code officials (45% in the 2012 IECC trainings and 59% in the 2015 IECC trainings) or architects or design engineers (17% and 18%, respectively). Based on the training records, the team estimated that 35% (270 out of 767) of the code officials in the state of Massachusetts received 2012 IECC commercial energy code training through CCSI and 37% (285 out of 767) received 2015 IECC training.

Feedback on the trainings was collected from participant surveys immediately following the training sessions, as well as from in-depth interviews with training attendees conducted approximately six months after the trainings. The purpose of the surveys and interviews was to evaluate training effectiveness and to determine if information from the courses was used by attendees to better comply with or enforce the energy code. In general, respondents provided positive feedback regarding the quality and usefulness of the training material and indicated that the trainings were likely to affect building practices, as evidenced by the following training evaluation findings:

- Immediate surveys found that training participants planned to use information from the training to assist with code compliance or enforcement. About 75% of both the 2012 IECC and 2015 IECC training respondents said they would use the information immediately or within three months (77% and 74%, respectively).
- Attendees indicated that the trainings were relevant to their job functions and reported sharing information from the trainings with others. In follow up interviews, 90% of 2012 IECC training respondents and 80% of 2015 IECC training respondents reported they shared information from the trainings with other parties.
- Training participants generally offered positive feedback on the trainings. In the follow-up interviews, respondents noted that training was informative, comprehensive, and kept the industry up to date with changes in the code.
- Most attendees (87% of 2012 IECC training participants and 93% of 2015 IECC training participants) said that they would recommend the training to others.
- The majority of code official and building professional respondents said that insufficient education posed the greatest barrier to compliance. In many cases, respondents said that this resulted from recent adoption of a new code and the subsequent learning curve.

To further enhance energy code compliance, the CCSI provided energy code technical support assistance via phone and email. Of the 67 phone calls or emails fielded by the statewide circuit riders from 2014 through 2017, nearly one-half (45%) occurred in 2017, the period of interest for the evaluation.

Efforts of Other Organizations. To determine the potential influence of non-CCSI enhancement efforts, the team sought to identify efforts of other organizations and entities designed to support energy code compliance in Massachusetts. Research conducted by the team found that the CCSI is the primary statewide resource for training and support related to commercial building energy codes. The team determined that only a few other organizations provide direct code training or support, and none provide it to the same extent as the CCSI.

Step 2: Utilize Delphi Panel Process to Determine CCSI Attribution

To produce an estimate that reflects the change in new commercial building code compliance attributable to the activities of the CCSI, the team assembled a panel of experts (Delphi panel) in building energy codes and code compliance who work in Massachusetts and nationwide. The team shared the background information and research included in the situation memo, as described in Step 1, with the Delphi panel. The panelists were asked to estimate what they would expect code compliance to be for the 2018–2021 period under a *with the CCSI* scenario and what it would be under a hypothetical *without the CCSI* scenario. The panelists provided this information in two rounds. The team participated in both rounds by developing an independent set of responses in the same manner as the rest of the panel. The team reviewed the information presented to the other panelists, independently developed initial compliance estimates under the two scenarios, and documented their reasoning. All responses, including those provided by the evaluation team, were reported anonymously.[6] Results from the Delphi panel were used to inform the forecast of attribution across the 2019–2021 period.

Delphi Panel Selection and Participation. The team created a candidate list of knowledgeable, objective panelists, both in and out of the state of Massachusetts. The selected candidates had the experience and credentials necessary to evaluate the impact of the CCSI on code compliance. Experts were selected because of their firsthand experience with the Massachusetts energy code, participation in code enforcement organizations and regional energy-efficiency organizations, and involvement in similar studies conducted in other states. The team invited 31 individuals to participate as part of the Delphi panel, including code officials, architects, engineers working in Massachusetts, and building energy-efficiency consultants and program evaluators working nationally. Eleven of the 31 experts agreed to participate, including seven in-state and four out-of-state experts. The in-state experts included one building plans examiner, two building commissioners, two architects, one design engineer, and one mechanical engineer. The out-of-state experts included two private consultants, an education and training expert, and one program manager.

Delphi Panel Process. For the first round of the Delphi panel, the team asked each panelist to individually review the situation memo and estimate attribution in the form of commercial building energy code compliance levels for 2018, 2019, 2020, and 2021 under two scenarios: (1) assuming the CCSI continues training and outreach in the future at a level similar to historical efforts and (2) assuming the CCSI was never implemented. The team instructed the panelists to assume the 2015 IECC would be effective for buildings covered throughout the period. The team also requested that panelists provide a brief explanation for their responses. All responses, including those provided by the team, were compiled into one document that included estimated compliance rates and rationales. All responses were presented anonymously.

For round two, panelists reviewed the estimates provided by the other experts, including the team, and revised their original answers in light of their peers' responses, if desired. Round-two responses were submitted with an explanation of changes, if applicable, and were again analyzed as a whole.

Delphi Panel Results. Figure 4 presents the average of the panelists' estimates of code compliance for the two baseline scenarios (with the CCSI and without the CCSI) for both rounds of the Delphi process. It is important to note that while the team provided all of the first-round responses and associated rationales to the panelists as part of the second round of the Delphi panel, the graph below excludes outliers from

[6] The team participated in the Delphi process just like all other panelists. The team's forecasts were one of 11 responses and were ultimately averaged with the others. Had the team's estimates been an outlier from the others, the results would have been removed after the second-round response — just like any other panelist.

the round-two results.[7] The two outliers were both Massachusetts code officials who estimated compliance at around 80% with little or no increase over the four years with CCSI in place, which is highly unlikely given the historical compliance rates in the state. It is important to note that the evaluation team provided all of the first-round responses and the associated rationales, including outliers, to the panelists as part of the second round of the Delphi panel. The team only removed these outliers from its final analysis.

In round one, the panelists' estimated compliance rates with the CCSI were high and increased each year. Estimates for 2018 showed that the panel thought the compliance rate would stay about the same when the 2015 IECC became effective as it was under the 2012 IECC. The estimated average compliance rates under both scenarios increased in round two. In contrast, more respondents decreased their compliance estimate for the second round than increased it. In both rounds, the panelists' estimated code compliance rates were higher under the *with the CCSI* scenario compared to the hypothetical *without the CCSI* scenario, indicating a certain amount of attribution for the CCSI.

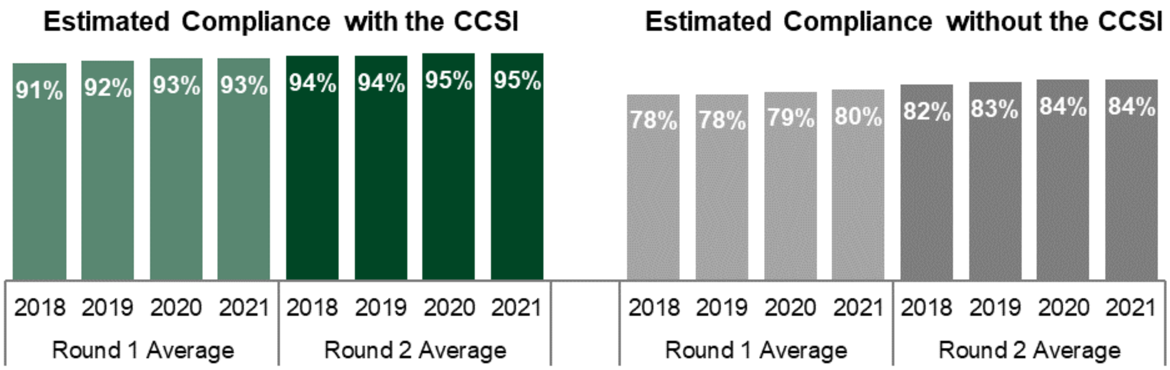

Figure 4. Panel Compliance Estimates with the CCSI and without the CCSI
Note: Removing the two outliers from round two increased the average compliance rates between the two rounds.

CCSI Attribution. The team relied on the Delphi panel's round two compliance estimates to project CCSI attribution over time; Table 2 shows the calculations used by the team. The logic employed by the team to develop each component of the projected values is described briefly below; the full report provides more information on detailed calculations and assumptions (NMR Group, Inc. and Cadmus, 2018).

Table 2. Estimated Compliance and CCSI Attribution Over Time

		2017	2018	2019	2020	2021
Compliance Estimate with CCSI	A	93%	94%	94%	95%	95%
Compliance without the CCSI	B	81%	82%	83%	84%	84%
Compliance if the CCSI Ceased to Exist After Implementation *Calculation: (A+B)/2*	C	87%	88%	89%	89%	90%
Compliance Attributable to CCSI *Calculation: A-C*	D	6%	6%	6%	5%	5%
Portion of GTP Savings Achieved *Calculation: D/(1-^{2017C})*	E	48%	46%	45%	42%	42%

Note: See below for an explanation of the calculations.

[7] The team identified responses outside 1.5 times the interquartile range as outliers. Two respondents were outside this range in round one. In the second round, one of the same respondents fell outside the range; the second respondent did not provide a round two response.

- **A. Compliance with the CCSI:** The 2018–2021 values for compliance *with the CCSI* represent the average results from the second round of the Delphi panel after removing two outliers from the results (explained above). Since the 2015 IECC went into effect in 2017, the team retrospectively calculated the 2017 value from the Delphi panel results. As such, Table 2 includes compliance estimates for 2017 and 2018 for the purpose of projecting program net savings.
- **B. Compliance without the CCSI:** The 2018–2021 values for compliance *without the CCSI* represent the average results from the second round of the Delphi panel after removing two outliers from the results. Since the 2015 IECC went into effect in 2017, the team retrospectively calculated the 2017 value from the Delphi panel results.
- **C. Compliance if the CCSI were to Cease to Exist After Implementation:** Because the period of interest covers 2019–2021, the team determined that it was appropriate to estimate compliance as if the CCSI were to end in 2018. Since the Delphi panelists were not asked to estimate impacts under this scenario, these values were derived by calculating the midpoint between panelists' estimates for compliance *with the CCSI* and compliance *had the CCSI never existed*.[8]
- **D. Compliance Attributable to CCSI:** These values represent the difference between estimated compliance rates with and without the influence of CCSI after 2018.
- **E. Portion of GTP Savings Achieved:** These are calculated values that were ultimately used to calculate net savings. The values represent the compliance percentage that is attributable to the CCSI divided by the overall level of non-compliance that would exist if the program were to cease to exist after 2018. The team fixed the comparisons to 2017 as this value most closely represents the sample that was used to calculate GTP. Modeled results from the 2018 DNV GL code compliance study represented the GTP from compliance enhancement at a fixed point in time. The buildings used in this analysis were built under the 2012 IECC but may display some improved efficiencies due to the CCSI. As a result, the team expects that had the program not existed, these buildings would have been less efficient and estimated savings would have been higher. However, the team also expected that buildings constructed to the 2015 IECC would be slightly more efficient than projects built to the 2012 IECC. For the purposes of this analysis, the team assumed that these factors would balance each other out and that the modeled results represent GTP savings at the beginning of the 2015 IECC under a scenario with no program influence.

Step 3: Calculating Gross Technical Potential

The team calculated GTP from two main inputs: baseline technical potential and projected growth in the commercial new construction sector. The estimate is simply a formula that multiplies technical potential by projected commercial new construction growth for 2019–2021; although, each of these two inputs involves multiple components, as explained below. Note that for this study, only actual new construction activity was included. While many retrofits of existing buildings may also require compliance with the energy code, existing building compliance was not studied, nor included in estimates of gross potential due to lack of data.

Baseline Technical Potential. The team used modeling results from the 2018 commercial baseline study to estimate baseline technical potential. The modeled results were reported separately by lighting (2015L) and HVAC (2015H) savings. The team assumed that these values correspond to Sections C406.2 and C406.3 of the code, which gives options for building professionals to meet the code requirements of

[8] This decision was made after both rounds of the Delphi panel concluded. The team, with input from the PAs and EEAC, derived the estimated compliance assuming the CCSI would cease to exist after 2018 by using the average compliance results (e.g., mid-point) provided by the Delphi panelists under the two scenarios listed above.

reduced lighting power density or more efficient HVAC performance.[9] The 2015L IECC option results in a negative value for gas savings because the reduced internal gains from high-efficiency lighting leads to an increase in the gas heating consumption of buildings. Assuming that roughly one-third of the lighting energy savings is offset by increased heating energy needs, the overall building energy use is reduced. However, the results for the options are not additive, which is why they were modeled separately. Table 3 shows the weighted outputs.

Table 3: Baseline Technical Potential

Code Option	Technical Potential		
	Overall (kBtu/sf)	Gas (kBtu/sf)	Electric (kWh/sf)
2015L IECC	1.3	(0.4)	0.5
2015H IECC	2.9	0.3	0.8

Commercial New Construction Growth. The team used data from Dodge Data & Analytics to estimate the growth in the commercial sector. The Dodge database provides a listing of all construction activity in a specified jurisdiction for a specified range of dates. The team relied on new construction starts in thousands of square feet (ksf). To project through 2021, the team assumed a 1.5% average growth rate[10] of new construction starts and further assumed that commercial new construction projects take between one and three years to complete, thus applying an even distribution for each three-year period. Since the 2015 IECC went into effect on January 1, 2017, the calculations affect two-thirds of the buildings projected for 2019 and all of the buildings for 2020 and 2021. Table 4 shows the overall results from these calculations.

Projecting Gross Technical Potential. Table 4 combines the inputs from Table 3 with projected new construction to derive projected GTP. As noted above, separate results are presented for the lighting (2015L) and HVAC (2015H) compliance paths.

Table 4. Estimated Gross Technical Potential

Year	Technical Potential (EUI)				New Construction Growth (ksf)	Gross Technical Potential			
	2015L IECC		2015H IECC			2015L IECC		2015H IECC	
	Electric (kWh/sf)	Gas (kBtu/sf)	Electric (kWh/sf)	Gas (kBtu/sf)		Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)
	A	B	C	D	E	A*E	B*E*10	C*E	D*E*10
2019	0.5	(0.4)	0.8	0.3	18,458	9,432	(77,347)	14,362	49,820
2020					27,897	14,256	(116,902)	21,707	75,298
2021					28,320	14,472	(118,673)	22,036	76,439
					3-year total	**38,159**	**(312,922)**	**58,106**	**201,558**

[9] The 2015 IECC added an "Options Package," specifying that code users must comply with one of six provisions. Section C406.2 requires more efficient HVAC performance and Section C406.3 requires a reduced lighting power density system. The Massachusetts amended code is generally more stringent than the base code as it requires at least two of these six options to be selected. Projects located in municipal utility territories that are not served by the Mass Save Program are only required to select one of the six options.

[10] The team also explored using data from U.S. Department of Commerce's Bureau of Economic Analysis to estimate new construction growth. According to those data, the average growth rate for construction gross domestic product (GRDP) from 2012 to 2015 was 8.7%. The team ultimately chose the Dodge data because the source is consistent with the square foot estimates, and the Dodge data offer a more conservative growth rate.

Step 4: Estimating Program Net Savings

Using the program attribution values, the team calculated program net savings with the following equation, relying on program attribution from Table 3 and GTP from Table 4:

$$Program\ Net\ Savings_{year} = Program\ Attribution_{year} \times Gross\ Technical\ Potential_{year}$$

Table 5 displays the estimates for 2019–2021 and the three-year totals. Alternatives for the overall net savings values are offered as Methods 1 and 2. Method 1 includes separate savings estimates for the lighting and HVAC compliance paths. Method 2 uses an average of the savings associated with 2015L and 2015H. The exact weighting of these savings depends on how builders comply with the code, which is unknown. For Method 2, absent existing data on this, the team assumed that 50% of builders would use one path and 50% would use the other. The average includes the negative gas savings associated with 2015L potential savings. For both methods, the three-year MMBTU values show that the electric savings more than offset the negative gas savings.

Table 5: Savings Attributable to CCSI

Year	Method 1: Net by Code Option				Method 2: Average Savings Including Negative Gas Savings	
	2015L IECC		2015H IECC			
	Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)	Electric (MWh)	Gas (therms)
2019	4,200	(34,445)	6,396	22,186	5,298	(6,129)
2020	5,952	(48,806)	9,063	31,437	7,507	(8,685)
2021	6,042	(49,545)	9,200	31,913	7,621	(8,816)
3-year Total	**16,194**	**(132,796)**	**24,659**	**85,536**	**20,426**	**(23,630)**
Savings in MMBTU						
2019	14,292	(3,444)	21,762	2,219	18,027	(613)
2020	20,250	(4,881)	30,836	3,144	25,543	(868)
2021	20,557	(4,955)	31,303	3,191	25,930	(882)
3-year Total	**55,100**	**(13,280)**	**83,902**	**8,554**	**69,501**	**(2,363)**

Conclusions and Recommendations

This paper offers important insights for PAs in other jurisdictions interested in assessing attribution of code compliance enhancement programs. The analysis highlights key considerations for selecting appropriate indicators for attribution and for estimating related energy savings, particularly those associated with commercial new construction. A few related considerations and implications are included below.

- **PAs and evaluators should recognize the need to capture a variety of data types when designing their compliance enhancement programs.** This evaluation documented and compiled information from a number of sources to present to the Delphi panel. The groundwork for these data sources was established years in advance of the attribution assessment. The team relied on a series of commercial baseline studies that occurred before and after the training was established. Other critical sources of information included the content of the training and evidence of its impact on training participants. PAs facing a similar task should be mindful of the lengthy timelines in the commercial new construction sector, and efforts to measure the impact in this market should account for these timelines.

- **PAs and evaluators should leverage multiple sources of data to develop reasonable assumptions regarding commercial new construction building trends.** In addition to the baseline studies, the team examined other sources, such as Dodge Data & Analytics and the U.S. Census, to establish previous market patterns and inform projected estimates. Since the study examines the commercial new construction market, the team carefully considered lag times associated with design, permit, and completion dates in this sector. The team also worked closely with the Massachusetts PAs and EEAC to vet and, as appropriate, iterate on the logic for projections.
- **PAs and evaluators should account for the timing of building energy code cycles and related impacts.** The CCSI was established in Massachusetts shortly after the state adopted the 2012 IECC. The timing of the training and compliance study offered an opportune time to assess the impact of the training on building practices and compliance rates. While the evaluation was defined by a certain timeframe, the assumptions and estimates will need to be re-examined after the state adopts the 2018 IECC and sufficient research has been conducted to assess related compliance rates.
- **PAs and program stakeholders considering a similar assessment should thoughtfully examine the feasibility and value of such an undertaking.** Finally, while this paper offers an innovative approach for assessing attribution of Massachusetts' code compliance enhancement program, stakeholders in other jurisdictions should carefully explore whether a similar undertaking is feasible for their program. As noted above, this evaluation relied on well-established research on the commercial new construction market in Massachusetts. Assessing attribution for code compliance enhancement programs is complicated because the market is influenced by multiple factors, including the building energy code environment, advances in certain technologies and building materials, and overall acceptance of efficient building practices. Ultimately, the potential savings from code compliance enhancement programs should be sizable in order to justify investing resources to research program impacts.

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