Commercial Energy Code Compliance Enhancement Pilot: Final Report

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Conservation Applied Research and Development (CARD) Final Report

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DISCLAIMER

Table of Contents

List of Figures

List of Tables

Definition of Terms and Acronyms

Btu—British thermal unit, which is a measure of natural gas energy use

Construction Documents—building plan drawings and specifications (aka Project Manual) that are part of the construction contract (aka Contract Documents)

CIP—Conservation Improvement Program, these energy saving programs are usually administered by an energy utility, and are regulated by the State of Minnesota's Department of Commerce, Division of Energy Resources

HVAC–heating, ventilating, and air conditioning

IECC—International Energy Conservation Code published by the International Code Council

kWh—kilowatt-hour, which is a measure of electric energy use

MCF—one thousand cubic feet of natural gas (equivalent to 1 million Btu)

Submittals—equipment selection and design detail documents that are submitted by the contractor for review by the designer(s) prior to construction

Therm—gas usage unit equivalent to 100,000 Btu or 100 cubic feet of gas (1 CCF)

U-value—a measure of the rate of heat loss (or gain) through an envelope assembly (e.g. window) for a given temperature difference (in units of Btu/hr °F ft^2); a lower value is more efficient

Executive Summary

Background

A number of programs aimed at comprehensive energy code compliance have been piloted or rolled out in other parts of the country over the last few years. Despite the important potential that this type of program has to contribute to Minnesota's 1.5% annual savings goal for CIP programs, no utilities in Minnesota currently offer such a program. While a combination of utility staff uncertainties about optimal utility program design and cost-effectiveness in a state with relatively low utility rates are barriers to the implementation of such programs in Minnesota, another key factor is historical CIP program policies in the state that have not allowed these programs to claim savings against the 1.5% goal or cost-reclamation mechanisms. Policy discussions within the last few years have suggested that increased code compliance programs could now be given credit for energy savings, but there has still been no precedent set for this in Minnesota.

Although commercial energy code compliance in Minnesota is relatively good, there is reason to believe that there is still the potential to achieve significant energy savings through increased compliance. Studies in other states have shown that even where there is a high percentage of compliance with energy code line-items, substantial energy performance improvements can be accomplished by bringing the remaining items up to the code level of performance. Moreover, the adoption of a more complex energy code in 2015 has led to confusion in the building industry, with both city building department staff and designers reporting being overwhelmed. It is, therefore, expected that energy code compliance rates may drop, leaving even more potential for energy savings through increased compliance.

In response to the above circumstances, the Center for Energy and Environment (CEE) undertook this project to test the potential to cost-effectively achieve CIP program savings by providing guidance and technical assistance to designers and/or city plan reviewers in a way that would improve compliance with the Minnesota Energy Code. The goals were to establish a local precedent for utility-funded energy code compliance enhancement programs in Minnesota that could serve as a model for the development of full-scale programs, and to evaluate the pilot program so that valuable information and recommendations from the experience will be available for utility staff and CIP program regulators.

Methodology

CEE's pilot program concept was to intervene at critical times in the building design and development process for individual building projects, and the development of the program was guided by the intent to maximize cost-effectiveness rather than savings. With the relatively low utility rates in Minnesota, it was deemed important to minimize costs while capturing the most readily available energy savings associated with increased energy code compliance. Towards this end, we targeted our program efforts at two dozen energy code line-items, selected due to their high energy impact and/or expectation of relatively low compliance. These targeted items represent about 14% of all energy code requirements, and were chosen based on reviews of previous studies of compliance in Minnesota, interviews with code officials in other states that had already been enforcing a similar combination of energy codes, changes from the previous energy code, and an engineer's line-item review of the likelihood of an item being missed. The program's focus on a limited number of items differs from previous programs, which work toward comprehensive compliance for every energy code line-item.

One of the pilot program approaches, design team support, was targeted at specific building types and limited sizes to limit program development and delivery costs. The design team support pilot included a kick-off meeting to provide early design phase guidance, the delivery of a one-page quick-reference guide for the program-targeted items, on-call technical support, and design review services that were available prior to the completion of construction drawings. The targeting of specific building types and sizes allowed for a simpler, easier to use quick-reference guide, and a minimization of plan review costs. A total participant incentive of $775 was split between the designer and the building owner. Recruitment efforts for the design team support pilot focused on local designers identified through Dodge Reports[1] and other means.

Table 1. Key elements of the two pilot program approaches

Pilot Approach 1	Pilot Approach 2
Design Team Support	City Reviewer Support
Small/Simple Buildings	Large/Complex Buildings
Prescriptive Code Path	Performance or Prescriptive

The other pilot program approach, city reviewer support, provided expert energy code plan-review services to city staff at the time that construction documents were submitted as part of a building permit application. City staff were given a detailed report summarizing the compliance and documentation status of the targeted items, along with specific information about each deficiency that clarified what was wrong or omitted, and what to request of the designer to achieve compliance. The design review services were provided to three cities that had partnered on the pilot program proposal before it was funded. The cities selected projects for our review, with a general focus on buildings that were large and/or had complexities that might stretch the technical/time availability limits of city staff.

The pilot program implementation was coupled with ongoing evaluation efforts to measure program performance and guide future iterations of similar programs in Minnesota. This evaluation quantified the maximum potential savings achievable through the targeted commercial energy code enhancement program design, the actual pilot program impact, and the expected cost-effectiveness of a full-scale

[1] Dodge reports is a service provided by McGraw Hill provides a database listing of active construction projects within certain jurisdictions. It is commonly used in the construction industry for identifying and marketing services.

program. Detailed plan reviews of 24 projects that received no program services prior to submission for a building permit provided a baseline for looking at potential program impacts and for measuring actual program impacts against. Compliance with each measure was categorized as: compliant, not applicable, clearly not compliant, or not providing enough design detail to clearly demonstrate compliance. For these 24 projects, the compliance rate for every targeted measure was tracked, along with quantification of both the value of every non-compliant item (e.g. a roof U-value that exceeds the maximum allowed), and the quantity of that item in the building (e.g. window area that is not compliant). Whole building energy simulations of representative prototype buildings were used to quantify the energy penalty of non-compliance for each measure targeted by the program, and then to develop tables of normalized savings. The normalized savings tables were used with each building's non-compliant value and quantity to calculate the energy impact of each instance of non-compliance. The clearly non-compliant items provided a low estimate of impact while the sum of non-compliant items, and items without enough design detail to demonstrate compliance, provided a high estimate of potential savings.

The observed impacts of each pilot program approach was applied to the 24 building baseline data set to project the per-building energy impact of a full-scale program. The impact of pilot program activities on buildings that participated was translated into the expected program impact by comparing the documented resulting design compliance against this baseline set of buildings that had plans prepared before any program intervention took place.

Results

The pilot program clearly demonstrated both the potential and actual achievement of significant energy savings with a cost-effective CIP program designed to increase compliance with targeted portions of the Minnesota Energy Code that represent about 14% of all energy code line-items. Various metrics of program performance, potential savings, and lessons learned are summarized below.

Recruitment efforts had mixed results. The recruitment of projects to receive design team support fell short of participation goals, with one-third of the pilot program's total per-building costs used on recruitment efforts (46% if the incentive cost is included). On the other hand, the participation of projects receiving city support for plan review exceeded the target with recruitments costs that were 10% (or less) of the total pilot per-building cost.

The analysis of program potential and actual impacts was based on 16 projects that received city plan review support, 8 "control" projects that were used for baseline comparison purposes, and 12 projects that received design team support. Although there were a few more buildings in each of these categories, they were excluded from the final analysis because they were inconsistent with this data set in various ways, such as following a performance path within the energy code, or having a limited scope renovation. For estimating expected program impact for the design support pilot, the measure-specific percent reductions in clearly non-compliant occurrences in the 12 buildings (compared against the measure-specific percent compliance in the 24 building baseline data set) was multiplied by the average energy impact per non-compliant occurrence of that measure in the baseline buildings. These results were summed across all program targeted measures. City support review impact was estimated by first evaluating the percent reduction in energy penalty for clearly non-compliant measures in 6 buildings that were reviewed at the time of permit application, and then again after the initial program review and report led to design revisions and the resubmission of construction documents that partner cities passed along to CEE.

Baseline Compliance and Potential Savings

The compliance of construction documents accompanying permit applications with the program's targeted line-items (within the 24 buildings that did not receive any services prior to permit application) is summarized in Figure 1. More than half of the individual targeted measures were either clearly non-compliant, or were not defined well enough by the construction documents to show whether or not the building would be compliant. Since this review was partially targeted toward items that were expected to have relatively low compliance, we expect higher rates of compliance with the energy code overall. Nevertheless, this result clearly shows room for improvement among these targeted measures.

Figure 1. Design rate of compliance with targeted code line-items among 24 buildings

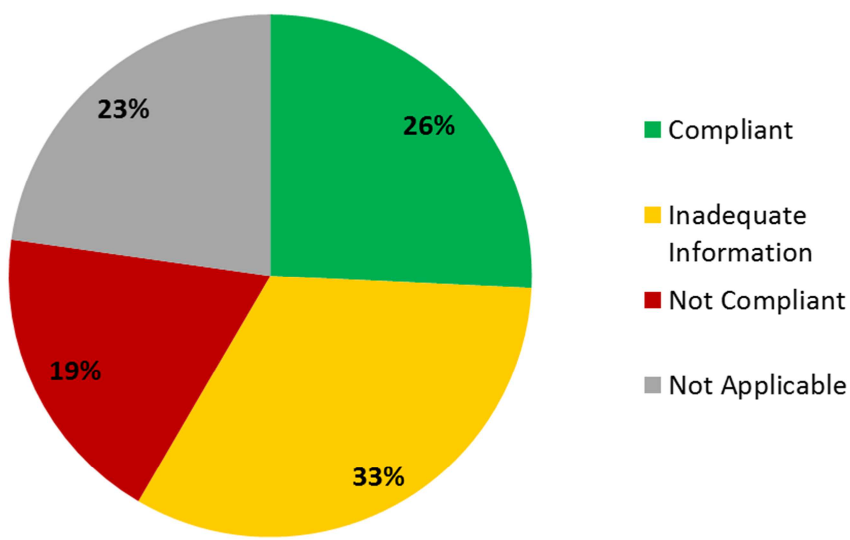


Table 2 (below) shows the Low and High Estimates of the penalties for not complying with the pilot program's targeted measures, based on 24 buildings that averaged about 84,700 square feet. The Low Estimate only includes instances of clear non-compliance, while the High Estimate includes the clearly non-compliant items and the items that are not clearly specified by the design documents (i.e. the red and yellow slices in Figure 1). These values represent the maximum per-building savings a code compliance enhancement program targeted at a similar population of buildings could achieve, or the potential savings.

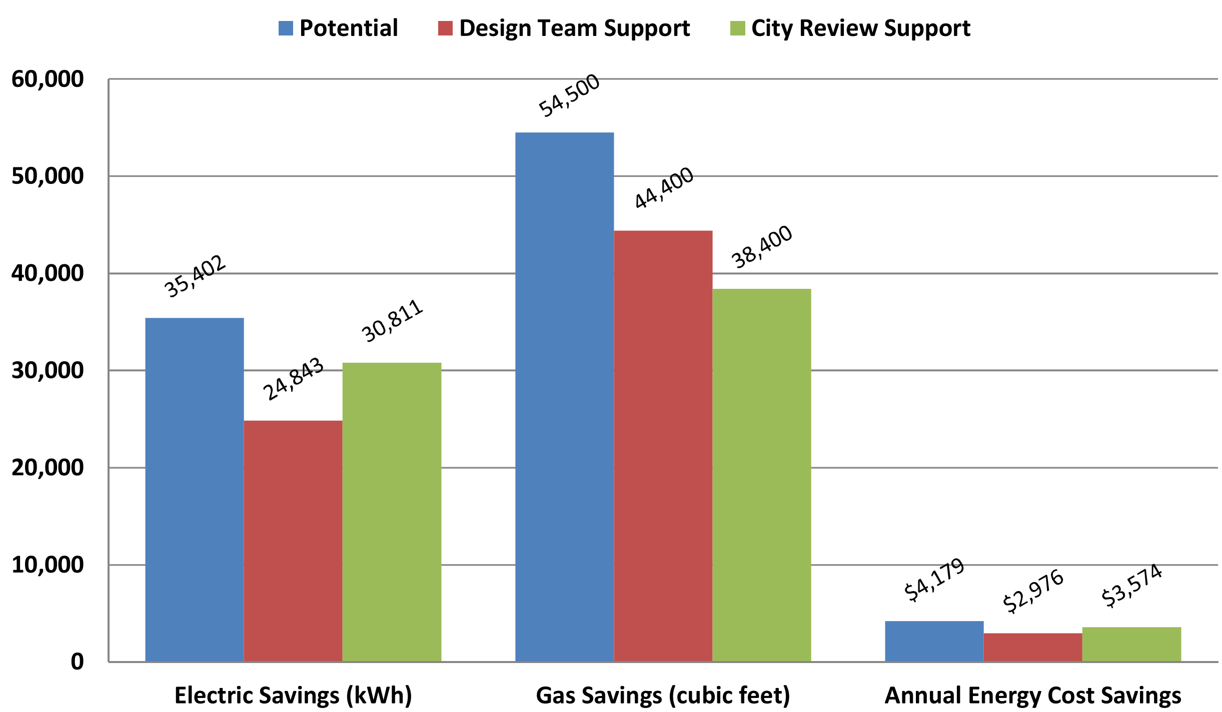
Table 2. Average building annual penalties for non-compliance with program measures

Savings Estimate Basis	Electric Penalty (kWh)	Gas Penalty (therms)	Cost Penalty
Low Estimate (Clearly Non-Compliant)	35,402	545	$4,179
High Estimate (Low + Not Defined)	71,501	1,476	$8,702

Pilot Program Impacts

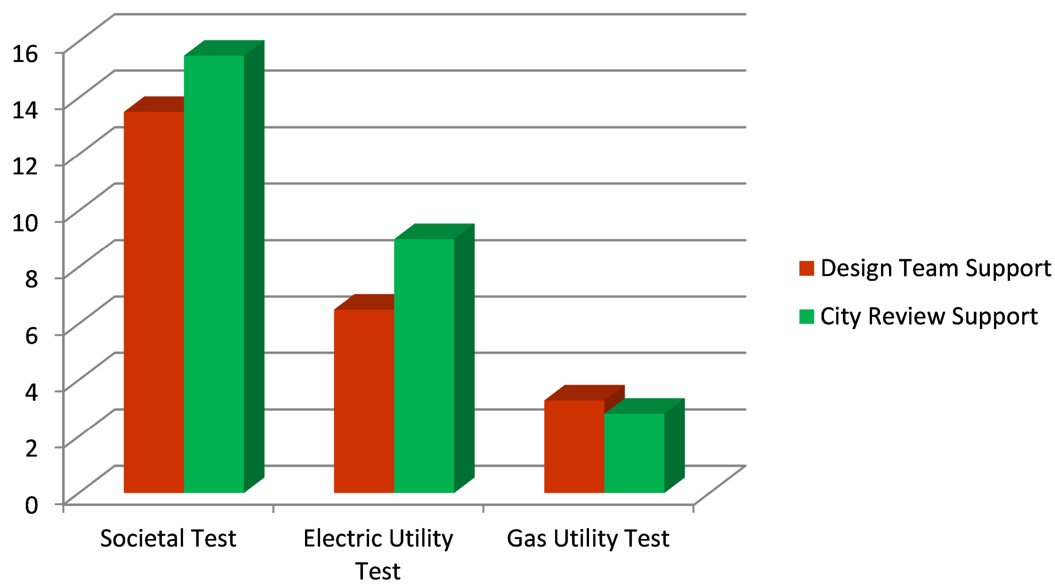
Each of the pilot program approaches to increase compliance with the energy code cut the percentage of clearly non-compliant target measures in half, while reaping more than half of the potential savings associated with bringing all clearly non-compliant targeted measures into compliance. The savings associated with each program's success at reducing clearly non-compliant energy code line-items is shown in Figure 2. The design team support and city reviewer support approaches were both similarly successful at capturing from 70% to 87% potential saving. These savings are higher than the improvements in overall compliance rate improvements because the program interventions were more successful at improving compliance amongst the highest impact measures. The electric savings was moderately higher for the city review support, while the gas savings was slightly higher for the design team support.

Figure 2. Projected per-building program savings (n=24, mean size=84,700 ft^2)



Based on the pilot program experience, full-scale program delivery costs were estimated to be $4,610 per building for pilot program support of design teams, and $4,650 per building for pilot program support of city plan reviewers. A large fraction of the design team support pilot program costs went towards recruitment and incentives, while the overwhelming majority of costs for the city review support went towards technical services. With these per-building costs, plus an assumed additional $75,000[2] utility administrative cost for a program serving 50 buildings per year, both pilot program approaches are projected to be cost-effective at both a societal and utility level. Utility program cost-effectiveness analysis results are shown in Figure 3 (below). While all benefit to cost ratios are significantly greater than one, the best results are for the societal test and the city review support approach. The electric utility benefit to cost ratios are also significantly higher than the gas utility values.

Figure 3. Projected CIP program benefit to cost ratios



Process Evaluation Findings

A focus group meeting part-way through the program delivery period identified the following challenges and opportunities related to energy code compliance.

[2] The allocation of the $75,000 annual utility administrative cost was assumed to be 75% from the electric utility and 25% from the gas utility.

Table 3. Key focus group findings

Challenges	Opportunities
• Separate/delayed submittal/review of mechanical & electrical plans.	• Earlier & more meetings between code officials and design teams.
• Expertise to review reports: energy simulations for performance path; commissioning; and COMCheck.	• Compliance forms to be filled out and submitted with application.
• Lack of political will to hold up projects for energy code deficiencies.	• Training: contractors, manufacturers, and code officials.
• Contractor-designed projects not being reviewed; especially lighting.	• Examples of best practices for design documentation.

Participant surveys rated the overall value of the pilot program services at 5.4 and 5.6 (out of a possible 6) for the design support and city reviewer support services, respectively. Other survey responses showed some enlightening trends that can inform future program design. Design team support participants ranked the early design stage kick-off meeting as the most helpful service, with the two quick-reference tools ranked next highest. While none of these were provided as part of the city reviewer support pilot, open-ended responses from city staff did indicate interest in both early meetings with design teams and checklist tools. While design teams gave the plan review service a low rank relative to other services, city staff unanimously ranked the plan review as the most valuable part of the pilot. On-site assistance/guidance with inspections was the next-highest ranked service among city staff. The survey findings also suggest that while CEE recruiters often found the incentive for participants in the design team support pilot helpful for keeping people on the phone long enough to learn about the program, it was ultimately rated of low importance to designers in their decision to participate in the program.

CIP Program Recommendations

The pilot program findings lead us to recommend that investor-owned utilities in Minnesota pursue the development and implementation of commercial energy code compliance enhancement programs. Key considerations in the development, planning, and implementation of the program are noted below:

- Work with regulators to develop a methodology for counting savings appropriate for the type and scale of the program.

- We suggest partnering with cities to support their energy code review and inspection process [rather than supporting design team directly], and to increase early design-phase meetings. This approach was more successful with recruitment (with a similar level of savings achieved per building), plus it provides more leverage for market transformation.
- If a design team support services program model is used, prioritize early design-phase meeting(s) and quick-reference tools over incentives and plan review services.
- Keep the pilot program's targeted focus on a short list of the most impactful and/or frequently missed energy code line-items, with some fine-tuning of the measure list.
- A code compliance enhancement program could strategically complement design assistance programs as a lower-cost, higher participation rate service, and there would still be additional participant benefits of participating in both types of programs.
- Provide a high level of technical expertise, including building energy simulation, among program delivery personnel so that participants value the program as a resource.
- Consider additional program approaches to increase the frequency and quality of both HVAC commissioning and lighting control system testing.

Conclusions

Pilot testing of two commercial energy code compliance enhancement program approaches demonstrated the potential to cost-effectively provide substantial savings. Both of these pilot programs were targeted to a limited number of key energy code measures and provided a high level of technical assistance with individual building projects. The two approaches differed in the method of engagement with the builder, one engaged the design team directly, while the other worked though the city code officials. The first pilot program approach provided design team assistance beginning with a kick-off meeting and quick-reference tools early in the design process. The other pilot program approach provided city staff assistance with reviewing construction documents for energy code compliance at the time of building permit application, with services continuing through the construction and inspection process in some cases. Once partnerships with participating cities were established, the city reviewer support approach had much lower recruitment costs, while also achieving a higher level of savings per building served.

In addition to achieving energy savings toward Minnesota's 1.5% annual energy savings goal, the pilot program services were perceived as valuable to the participants in each pilot. Despite this, the program's experience and participant survey results suggest that a number of program changes might further optimize its impact and cost-effectiveness (an increased focus on early meeting(s) with the design team would be valuable for either pilot approach). Some fine-tuning of the list of targeted measures is also recommended.

One barrier to the development of code compliance enhancement programs in Minnesota is uncertainty in the ability and approach to count savings towards CIP program goals and/or cost-reclamation. A companion policy brief outlines a range of approaches that might be used for savings quantification, including precedents that have been established in other states.

Background

Introduction

This report details the effort and findings of the Center for Energy and Environment's (CEE) commercial energy codes support pilot program that was supported by a grant from the Minnesota Department of Commerce, Division of Energy Resources through the Conservation Applied Research and Development (CARD) program.

In Minnesota, it's been reported that there is currently over 90 percent commercial energy code compliance, which may suggest little potential for energy savings (Hernick, Nelson and Sivigny 2013). However, this 90 percent compliance rate is based on a federal protocol that counts the percentage of a select number of specific code line-items that are compliant, rather than the percentage of buildings that are completely in compliance. Moreover, a number of administrative items that may have little impact on energy use are included in the federal protocol's count. A similar study in New York with 85 percent line-item compliance found total building compliance, with every energy design item, to be less than half of that (Harper et al. 2012). This suggests that there may be more opportunity for energy savings than a 90 percent compliance rate alone may imply.

This project was undertaken to develop and test two specific innovative program approaches and optimize these for cost-effectiveness in Minnesota commercial buildings. Rather than trying to broadly increase energy code compliance for all commercial building projects and code line-items, this project uses a carefully targeted approach to maximize cost-effectiveness. The project plans to achieve significant improvement in particular parts of the market through support of project development teams and/or city staff at the time they are working on actual projects. The pilot will focus on the specific combinations of building project types and code requirements where the largest energy cost savings are expected. This targeted program approach takes into account the need to maximize program impact while minimizing costs. It also recognizes the challenges of designers and reviewers who are often overwhelmed by the complexity of energy codes.

The pilot program was developed in the first three quarters of 2015. In June 2015, Minnesota underwent a commercial energy code update, six years after the previous code update. The new code provides projects with the option of following IECC 2012 with Minnesota amendments or ASHRAE 90.1-2010 (unamended). Marketing of the program began in the fourth quarter of 2015. Program delivery began in January 2016 and continued through the third quarter of 2017, with an evaluation that collected data throughout program implementation and compiled results at the end of 2017. This paper reports on program development efforts, resulting program design, and program implementation results.

Commercial Codes Program Climate in Minnesota

Several programs aimed at comprehensive energy code compliance for commercial buildings have been piloted or rolled out in the last few years, but CEE concluded that a more focused approach would be most appropriate in Minnesota for a number of reasons (Lee et al. 2013). First of all, the effective average electric utility rates of ~$0.11 per kWh are much lower than in most areas where codes programs are underway. Secondly, previous research has found that Minnesota already has a higher rate of commercial energy code compliance than most states, so a blanket approach is likely to expend resources in areas where compliance is strong, reducing the opportunity to maximize savings (Hernick, Nelson, and Sivigny 2013). It is also noteworthy that the programs in other states typically have elements that would intervene in the relationships between cities and development teams in ways that many cities in Minnesota may not accept (e.g. allowing a project team to hire a third-party plan reviewer and inspector of their choice from amongst “program approved” reviewers). While utility Energy Design Assistance programs have a proven record of success in Minnesota with cost-effective energy savings through early design intervention for large projects, that approach is too expensive to cost-effectively impact small projects. Finally, when asking about the energy code, the project team has consistently heard from a wide variety of designers and code officials that it is much too large and complex. This call for energy code simplification echoes the findings of previous commercial energy code compliance programs (Madison and Baylon, 1998). Taking all of the above factors into account led us to propose a pilot Conservation Improvement Program (CIP) utility-funded program that strives to reap significant energy impact at a low cost, rather than broadly pursue 100 percent compliance with all energy code items across all commercial building types.

In addition to questions about optimal program design and cost-effectiveness, utilities in Minnesota have also been hesitant to initiate energy codes support programs because of other uncertainties. In discussions with utility representatives, concerns were expressed about the coordination with other programs and the appropriate crediting of savings for such programs. Utility regulators in Minnesota have historically been rigid in defining compliance with the current energy code as the reference point for calculating utility program impact in new construction situations. Policy discussions within the last few years have suggested that increased code compliance programs could be given credit for energy savings, but there has been no precedent set for this in the state.

The current energy code structure and history in Minnesota also has a significant impact on this program. Minnesota had an ASHRAE 90.1-2004 based energy code in place for six years before the transition to the current combination of an amended IECC 2012 and unamended ASHRAE 90.1-2010, which occurred in June of 2015. While the ASHRAE 90.1 standard document is much more expensive than the IECC code book, Minnesota is unique in providing a single code volume that combines the IECC as amended by Minnesota with ASHRAE 90.1 in a single volume that is less expensive than ASHRAE 90.1-2010 alone. This makes it more affordable and practical for industry professionals to have both documents readily available as a reference.

Looking ahead, the stated intent is for the state to adopt the latest version of ICC codes, including IECC (which refers to ASHRAE 90.1), every six years. These reference documents are updated on a three-year cycle, so this schedule skips every other update and then jumps to the most recent release. The current goal is for the 2018 IECC (and ASHRAE 90.1-2016, which it references) to become effective in March of 2020, which would make this next round of updates occur in a little under six years.

Program Design

Overview

The overall pilot program goal was to establish a successful model for a utility-funded commercial energy code compliance support program in Minnesota. This was done with a targeted approach to cost-effectively achieve energy savings in a state with relatively low utility rates. Rather than striving to achieve compliance with all energy code line-items for all projects, the goal was to achieve higher compliance for line-items that have a high energy impact and/or are most commonly missed. The method for selecting these line-items is described in detail in the next section. The pilot program tested two different strategies to improve compliance, as outlined in the following sections. While these approaches could allow for overlap in terms of building projects served, the pilot strove to avoid overlap to allow for better evaluation of each approach.

Program Development

The subsections below focus on key technical program development efforts and decision-making regarding key pilot program issues.

Selecting Program Target Measures

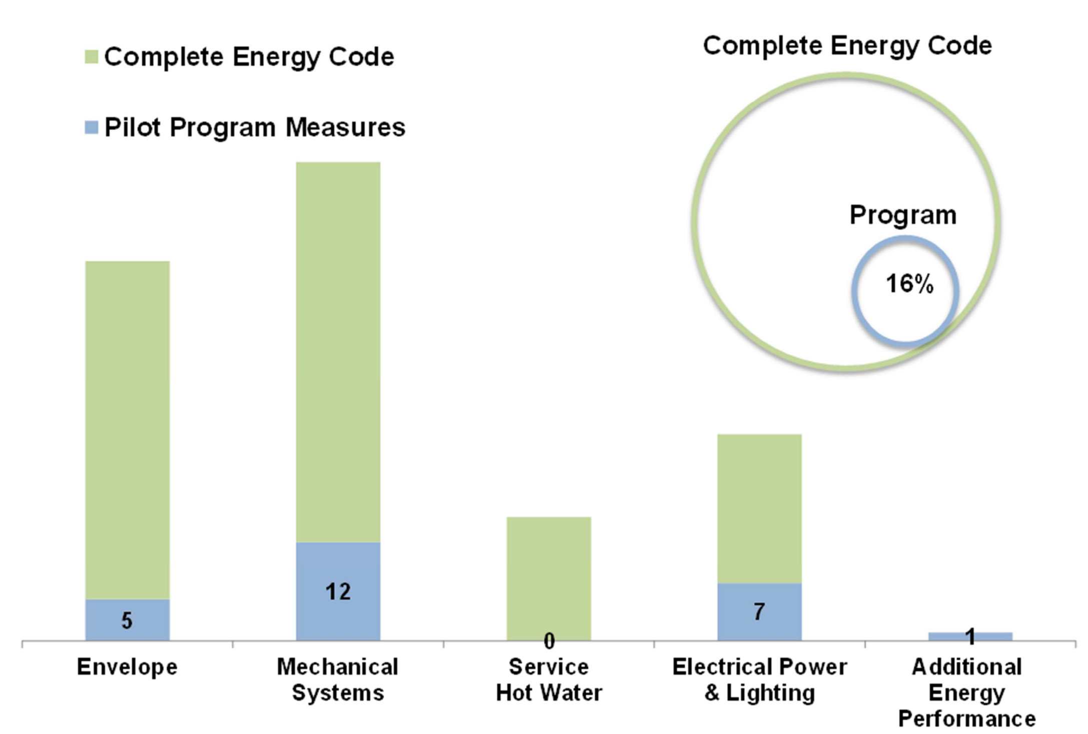
The main technical program development challenge was the selection of key (high impact) energy code line-items and building project types. This occurred in 2015 before there was any local history with application of the new energy code. Engineers reviewed information from a number of sources to develop targeted lists of energy code line-items and building types, including:

- A statewide study of compliance with Minnesota's previous commercial energy code (Hernick, Nelson, and Sivigny 2013).
- Interviews with 13 code officials representing 11 cities and 6 states that were already enforcing codes similar to Minnesota's new code, but at an earlier time.
- A published analysis of specific updates to the codes (Wallace, Deringer, and Hudson 2014).
- Interviews with 17 code officials, architects, engineers, and builders in Minnesota.
- Preliminary analysis of energy impacts of energy code changes.
- Historical data from a construction industry project database service.
- Historical data from partner cities on previous permits.
- Detailed engineer line-item review of state-specific amendments.
- Detailed engineer line-item review of all code items to evaluate the complication and likelihood of being missed.

In addition to weighing the likelihood of being missed and the magnitude of energy impact, consideration was also given to the level of effort involved in determining compliance. For example, heating and cooling equipment sizing was omitted from the list because the information needed to determine compliance is typically not part of a construction drawing set, so we expected that we would not consistently have the additional documentation and/or would need to undertake significant efforts to obtain this documentation. Similarly, HVAC system fan power is a key energy component, but the limit on fan power; often referred to as fan power allowance, wasn't targeted due to expected high compliance and a very involved calculation procedure needed to show compliance (with some of the calculation inputs not always expected to be well-documented on the plan set).

After drafting a preliminary list of energy code line-items and building types to focus on, the pilot program developers obtained feedback from partner cities and a small number of local designers before establishing the final list that would be used for this pilot program rollout. An example of the impact of discussions with city code officials is the late program addition of dampers that are motorized and/or have strict air leakage limits. Early work with city code officials made it clear that many code officials would be targeting this item and that there was significant confusion surrounding these requirements. After this was brought to our attention by city code officials, a close review of the IECC code structure for this item gave us reason to believe that it would most likely be missed by many designers. This is because while it includes requirements for HVAC system dampers, some of the strict technical details for this in the IECC appear only in the Envelope section of the energy code, where HVAC designers and contractors would be unlikely to look.

Figure 4. Results of target line-item measure selection by building system



Through the efforts outlined, the pilot program developed a targeted list that focuses on 16 percent of the total energy code line-items. Figure 4 summarizes the breakdown of targeted measures by building system. No measures related to service hot water systems were included in the program target items. The three main building systems targeted are: Envelope, Mechanical (mostly HVAC), and Electrical (mostly lighting). Within IECC, there is another category of additional energy performance, which gives the project teams the option of achieving lower energy use through upgrades in one of three areas.

Error! Not a valid bookmark self-reference. includes the final list of pilot program target line-items. While there are many more measures related to mechanical systems, a number of them will not apply to any given building depending on the mechanical system type, size, ventilation requirements, and other variables.

Table 4. Energy code line-items targeted by pilot program

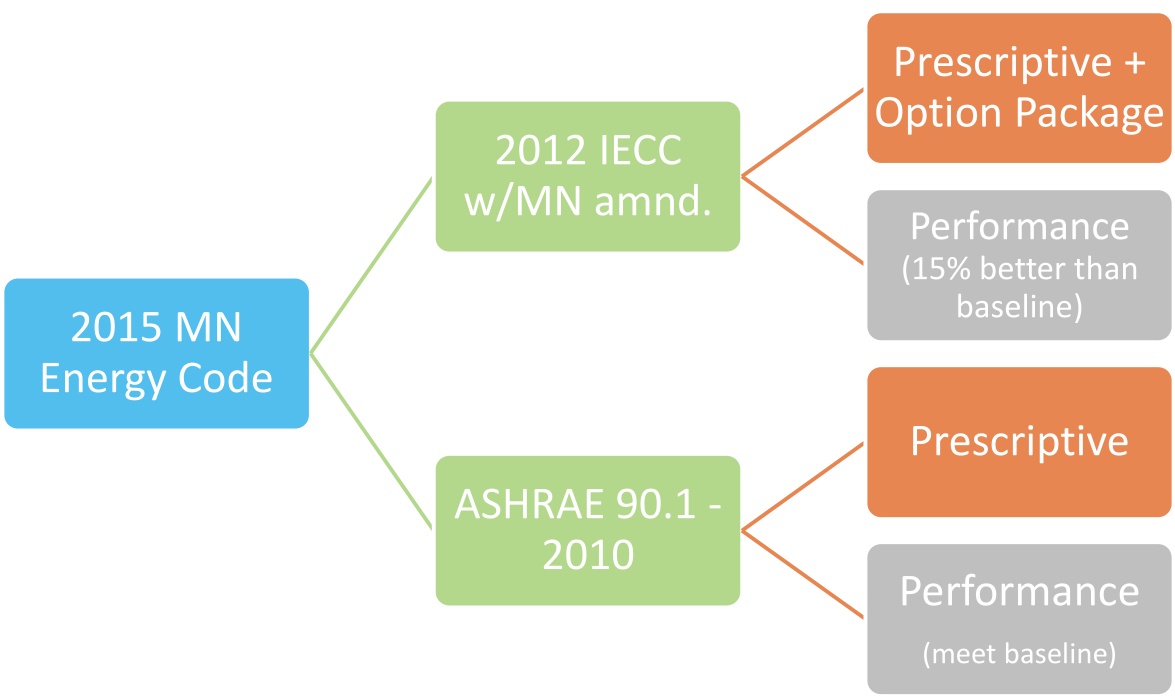
Envelope Measures	Electrical Measures	Mechanical Measures	Additional Efficiency Package Option
Roof Insulation	Automatic Lighting Shutoff	Economizer	Increased HVAC efficiency
Above Grade Wall Insulation	Daylight Zone Control	Demand-Controlled Ventilation	OR Reduced LPD
Window U-value	Multilevel Lighting Control	Energy Recovery Ventilation	OR Renewables
Window Area/ Orientation	Interior Lighting Power Density	Boiler/Chiller System Control	-
Slab Edge Insulation	Conductor Sizing	Variable Flow Pump Control	-
-	Automatic Outlet Shutoff	Duct Sealing	-
-	Lighting Functional Testing	Piping Size	-
-	-	Supply Air Temperature Reset	-
-	-	Fan Motor Sizing vs. BHP	-
-	-	Pool Cover	-
-	-	Low Leakage Dampers	-
-	-	HVAC Commissioning	-

Addressing Multiple Code Paths

Another set of questions the pilot program wrestled with was how to address the multiple path options in the code. The high-level code compliance options under the 2015 Minnesota Energy Code are outlined in Figure 5. The difficulty in decision-making during the program development phase was exacerbated by great uncertainty about what code path project teams would choose with the new option of using the 2012 IECC with Minnesota amendments or ASHRAE 90.1-2010. Interviews with code officials in other states indicated IECC 2012 was overwhelmingly used by small projects, and ASHRAE 90.1-2010 was dominant for large projects. However, the combination of Minnesota's history with ASHRAE 90.1, and the publication of a Minnesota-specific energy code book that includes both IECC 2012 and ASHRAE 90.1-2010, gave us reason to suspect this pattern might naturally be different in Minnesota. Therefore, we expected that absent of any pilot program influence, larger buildings would tend to follow ASHRAE 90.1 while smaller buildings could be mixed in following either IECC or ASHRAE 90.1.

In addition to the basic option of IECC versus ASHRAE, each code has an option of following a list of prescriptive items or a performance path. Even projects following the performance path must meet a set of mandatory requirements that apply to the various building systems. The IECC performance path was not expected to be used because (1) it has a high threshold for compliance of 15 percent better than a similar building that meets the prescriptive measure requirements exactly, and (2) none of the software commonly used by local designers for simulation appeared to meet the IECC requirements. On the other hand, ASHRAE 90.1 only requires that a building following the performance path, perform no worse than if the building were following the prescriptive path. Moreover, there was already an established pattern within members of the local design community to follow the performance path within ASHRAE 90.1 for larger projects (as a way to avoid specific prescriptive requirements).

Figure 5. Current Minnesota energy code path overview



While different approaches to addressing the multiple code paths could be used, we decided to provide the same level of service to projects following either of the higher level code path choices (IECC vs. ASHRAE). With larger incentives, or higher incentives for one code path versus the other, a code compliance enhancement program could also be a tool to encourage the use of one energy code standard over another. While this could be appropriate for a future program, we were concerned that favoring specific paths could severely limit the pool of potential participants (and control projects to compare against), and we wouldn't know if the program impacted the code path choice, given the uncertainty of direction the compliance path would generally take in this market. This decision proved to help with recruitment—in fact, one of the first impacts of the program on a project was providing neutral, third-party help to the design team in deciding which energy code path was best suited to their building project. However, dealing with both code path options had cost-implications associated with the need to develop program materials to address both of the code paths, and to have staff adequately trained in both standards. Within the pilot program, we initially considered producing a separate series of documents for each code path (i.e. IECC vs. AHSRAE 90.1) to make each document simpler. However, the similarities in the requirements of the two paths were consistent enough to make it practical to produce a single version of each program document (although the documents are more complex because of the need to have multiple lists where the two codes differ).

The other dimension regarding code paths was how to address the prescriptive versus performance path options. Thorough review and/or assistance for projects following a performance path generally require a higher level of expertise and effort than what is needed for a prescriptive path project. While prescriptive path projects have fewer set measures to check, the flexibility of essentially allowing "credit" for a higher level of performance in almost any aspect of the building design, and the use of energy modelling software, makes meaningful support or review much more complex. With the primary intent of the program's pilot of design team support being to provide a low-to-moderate cost service across a large number of smaller buildings, we decided to generally exclude performance path projects from participating. We also expected that few of these smaller building projects would choose to follow a performance path. On the other hand, performance path projects were welcomed in the city staff support pilot, which focused on buildings that were larger and/or more complex, and buildings for which a city's ability to thoroughly review energy code compliance would more likely be limited by time constraints and/or expertise.

Choosing a Second-Tier Option

The selection of a second-tier set of guidelines for project teams wishing to go well beyond the code was another technical challenge for the pilot program. Key considerations were both energy impact and simplicity for design teams to digest and implement. While the New Building Institute's New Construction Guide (NBI 2015) was considered to be an appropriate option, we ultimately chose to use the ASHRAE Advanced Energy Design Guide 50% series for the pilot program (ASHRAE 2011-2012). The most critical factor for this trial use was the simplicity of having multiple people on the project team who could download the documents at no cost and without any special instructions. The variety of building types and the short-comprehensive list of requirements tailored to each building type are additional advantages of the ASHRAE Advanced Energy Design Guides.

Program Approach 1: Design Team Support for Specific Small Building Types

The first program approach aimed to impact the underserved market of small building design by providing tools and support to project design/development teams from early design through construction. The approach is similar to design assistance programs, with a much narrower scope and lower program cost per project. The goal, and a key incentive for participating project teams, is to clearly address key energy code items early in the design and development process to avoid costly, late-stage changes. The pilot targeted specific building types in order to keep the set of project requirements and tools as simple, accessible, and useful as possible. While new construction projects were eligible, it was expected that the majority of projects would be renovations of existing buildings. For renovation projects to be eligible, at least two of the three types of building systems addressed by the program (i.e. Envelope, Electrical/Lighting, and HVAC) had to be included in the scope of work. The key elements of program approach 1 are shown in Table 5 below.

Table 5. Features of program approach 1: design team support

Program Scope	Benefits/support to design and development teams
Small buildings or simple systems	Early design stage kick-off meeting
22 energy code line-items	Energy code quick reference guide
4 specific building types	Documentation best practices guide
Whole building tier 2 package	Incentives to owner & design team
New & existing buildings	Plan review(s) prior to permit application
Prescriptive compliance paths	Construction phase support

Building owners and project team members participating in the pilot were given modest incentives for successfully incorporating a number of basic efficiency requirements into their project. The incentive amounts were $500 to the building owner/developer and $275 to the design team. Larger incentives of $750 and $475, respectively, were also offered for achieving a second-tier level of compliance with a simplified set of energy design requirements that exceed code (the 50% reduction series of ASHRAE Advanced Energy Design Guides, where applicable [ASHRAE et al. 2011-2012]). The basic energy efficiency requirements represented a targeted list of energy code line-items with the lowest compliance and/or largest energy impact for the specific types of buildings targeted—office, retail, restaurant, and multifamily/lodging. These building types were chosen primarily because of the volume of construction expected in jurisdictions like the partner cities. For most building types, design team support was limited to projects 50,000 square feet or less, but exceptions were made for multifamily and hospitality buildings. These building types were still simpler to serve, despite their larger size, because most of the areas in these buildings have simple mechanical systems repeated for each room, and the dwelling unit lighting is exempt from most requirements.

Participants were provided the program requirements in the form of a one-page front and back applicability guide document that provides design teams with guidance on the targeted energy code line-items. This quick-reference document aimed to provide a more accessible approach to help designers determine whether a code line-item was required for a particular project and to understand what was required (while also providing specific code section references). Both the document flow and language contribute to greater accessibility. For example, the code often has key criteria for when an item is required in a nondescript location buried within a list of exceptions at the end of the requirements section, while the program's quick-reference document highlights these key notes about when an item is required in a prominent, consistent location. Figure 6 shows an excerpt from the applicability guide document, and a full version of this guide can be found in Appendix A.

Figure 6. Excerpt from applicability guide document

TECHNOLOGY	TECHNOLOGY DESCRIPTION / ENERGY IMPACT & CODE REFERENCE	MEASURE REQUIREMENT	WHEN IT APPLIES	Targeted Building Use Types	APPLICABILITY SUMMARY
Air Economizer	Equipment that uses cool outside air to meet air conditioning needs (when possible) instead of running the AC compressor(s). This reduces compressor	**IECC & ASHRAE:** Specify and install air economizer system capable of providing up to 100% of design supply air as outdoor air (for cooling). *IECC References: C403.3.1 & C403.4.1* *ASHRAE References: 6.5.1*	**IECC:** When a fan cooling unit has a cooling capacity of ≥33,000 Btu/hour (>2.75 tons); Multifamily: ≥165,000 Btu/hr (13.75 tons) **ASHRAE:** When a fan cooling unit has a capacity ≥54,000 Btu/hr (≥4.5 tons) [Multifamily: ≥270,000 Btu/hr (≥22.5 tons); Computer Rooms: ≥135,000 Btu/h (≥11.25 tons)]	**Multifamily**	Seldom applies
				Offices	Applies to most systems serving floor areas large than listed (or smaller areas with high cooling loads): IECC ≥~1,100 sf ASHRAE ≥~1,800 sf
				Restaurants	
				Retail Spaces	
Demand Control Ventilation (DCV)	A control that automatically reduces the amount of fresh outside air being brought in through the ventilation system when few or no people are in a space. This reduces the energy use for heating and cooling outside air.	**IECC & ASHRAE:** Specify and install a demand control ventilation system (or exhaust air energy recovery ventilation) for high occupancy spaces (Occupant Density is based on the MN 2015 Mechanical Code, Table 403.3 *Minimum Ventilation Rates.*) *IECC References: C403.2.5.1* *ASHRAE References: 6.4.3.9*	**IECC & ASHRAE:** When design occupancy is: IECC ≥25 people/1,000 sf ASHRAE >40 people/1,000 sf for a space >500 sf with ≥1,200 cfm of supply air flow AND there is an economizer, automatic modulating outdoor air damper control, OR outdoor airflow is >3,000 cfm AND the hvac system has ≥1,200 cfm of outdoor air AND the hvac system does NOT have exhaust air ventilation recovery with and effectiveness of at least 50%	**Multifamily**	May apply to common spaces
				Offices	Often if large meeting room, reception area or phone/data entry.
				Restaurants	Almost always applies unless very small
				Retail Spaces	Seldom applies (except mall commons or other gathering space)

A second, shared document also provided guidance and was meant to serve as the key avenue for providing design teams with feedback at the time of design reviews. An excerpt from this is shown in Figure 7, and a complete version appears in Appendix A. The first columns of this documentation checklist notes basic and best practices for clearly documenting design elements to ensure that the project would achieve compliance with the targeted list of code line-items. Then, an interactive set of columns allowed design teams to fill out a checklist and add special notes. Finally, there are columns used by program staff to provide feedback when a design review was completed. This form of feedback combined an at-a-glance visual summary, with detailed measure-specific feedback. An intuitive color code gave project-specific feedback on each measure relative to the program (and code) requirements. For those measures that either do not meet the requirements or need more detailed design documentation, program staff provided project specific notes to aid the design team in achieving compliance.

Figure 7. Excerpt from documentation checklist document

ELECTRICAL REQUIREMENTS						
MEASURE	REQUIRED INFORMATION (when applicable)	DOCUMENTATION BEST PRACTICE	Design Team	CEE Review	PROJECT TEAM NOTES	CEE REVIEW NOTES
Daylight Zone Control	1. Document daylight zone control locations and the fixtures controlled by each controller. 2. Document the power level steps that each daylight zone control will use.	1. Include a Daylight Zone Control section in the Specifications. 2. Besides noting daylighting sensors and fixtures controlled by each on drawings, include a Lighting Controls Schedule that includes notations about lighting control by room.	-		Engineer will show state energy code minimum or as directed by CEE.	A number of spaces have no lighting controls of any kind drawn yet. This includes the following rooms that will need daylighting control: 156, 160 and 181.
Multi-Level Lighting	1. Indicate lighting fixtures are controlled by the same switch.	1. Show this information in the Drawings.	-		Will be shown on drawings.	Although a number of spaces have no lighting controls drawn yet, none of the spaces with lighting controls information show any sign of multi-level lighting control.
Interior Lighting Power Density	1. Include all information needed to determine lighting fixture wattage and count.	1. In the Lighting Schedule, include a dedicated column that lists the maximum allowable wattage for the fixture as a whole. 2. If using space by space calculation method, indicate this and include table of assumed space types and areas.	-		Lumen output & Wattages will be shown on the fixture schedule. This is a spec item, which calls out for programmed start ballast with 90% or higher ballast factor.	Fixture K5 was omitted from the schedule. It is clear that any reasonable assumption for wattage of this fixture will lead to compliance following the Building Area Method approach.

After project teams were enrolled in the program and received the guidance documents—usually during a kick-off meeting—the pilot program periodically checked in to discuss design progress and offer assistance in the form of a preliminary design review by program staff who were all International Code Council (ICC) certified[3] for energy code plan review or inspection. The program required quick turnaround on requests for design review in order to allow time to redirect design teams while it was relatively simple and inexpensive to make design changes.

Once project design was complete, program staff tracked the progress of the project through monthly program level check-ins with city code officials and/or the project teams. In some cases, program staff provided direction to contractors on how to avoid common pitfalls for particular energy code line-items. When construction was complete, program staff performed inspections to confirm compliance with the targeted code line-items before issuing the incentive checks. The inspections were limited to a small sample of the buildings because of the long timeline between completion of plans and completion of construction.

Program Approach 2: City Plan Reviewer Support for Large, Complex Buildings

The second program approach provided the technical assistance of an energy engineer to city staff as they review plans and other detailed submittals. Technical support of city staff during the permit plan review stage allowed for the identification and correction of problems before the time of construction, otherwise it would generally be impractical or cost-prohibitive to make substantial changes. Reviewers with specialized expertise in energy code and building simulation were expected to identify more energy code issues at the design submittal phase. This program approach was expected to have a much higher fraction of new construction or addition projects than the design team support approach, but was also considered likely to serve a number of renovation projects. At least two of the three main building systems (Envelope, Electrical/Lighting, and HVAC) must have been in the scope of work for a renovation project to be eligible. The key elements of program approach 2 are highlighted in Table 6.

City staff have finite amounts of expertise and time available for the review of plans regarding health and safety concerns, resulting in little time for the review of energy specific issues. Projects requiring the

[3] See http://www.iccsafe.org/education-certification/certification-and-testing/

review of building energy simulations were also a focus of this approach. These simulations allow exemptions from a large number of code line-items by showing a level of performance for the building as a whole, and few code officials have the expertise or time to review these submittals. A specialist could develop a checklist of the key design elements that exceed code and make up for exemptions in other areas (allowing inspectors to verify these), and reviewed the simulation analysis for accuracy and bias. The checklist of items exceeding code would then be valuable to city staff as they later inspect the project to verify compliance. City staff also reported that technical assistance with the review of commissioning reports is valuable, and was expected to be effective at providing energy savings through the identification of issues that could still be easily addressed at the end of the construction phase of the project.

Table 6. Features of program approach 2: city code official support

Program Scope	Support to City Code Officials
Large buildings or complex systems	Permit set plan review and detailed, formal report
24+ energy code line-items	Review of building energy simulations submitted for performance documentation
New building, additions, and major renovations	Checklist for inspection of performance path items
Prescriptive and performance compliance path	Construction phase inspection assistance

The program staff report of review findings for city staff was similar, but more detailed than the small project reporting to design teams. A formal, multi-page report started with a one-page summary of the service, building, design phase, and an at-a-glance summary of review findings. The findings summary was in a color-coded format that is similar to the documentation checklist used for small building reviews. Figure 8 (below) shows a sample of the Summary Table in this report, and a sample report can be found in Appendix B. After the Summary Page, any measure with an unresolved issue had at least a paragraph of text noting the current problem and how to address it.

A full-scale program with this approach would be expected to eventually lead to upstream improvements in designs before these reach code officials, as design teams come to expect a much closer review of energy code items than in the past. For this project, in order to better evaluate the potential energy impact of this program approach, code officials were asked not to “warn” design teams that a third-party energy code review would be taking place.

Figure 8. Summary table excerpted from city support review report

	REQUIREMENTS	STATUS
ENVELOPE REQUIREMENTS	**Roof Insulation R Value** IECC: C402.2.1	
	Above Grade Wall Insulation IECC: C402.2.3	
	Window U value IECC : Table C402.3, Sec:C402.3.3 & C402.3.4, (C303.1.3)	
	Window Area & Orientation IECC: C402.3.1	
	Slab Edge Insulation IECC: C402.2.6	
ELECTRICAL REQUIREMENTS	**Automatic Lighting Shutoff** IECC: C405.2.2.2 & C405.2.2.1	
	Daylight Zone Control IECC: C405.2.2.3.1, C405.2.2.3.2 & C202	
	Multilevel Lighting Control IECC: C405.2.1.2	
	Interior Lighting Power Density IECC: C405.5	
	Conductor Sizing IECC: C405.8	
	Lighting System Functional Testing IECC: C408.3	

	REQUIREMENTS	STATUS
MECH	**Economizer** IECC: C403.3.1	
	Demand Controlled Ventilation IECC: C403.2.5.1	
	Energy Recovery Ventilation IECC: C403.2.6	
	Boiler & Chiller System Control IECC: C403.4.3.4	
	Variable Flow Pump Control IECC: C403.4.3.4	
	Duct Sealing IECC: C403.2.7	
	Supply Air Temperature Reset IECC: C403.4.5.4	
	Fan Motor Sizing vs bhp IECC: C403.2.10.2 & C403.2.10)	
	Pool Cover IECC: C404.7.3	
	HVAC Commissioning IECC: C408.2	
	Low Leakage Intake and Exhaust Dampers IECC: C402.4.5	
Add. EE	**Additional Energy Efficiency Package (3 Options)** *IECC: C406*	

Status Legend:
- Code requirement met
- Not enough information to determine/ensure
- Code requirement not met
- Not required for this project

Evaluation Methodology

In addition to regular program development and delivery activities, the pilot program incorporated evaluation activities to thoroughly evaluate the results and lessons learned from the pilot program to inform future program development, and to quantify the energy impacts of the two pilot program approaches. The key results of this task include quantification of the program impact in terms of percentage implementation, energy savings, and cost-effectiveness. Secondary results include the critical evaluation of numerous program elements to determine what changes may be expected to further optimize the program approaches. In addition to the collection of typical program delivery data, the evaluation required thorough documentation of items such as sales call success rates, the specific design element deficiencies pointed out through program activities, and technical details of each non-compliant item to enable energy estimation. Additional evaluation activities also include surveys of program participants as individual projects were completed, discussions with code officials, surveys of city staff, and technical review of a "Control" set of building projects that were completed over the same time frame as the program participant building projects.

Key Program Metrics

Capture of Data on Key Project Design Elements

The detailed evaluation of the pilot program required additional effort for the plan reviews of building projects beyond what may be needed for the routine delivery of a code compliance enhancement program. Program delivery and city staff would typically perform reviews of plans and inspections only to the extent needed to make pass/fail determinations of each code line-item, and to provide specific design change feedback to the designer. However, the pilot program evaluation needed additional information in order to make a definitive determination of energy savings. In particular, we needed to quantify two items for each of the "key" design elements:

1) The level of efficiency achieved [e.g. window U-value]

2) The quantity of the design element [e.g. square footage of window area]

A tracking spreadsheet was used to capture information about compliance/noncompliance, the noncompliant performance level, and an indication of the size of the noncompliant system. Late in the program delivery phase these three pieces of information were captured all at once for projects participating in the program. For a number of the early reviews the initial effort only captured enough information to report to the design team or city staff about what needed to be done to correct deficiencies for specific energy code requirements. For these projects, the plans were later revisited to capture the additional data needed for energy impact quantification. For the non-participating control buildings, all data was captured during one plan review.

For a portion of the buildings where the development timeline allowed, tracking beyond construction document preparation was performed to make a best estimate of the final building compliance with the targeted energy code items. Prior to construction completion, the review of contractor submittals often provided more technical detail and clarity than was provided in the construction documents. Examples where the submittal information gave a better indication of compliance are U-factors for both insulation and windows, and HVAC unit technical information. For example, construction documents were often silent regarding HVAC outdoor air damper leakage limits, while the submittal for the specific make and model chosen by the contractor would note compliance with a specific air leakage limit. In this way, submittals can be an invaluable resource when trying to conclusively determine energy code compliance.

Where the construction timeline allowed, on-site inspection was also carried out for 11 of the buildings. For a number of items that could not be readily observed directly on-site at the time of inspection (e.g. HVAC control logic or window U-values), product information was recorded and follow-up was undertaken to obtain additional documentation. Besides submittals, examples of this documentation include: HVAC unit installation and operations manuals describing the control features in detail, and an invoices showing the specific window glass package and/or performance information. The low number of inspections and inability to directly observe a number of items led us to conclude that systematic comparison of inspection results to plan review results would not provide a data set that was adequate for drawing meaningful conclusions.

Calculation of Potential and Actual Energy Impact

The purpose of this analysis was to evaluate the energy impact the program has had on projects that participated, and provide a simple way for estimating the impact of the code items that a program could target in the future. Each measure was analyzed individually, with individual measure energy impacts added together for projects had more than one deficiency. While slightly less accurate than fully taking into account interactive effects, this individual measure approach provides results that are much more easily translated to a larger scale program while moderately underestimating the energy impact.[4]

The potential energy impact analysis was conducted based on Department of Energy (DOE) prototype building models (generated based on ASHARE Standard 90.1-2010) in EnergyPlus building energy simulation software (DOE 2017). These prototype building models provided defaults for the performance (e.g. U-factor) and quantity (e.g. window area) of each measure. Using prototype building models organizes buildings by building type with the assumption that the same group of buildings will have similar operation schedules, space types, HVAC types, thermal loads, and end-use percentages. Based on the reviewed project information (building types, area and HVAC types), the following prototype building models were selected for analysis, as well as the types they represent.

[4] This underestimation is demonstrated by an example of less insulation and lower furnace efficiency. The higher heating load (due to less insulation) would be analyzed using a code efficiency furnace that is more efficient than the actual furnace. Also, the impact estimation of the lower furnace efficiency would be calculated from a lower than actual heating load based on code compliant insulation.

Table 7. Prototype buildings and the represented building types

DOE Prototype Building Model	Building Types Represented
ASHRAE90.1_HotelSmall_STD2010	Hospitality, Multifamily
ASHRAE90.1_OfficeMedium_STD2010	Office, Other
ASHRAE90.1_RestaurantSitDown_STD2010	Restaurant
ASHRAE90.1_RetailStandalone_STD2010	Retail
ASHRAE90.1_SchoolSecondary_STD2010	Education

Normalized energy impact factors were calculated for each item; one factor for electric use (kWh) and one for gas use (therms). The normalized energy impact of each targeted code item is listed in Appendix E.

The typical steps for calculating the factors are listed below:

1. Identify the key simulation input for the code item in the model.
2. Change the key input value from the code required value to a non-compliant value (the most frequently used non-compliant values are ASHRAE 90.1-2004 required values, if worse than the requirement of version 2010).
3. Compare the new electric and gas usages with the original ones to get the energy penalties of not meeting the code requirement.
4. Determine normalizing parameter(s) for the code item, and normalize the penalty with the parameters to get the final energy impact factors. One code item could have one or multiple normalizing parameters, and the parameter can represent the whole building or only a fraction of the area where the code applies.

This typical analysis process was applied to most of the code items. One example is the analysis of item Roof Insulation R-value. The key simulation input was identified as the roof insulation U-factor. Take building type OfficeMedium as an example, the code required roof insulation U-factor is U-0.049, and it was changed to the ASHRAE 90.1-2004 required value, which is U-0.065. The penalty of not meeting this requirement was simulated and calculated to be 6561 kWh for electric usage, and 62 therms for gas usage. The normalizing parameters for this code item were determined to be the area of the roof section that didn't meet the requirement (17876 sf), and delta U-factor (0.016 BTU/ ($h \cdot ft^2 \cdot °F$)). The normalized energy impact factors for code item Roof Insulation R-value for OfficeMedium was then calculated as 22.94 kWh/delta-U/roof-sf and 0.22 therms/delta-U/roof-sf.

The impact of some code items cannot be estimated within (or only within) the prototype building models. For those items, engineering calculations were used to post-process the model data. One example is the analysis for code item HVAC commissioning. HVAC commissioning has numerous, small impacts on building operations that vary significantly for each building, and some of these impacts are not well-represented in typical building simulation efforts. Based on PNNL's research on energy cost savings, the total energy impact was estimated as 8% of the prototype building HVAC end usage (PNNL 2016), and the impact was normalized by the total floor area. The normalized energy impact factors for OfficeMedium were calculated as 0.27 kw/floor-sf and 0.01 therms/floor-sf.

The normalized parameters for all code items are listed in Appendix E.

Table 8 (below) shows the analysis process for each code item.

Table 8. Energy analysis method of each measure

Division	Measure	Energy Analysis
Envelope	Roof Insulation R-Value	Within Simulation
Envelope	Above Grade Wall Insulation	Within Simulation
Envelope	Slab Edge Insulation	Within Simulation
Envelope	Window U-Factor	Within Simulation
Envelope	Window Area -- Whole Building WWR	Within Simulation
Envelope	Window Orientation -- Both E & W < S	Within Simulation
Envelope	Envelope Tradeoff	Not Quantified
Electrical	Automatic Off Lighting Controls	Within Simulation
Electrical	Daylight Zone Control	Within Simulation
Electrical	Multi-Level Lighting	Post-Processing of Simulation Results
Electrical	Interior Lighting Power Density	Within Simulation
Electrical	Conductor Sizing	Post-Processing of Simulation Results
Electrical	Automatic Outlet Shutoff	Within Simulation
Electrical	Lighting System Functional Testing	Post-Processing of Simulation Results
Mechanical	Air Economizer	Within Simulation
Mechanical	Demand Control Ventilation (DCV)	Within Simulation
Mechanical	Energy Recovery Ventilation (ERV)	Within Simulation
Mechanical	Boiler & Chiller System Controls	Within Simulation
Mechanical	Duct Sealing & Testing	Within Simulation
Mechanical	Supply-Air Temperature Reset for Multi-Zone	Within Simulation
Mechanical	Fan Motor Sizing	Post-Processing of Simulation Results
Mechanical	Pool Cover	Post-Processing of Simulation Results
Mechanical	Low Leakage Intake and Exhaust Dampers	Post-Processing of Simulation Results
Mechanical	HVAC Commissioning	Post-Processing of Simulation Results

The actual building energy impact analysis was conducted based on normalized energy impact factors and the normalizing parameters from the design. An example is that for reviewed office buildings, the energy impact of not meeting code item Roof Insulation R-value was calculated as follow:

Impact on electric usage:

$$22.94 \times (\text{Design U factor} - \text{Code Required U factor}) \times \text{Design Roof Area}$$

Impact on gas usage:

$$0.22 \times (\text{Design U factor} - \text{Code Required U factor}) \times \text{Design Roof Area}$$

The impact of item HVAC commissioning was calculated using the equations below:

Impact on electric usage:

$$0.27 \times \text{Design Floor Area}$$

Impact on gas usage:

$$0.01 \times \text{Design Floor Area}$$

Delivery Cost and Cost-Effectiveness

The program delivery costs were tracked separately from the extra pilot evaluation costs, so that more typical program delivery costs could be used as the basis for cost-effectiveness analysis. Separate project codes were used in staff timesheets for tracking of various program activities (e.g. program development, marketing, and plan review), and for evaluation activities that go beyond typical program implementation effort (e.g. compiling information about the square footage of non-compliant windows and calculating the energy impacts). This allowed for an estimate of costs, to be quantified for the pilot program activities, to be parsed out in a way that will give an indication of the expected future program delivery efforts for a mature program. In addition to looking at the program marketing and delivery efforts over the course of the entire pilot program period, the costs of activities over a 9-month period from January, 2017, through September, 2017, were examined to get information about per participant costs after program processes had been fine-tuned and staff were more practiced with the review processes. While time was not tracked separately for each participating building, the timing of plan reviews was captured in a way that allowed for accurate counts of the number of buildings receiving plan reviews over the same 9-month period. This allowed for calculation of per-project costs over the course of the project and towards the end of the program delivery period.

In addition to the higher level activity tracking via our timesheet system, there was additional tracking of the time needed to evaluate lighting power density. We decided to track this because of both the very involved effort required to determine lighting power density (which was expected to be a significant fraction of the plan review task), and the likelihood that this measure might not be included in a revised program. While we expected very high compliance with the lighting power density line-item, this effort was continued throughout the pilot because of its importance in determining the energy impact of lighting control measures. The method of tracking the time for determining the lighting power density task was conducted through entry of a single number of hours value into the spreadsheet with the lighting power density calculations.

Utility program cost-effectiveness calculations were made in a spreadsheet tool that follows long-standing industry standards that have been used in Minnesota (California Energy Commission, 2001). Input assumptions for the calculations are based on recent filings for the largest investor-owned electric and natural gas utilities in Minnesota, starting with the year 2018. These key utility system level input assumptions are summarized in Table 9. For those items with variable escalation rates, the source's projections of the future value for each year were used.

Table 9. Utility system level assumptions for cost-effectiveness calculations

Input Name	Value for 2018	Source	Escalation
Electric utility discount rate	7.53%	(Xcel, 2017)	-
Gas utility discount rate	7.04%	(Xcel, 2016)	-
Societal discount rate	2.55%	(Xcel, 2016)	-
Participant discount rate	7.37%	(OES, 2009)*	-
Marginal energy cost	$0.0259/kWh	(OES, 2009)	Variable
Avoided capacity cost	$98/kW	(Xcel, 2017)	2.28%
Variable electric operations & maintenance cost savings	$0.0056/kWh	(Xcel, 2016)	4.00%
Avoided environmental damage costs	$0.036	(OES, 2009)	Variable
Percent line loss	6.80%	(Xcel, 2017)	-
Retail energy rate	$0.0611/kWh	(Xcel, 2017)	1.76% (OES, 2009)
Retail demand charge, summer	$13.55/kW	(Xcel, 2017)	1.76% (OES, 2009)
Retail demand charge, winter	$9.42/kW	(Xcel, 2017)	1.76% (OES, 2009)
Gas commodity cost	$4.6184/MCF	(Xcel, 2016)	4.00% (OES, 2009)
Gas demand cost	$86.79	(Xcel, 2016)	4.00% (OES, 2009)
Gas Variable O&M cost	$0.0441/MCF	(Xcel, 2016)	4.00% (OES, 2009)
Environmental damage factor	$0.3966/MCF	(Xcel, 2016)	2.16%
Gas retail rate	$6.9763	(Xcel, 2016)	4.00%

*Weighted average of utility discount rates (2/3 electric and 1/3 gas).

Program inputs into cost-effectiveness (e.g. program costs and savings) are based on the pilot program results as reported in the subsequent sections. In addition to the pilot program per building delivery and incentive costs, each pilot program element is assumed to have $75,000 in utility administrative costs and 50 participants. All program costs are assumed to be split between both the electric and natural gas utilities, with the electric utility covering 75% of the cost and the gas utility covering 25% of the cost.

Process Evaluation Activities

Code Official Focus Group

As the new Commercial Energy Code went into effect in Minnesota in June of 2015, new trends in non-compliance were expected to occur. In order to allow the program to respond to these changes, program staff held a group meeting in April of 2016 with 7 government staff (code officials) representing 6 different jurisdictions. Five of the participants represented jurisdictions in the twin cities metro area while one had statewide responsibilities and one represented a jurisdiction in greater Minnesota.

Because projects that are in the design process at the time of the new code adoption are often allowed use the old code, there is a significant time lag between the date of adoption and when officials have had many project go through the plan review and inspection process. Officials involved in the meeting made numerous statements suggesting that they were just starting to get a good feel for trends at the time of the meeting, nearly a year after the code was introduced. Because of the limited number of projects within each jurisdiction to have been completed under the code at that time, this group discussion format was chosen over plan review and field verification. This approach was judged to be more effective at getting timely feedback from code review staff that had each dealt with a number of projects. Meeting participants were asked about trends for compliance paths chosen, types of code items where non-compliance is an issue, issues at plan review, issues at the time of inspection, project review/approval process issues, and numerous ways that improved compliance might be achieved.

Program Participant Surveys

For the purpose of gathering pilot participant feedback, we conducted three surveys over the course of the pilot program. One of these surveys was administered to design team members of projects receiving design team support. The other two surveys were administered to city code officials based on the projects where partner cities receiving design review support from CEE. The first of the code official surveys were administered 5 to 10 months into the pilot, after one or two project collaborations. The second was administered at the terminus of the pilot services. The first and second code official surveys were the same, with some additional end-of-pilot questions asked in the second survey. The questions asked in each survey are included in Appendix C.

For both the code official surveys and the design team surveys, the sample sizes are too small to make any statistically significant conclusions. For the design team survey, this included 10 complete responses and one partial response. Of these responses, all data was used— 11 responses in total when answers were available. For the code official survey, the early survey included just three participants with two complete responses. The late survey included eight responses with six complete responses. Responses were tracked by city code officials so longitudinal trends about the benefits of the pilot services could be tracked over time. However, with such small survey samples, these results were only used to make observations about potential trends that would need further study to be conclusive.

All surveys were administered via an online survey tool emailed to participants at triggering stages in the pilot program. Survey participation was part of the participation agreement that all participating team leads signed. Additionally, a small $50 incentive was offered to the companies where each team member worked. Each team was encouraged to have one person from each area of expertise, including an architect, lighting designer, engineer, mechanical engineer, and a contractor (although this wasn't common). While there were 15 projects that received design team support, eight or nine of these projects were represented in the survey responses. Due to measures taken to keep survey responses anonymous, we were unable to confirm if eight or nine projects were represented. The data gathered was evaluated based on numeric responses or short answers from which common responses were grouped to find trends.

Results

Key Program Metrics

Program Recruitment and Participation

Recruitment of Small Buildings to Receive Design Team Support

The recruitment rate for projects receive design-team support for small building was much slower than hoped for, and resulted in only 15 projects receiving plan review services. Despite multiple escalations of the recruitment efforts and adjustment of tactics, the "cold calling" of contacts had percentile recruitment rates in the single digits.

The originally planned recruiting approach was to contact design teams based on specific projects identified by Dodge Reports as being in a very early phase; this had limited success. The project team then transitioned to market player-based recruitment as the primary approach. The original pilot plan envisaged the majority of recruitment calls being made to design and development team members in the partner cities when they were beginning to design a specific project. The plan assumed that project status information in Dodge Report's database from McGraw Hill, along with information from city planners, would provide numerous leads for project team members to contact at just the right time for them to commit and then quickly move into program participation. However, over the first few months, it became clear that these sources and contacts are not as comprehensive in scope, and/or are not as reliable in providing current project design and development stage information as was hoped. For these reasons, our calls to design teams based on project database tracking information often failed to secure a commitment for the intended projects. However, these calls did frequently lead to discussions about other projects the industry contact would consider for inclusion in design team support program if and when those projects reached the appropriate design phase. In addition, the pilot program reached out to a number of design firms within CEE's network of contacts, and obtained long-term program interest along with commitments for pilot program participation for specific building projects. While this approach of working on long-term relationships with industry players has been very successful for CEE's One-Stop Efficiency Shop program, it took years to fully gain traction in the market. Referrals from city staff involved in the other pilot program also led to a small number of leads, but these had a much higher percentage of successful recruitment.

In addition to reaching out to a broader network of designers, the target area for inclusion of design team support pilot participants has been expanded beyond the borders of the three partner cities. This change greatly increased the pool of eligible projects, while maintaining a level of consistency in the local commercial building industry players and market practices. The original size limit of 50,000 sf was also relaxed for multifamily and hospitality buildings where the use of simpler, individual unit HVAC systems keeps the building energy code issues relatively simple to address (compared to most larger buildings).

Although renovation projects were eligible for the program and represent the vast majority of building permit applications, they were a very small minority of projects recruited. These renovation projects reportedly tend to have less formal design/development processes that are led by contractors rather than architects, so special targeting of marketing and/or services may be needed to reach more of these projects.

The building types and sizes that were recruited for design team support, received plan review services, and were included in our final data set for impact evaluation are shown in Table 10 (below). Three other projects that received plan review services were not included in this comparison data set because of characteristics that were judged to make them inconsistent with the group and/or the baseline set of buildings (e.g. renovation or changed to a performance compliance path). The two largest categories of participants were *multifamily* and *office*, which together represent half of the buildings.

Table 10. Buildings receiving design team support: evaluation set

Building ID	Building Type	Floor Area (ft^2)
SHS1	Hospitality	88,364
SMT1	Multifamily	86,983
SMT2	Multifamily	260,300
SMT3	Multifamily	62,807
SOF1	Office	41,234
SOF2	Office	11,288
SOF3	Office	5,906
SOF4	Office	45,699
SOT1	Assembly	44,344
SRR1	Restaurant	11,167
SRR2	Restaurant	7,347
SRT1	Retail	13,946
SRT2	Retail	3,088
SRT3	Retail	121,788
#/Average	**14**	**57,447**

Recruitment of City Review Support Participants

The city review support pilot (approach 2) established close working relationships with three partner cities, who looked to program staff as a resource beyond what was originally envisioned. Each partner city is a suburb in the Minneapolis-St. Paul metro area. This pilot program generally that found city staff were open to our third-party involvement in plan review and inspection, although this may not be the case in other jurisdictions. This positive response contrasts with our original assumptions about city staff sensitivity to someone “looking over their shoulder.” The cities the pilot program partnered with even asked CEE to perform inspections alongside some of their staff for training purposes, and these relationships with city codes enforcement and planning staff have been invaluable for the implementation of the pilot program.

The most critical result from these city partnerships were the commitment of 7 specific projects for review within the first 4 months of program roll-out, with additional requests for support throughout the pilot program implementation period. The city review support pilot program exceeded its participation goal with 17 participants. The vast majority of buildings served were new construction projects.

Summary information about the buildings included in the city reviewer support pilot is provided in Table 11. The buildings marked with an asterisk received a second round of plan review after the city requested plan updates based on CEE's review report. All but one of the participating buildings was a new construction and nearly half were within the *multifamily/hospitality* category. Also note that a number of smaller buildings were included in this set because of a combination of strong partner city interest and the program's desire to include building types that had been under-represented to date. The cities had also asked for the inclusion of several other projects that did not fit our criteria for building size or type, and thus were not included in the pilot, indicating broad acceptance and demand for this approach. It is also noteworthy that the partner city commitments have included repeat requests after receiving their first participating project's review report. This reinforces the project team's expectation that cities will see value in the delivery of this program that goes far beyond a one-time training activity.

Table 11. Buildings receiving city review support: evaluation set

Building ID	Building Type	Floor Area (ft^2)
LHS1	Hospitality	117,583
LHS2	Hospitality	64,773
LHS3*	Hospitality	81,662
LHS4	Hospitality	73,150
LMT1	Multifamily	278,095
LMT2*	Multifamily	283,924
LMT3	Multifamily	139,579
LOT1*	Office/Other	71,991
LRT1	Retail	3,503
LRT2	Retail	3,440
LRT3	Retail	41,560
LRT4*	Retail	29,167
LRT5	Retail	27,198
LED1*	Education	89,281
LED2*	Education	8,909
LED3	Education	10,153
#/Average	**16**	**82,748**

*Received 2nd reviews after construction document revisions.

Beyond providing sites for large building reviews, the pilot program leveraged the relationships with partner cities to aid in the identification and recruitment efforts for small building program participants, and to help track projects after the design review so that the pilot program could time our field verification visits accordingly. Moreover, the partnerships and code officials' awareness of our program activities lends more credibility in the eyes of the building project development and design teams.

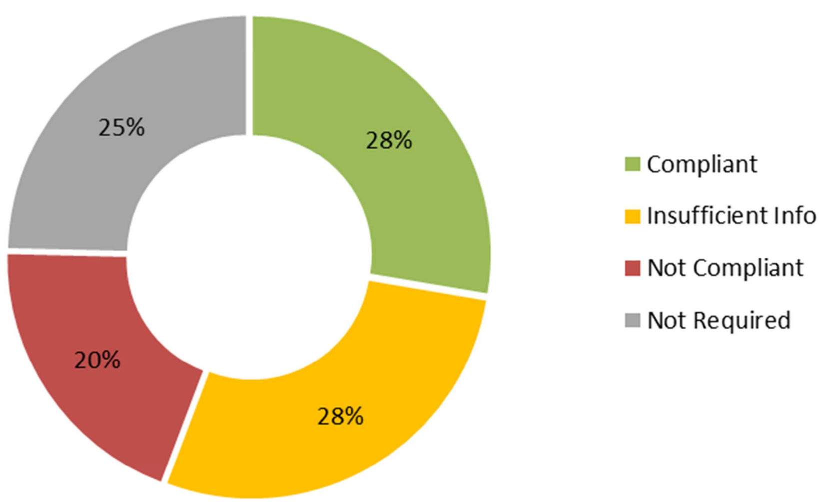
Frequency of Compliance with Program Measures

Without Program Intervention

The compliance rates of the pilot program's targeted code items for various groups of buildings were calculated and compared. The most important distinction between different buildings was whether or not the design team received any pilot program support prior to submitting plans for building permit review by city staff.

Figure 9 (below) shows the overall compliance rate for the No Support group. "Insufficient Info" represents the percentage of reviewed items that don't have enough information provided in the plans, and "Not Required" represents the percentage of items that are not applicable to the reviewed projects. A total of 24 buildings were reviewed in this group. Although the sample size is not large, the result can still reflect the current code compliance status of the projects submitted to the code officials. The chart shows that, for the code items targeted in this program, only 26% of them were meeting the code requirements, and over half of the items were either not meeting the requirement or the project teams didn't provide enough information to verify them (e.g. insulation thickness is shown without clearly indicating the material and/or its minimum thermal performance).

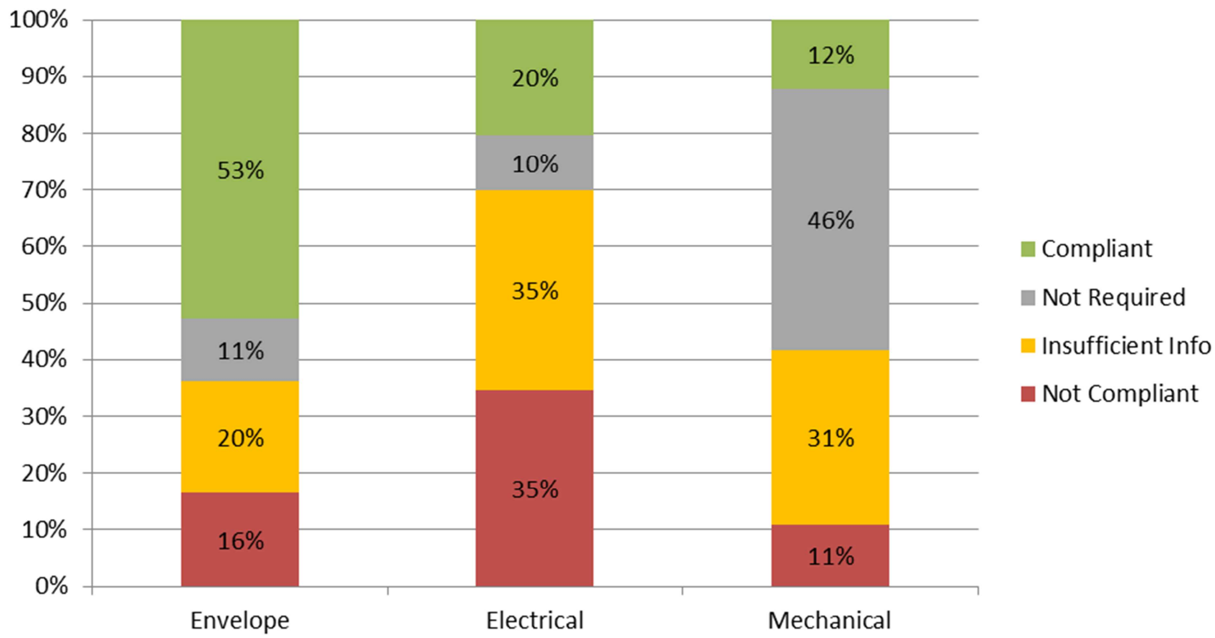
Figure 9: Program measure compliance for buildings receiving No Support prior to permit submission



The compliance rates of the three major construction divisions addressed are shown in Figure 10. Comparing between different divisions, the Envelope section has the highest rate in meeting the requirements, while the Electrical section has the highest rate of not meeting the requirements. Both

Electrical and Mechanical divisions have high rates of not providing enough documentation. Most of the not applicable items are shown in the mechanical section, as a number of energy code requirements for mechanical systems only apply in certain situations (e.g. to a particular type or size range of equipment).

Figure 10: Program measure compliance by division: for buildings receiving No Support



To take a more detailed look into each section, Figure 11 through Figure 13 illustrate the compliance rates for each item of each section. Figure 11 clearly shows that, among all the targeted code items in the Envelope section, both Above Grade Wall Insulation and Slab Edge Insulation have relatively high noncompliance rates, and item Window U-Factor has the highest rate of not providing enough information. Figure 12 shows that all of the targeted code items in the Electrical section have high noncompliance rates; except for Interior Lighting Power Density. The most noteworthy items in Figure 13 are Duct Sealing and Testing, Low Leakage Intake and Exhaust Dampers, and HVAC Commissioning. All three have high rates of either not meeting the requirement or not having enough information in the construction documents to determine compliance. Finally, Fan Motor Sizing also has a relatively high rate of not providing enough information.

Figure 11: Individual Envelope measure compliance for buildings receiving No Support

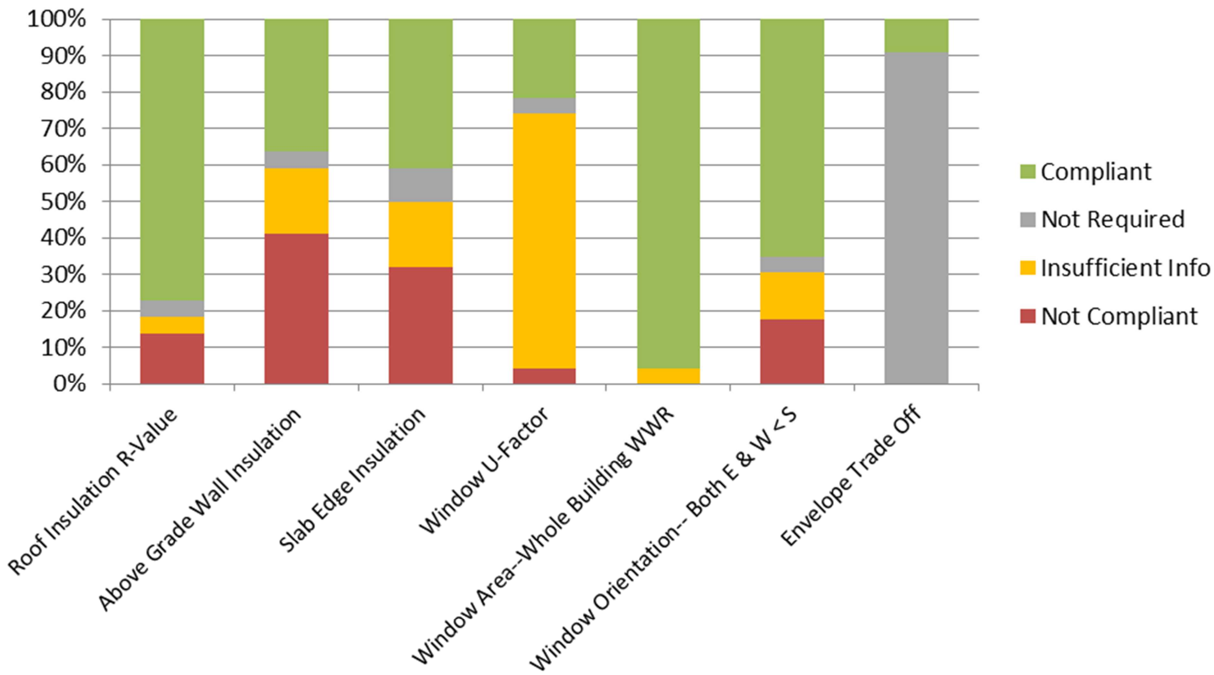


Figure 12: Individual Electrical measure compliance for buildings receiving No Support

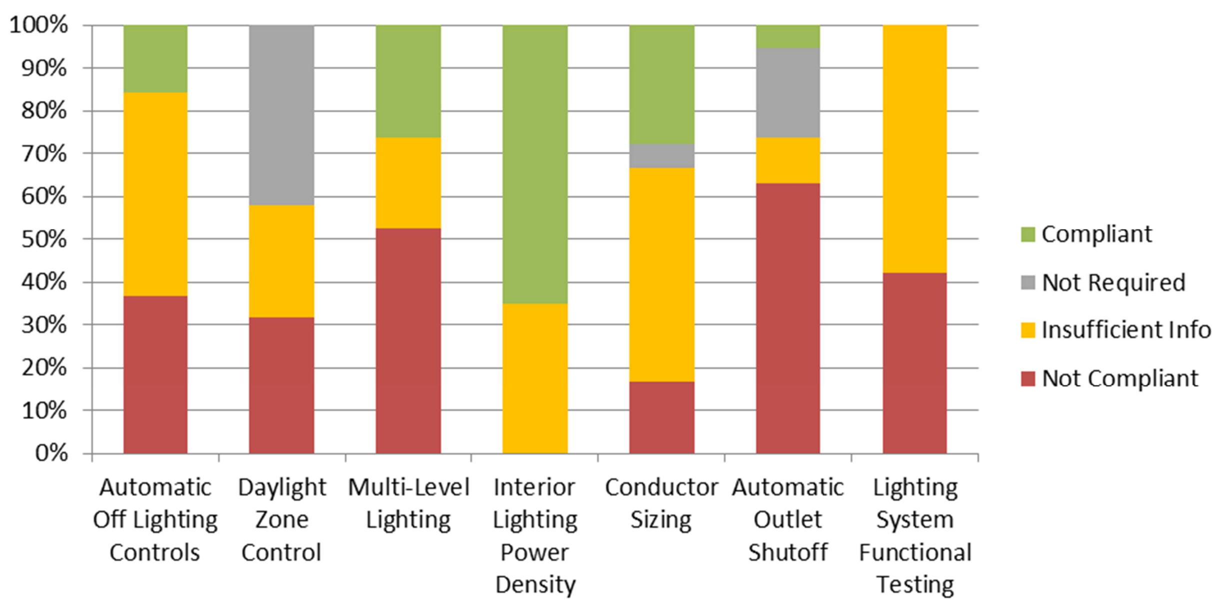
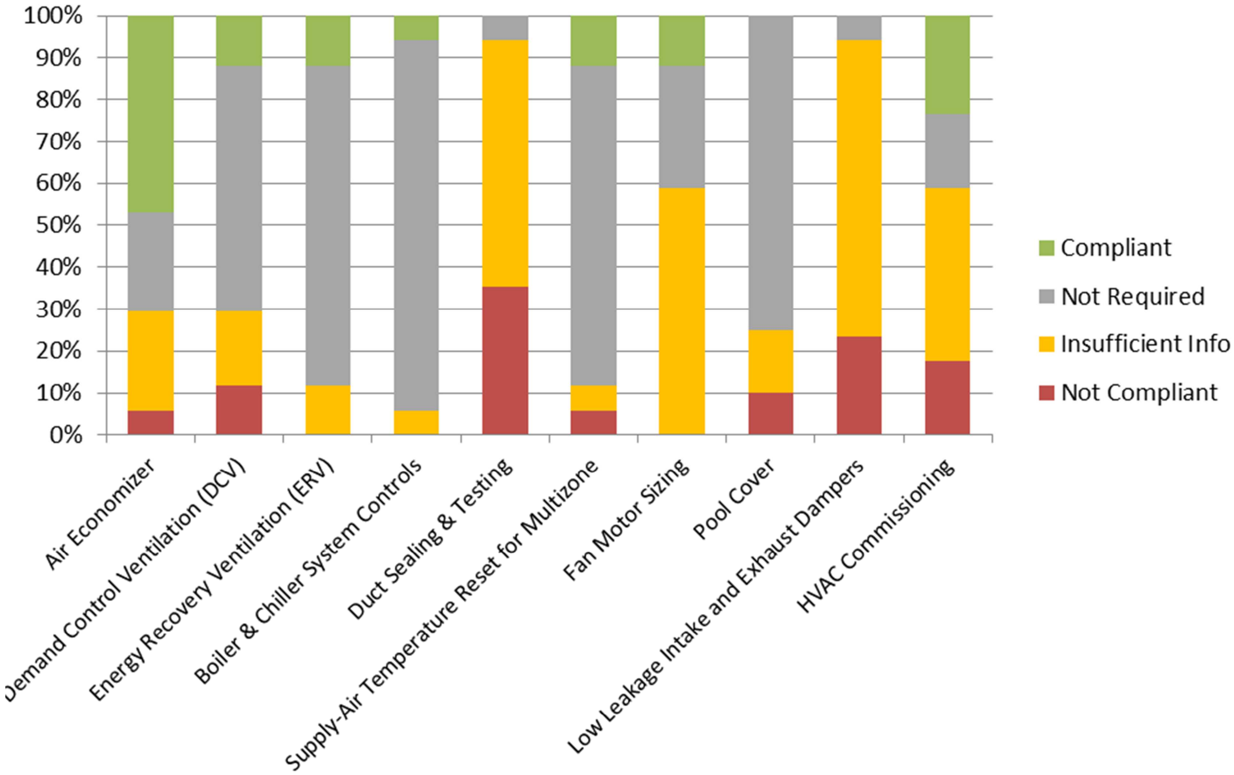


Figure 13: Individual Mechanical measure compliance for buildings receiving No Support



With Program Intervention

The improvements in program measure compliance rate of buildings receiving pilot program services are shown in this section. Each pilot program effort—design team support, and city reviewer support leading to plan updated—are compared against projects receiving No Support prior to submission for a buildings permit.

Table 12 (below) shows a comparison between both the No Support group and Design Team Support group. The No Support group includes 24 buildings, and the Design Team Support group includes 14. The Table shows that the support to the design team has had a noticeable impact on the code compliance process, especially in regards to reducing the noncompliance rate to less than half of the baseline value.

Table 12: Program measure compliance (No Support group vs. Design Team Support group)

Review Result	No Support, n=24	Design Team Support, n=12	% Change
Compliant	26%	31%	+5%
Not Required	23%	27%	+4%
Insufficient Info	33%	32%	-1%
Not Compliant	19%	9%	-10%

The comparison between the City Reviewer Support and the No Support group is shown in Table 13. The City Reviewer Support group has 6 buildings, which is a subset of the buildings of the No Support group. The 6 buildings were reviewed multiple times, with the results of the first review included in the No Support group, and the last review in the City Reviewer Support group. To better estimate the improvement that resulted from providing support to city code officials, the comparisons in Table 13 are only between the first and the last review of those 6 buildings.

Similar to Table 12, Table 13 also demonstrates that with support to the city reviewers, project plans have overall higher rates of meeting the requirements, and lower rates of not Compliant and not providing enough documentation. In addition to reducing the rate of non-compliance by 60%, the rate of clear compliance was doubled. Based on the changed percentage in both tables, providing support to city reviewers appears to have a higher impact on the number of compliance items than providing support to design teams.

Table 13: Program measure compliance. Improvement for 6 buildings receiving City Reviewer Support.

Review Result	At Initial Permit Application	After City Requested Updates	% Change
Compliant	28%	56%	+28%
Not Required	17%	20%	+3%
Insufficient Info	36%	16%	-20%
Not Compliant	20%	8%	-12%

The comparison of compliance rates for the construction divisions is shown in stacked charts (below) for the same building groups. Both charts show that the program interventions have the highest impact on lowering the noncompliance rate in the Electrical section. However, all construction divisions were positively impacted, in terms of clear compliance and/or reduced noncompliance.

Detailed compliance rates for each code item addressed by the program for the No Support group, the Design Team Support group, and the City Reviewer Support group are shown in Appendix D.

Figure 14: Program measure compliance by division: No Support vs. Design Team Support.

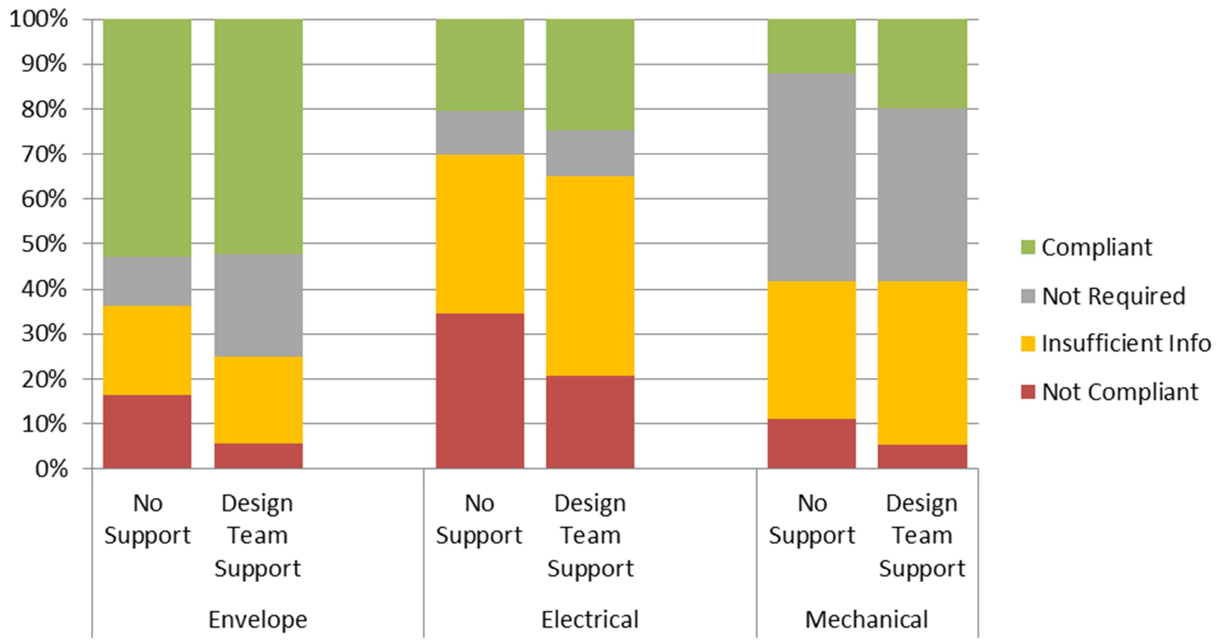
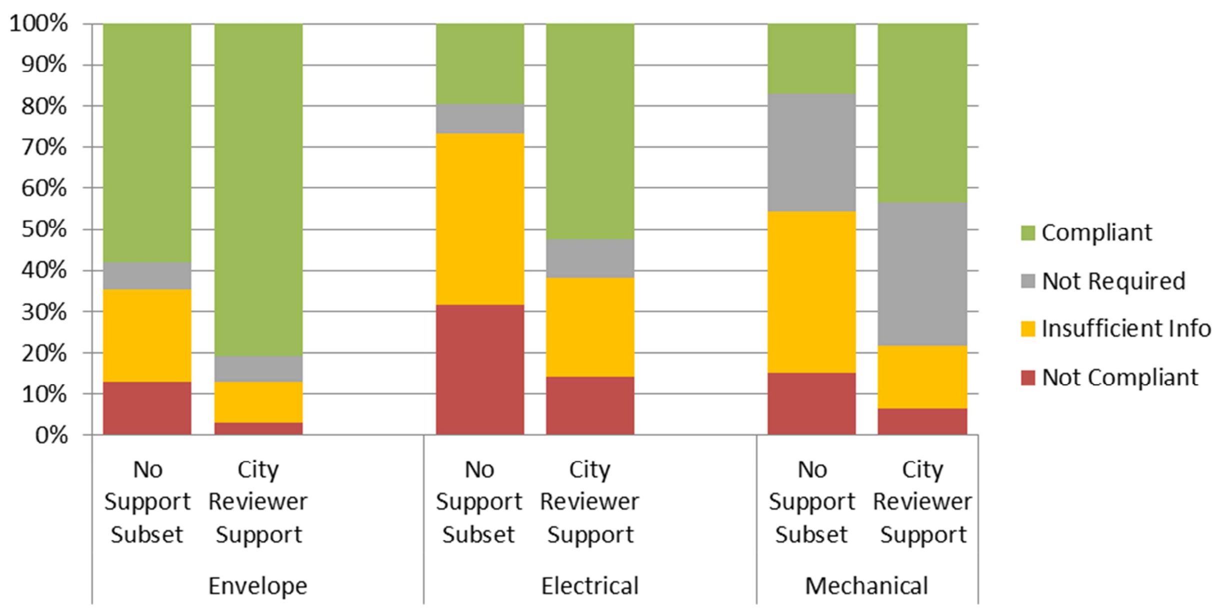


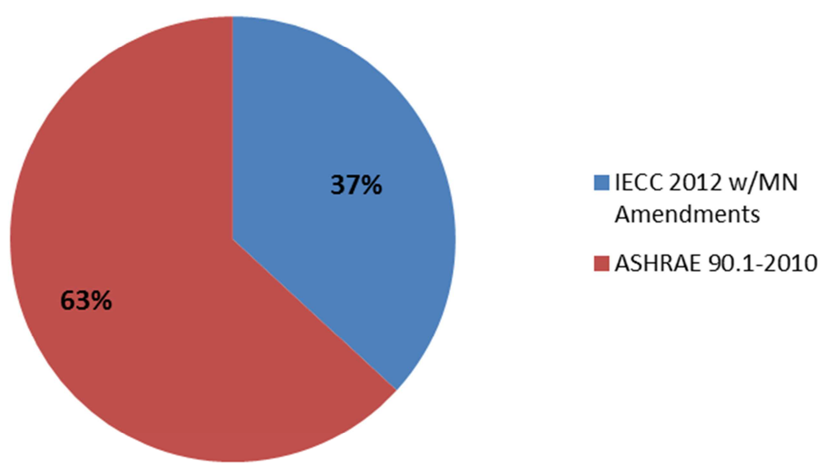
Figure 15 Program measure compliance by division: 6 buildings before and after Reviewer Support.



Compliance Paths

The projects reviewed showed mixed trends in regards to energy code compliance path chosen. The most obvious impact of compliance path trends on program design include whether materials for certain size buildings need to include options for both code paths. While this was not incorporated into the original program design, the results could also inform whether it could be cost-effective for a utility program to encourage building designs to comply with one particular code compliance path. The percentage of projects choosing each energy code option are shown in Figure 16. Only 3 projects used a performance path, and all of those followed ASHRAE 90.1. While the majority of projects followed an ASHRAE path, we did observe a significant fraction of “large” projects using IECC and most “large” projects using a prescriptive, which path differs from the findings of interviews with code officials and designers prior to program launch. These interviews suggested that only small projects would use IECC and that most large projects that use ASHRAE would use the performance path. A few projects also used envelope trade-offs within either path. This allows one envelope item to be less efficient if the overall UA calculated for the building envelope is at least as good as the same building with every building envelope U-factor exactly matched the code.

Figure 16. Code compliance path trend among all buildings reviewed



For many of the projects, the compliance path had to be determined through verbal inquiry because the construction documents did not indicate which energy code compliance path was being followed. City staff reported that project team representatives often weren’t aware of the need to choose an energy code compliance path when submitting the plans , or which path the project was taking. Even some projects that did note a compliance path on the code summary sheet had some contradictory information provided elsewhere, and one project decided to change from the ASHRAE 90.1-2010 compliance path to 2012 IECC after a major issue with window area and orientation was noted in the program’s initial review. The inconsistent level of knowledge of the 2015 energy code paths suggests that building industry professionals were still adapting to the new code, so that the pilot program's findings related to code compliance path selection trends could change over time.

Energy Impacts

Potential Impact

Based on the calculated energy impact of each item, the energy penalty of each reviewed project was calculated. The average and the median energy penalty per building are calculated and shown in Table 14 for the No Support group. Since some of the projects were lacking documentation for one or multiple divisions (e.g no electrical or mechanical drawings were submitted), another set of values that includes only the fully reviewed buildings was also calculated. The low estimations in Table 14 are the penalties of only the noncompliant code items, and the high estimations are the sum of both the noncompliant and the insufficient info items. The costs were estimated based on Minnesota average price of electricity (10.73 cents/KWh [EIA, 2017a]) and gas ($0.698/therm [EIA, 2017b]). Table 14 shows that buildings without any support can be estimated to have an average $4,931 cost of electric penalty and $409 of gas penalty.

Table 14 Excess energy and cost per building for non-compliance with program measures*

Penalty	Electric Penalty Low Estimation (KWh)	Electric Penalty High Estimation (KWh)	Gas Penalty Low Estimation (therms)	Gas Penalty High Estimation (therms)
Energy: Average	35,402	71,501	545	1,476
Energy: Average fully reviewed	45,959	99,934	586	2,050
Energy: Median	2,849	20,017	73	409
Energy: Median fully reviewed	12,438	29,781	299	642
Cost: Average	$3,799	$7,672	$380	$1,030
Cost: Average fully reviewed	$4,931	$10,723	$409	$1,431
Cost: Median	$306	$2,148	$51	$286
Cost: Median fully reviewed	$1,335	$3,196	$208	$448

*Based on permit submissions of construction documents for 24 buildings averaging 84,700 square feet.

The analysis above did not group the buildings into different building types since there are not enough buildings in each building type to get representative values. Instead of using the reviewed results, energy penalty and $ costs for each building type are calculated based on the information of the prototype building models. The values are shown in Table 15, and represents the possible penalties if all the targeted code items are noncompliant. It appears that, since educational buildings are normally with bigger sizes, the total energy penalties will be higher than other types; restaurants are possible to have low penalties because of their small sizes.

Table 15 Prototype building energy penalty

Building Type	Area (sf)	Electric Energy Penalty (KWh)	Gas Energy Penalty (therms)	Electric Cost Penalty	Gas Cost Penalty	Total Cost Penalty
Hotel	43,202	141,227	8,688	$15,154	$6,064	$21,218
Office	53,628	209,187	2,500	$22,446	$1,745	$24,191
Restaurant	5,502	46,480	1,721	$4,987	$1,201	$6,189
Retail	24,692	73,242	2,262	$7,859	$1,579	$9,438
Education	210,886	627,563	106,397	$67,337	$74,265	$141,603

Table 16 (below) shows the penalties per square foot for each building type. It appears that for similar size buildings, restaurants will have higher energy penalties if not meeting the code requirements, and hotels and educational buildings will also have higher penalties in gas usages.

Table 16 Prototype Buildings Energy Penalty Per Square Foot

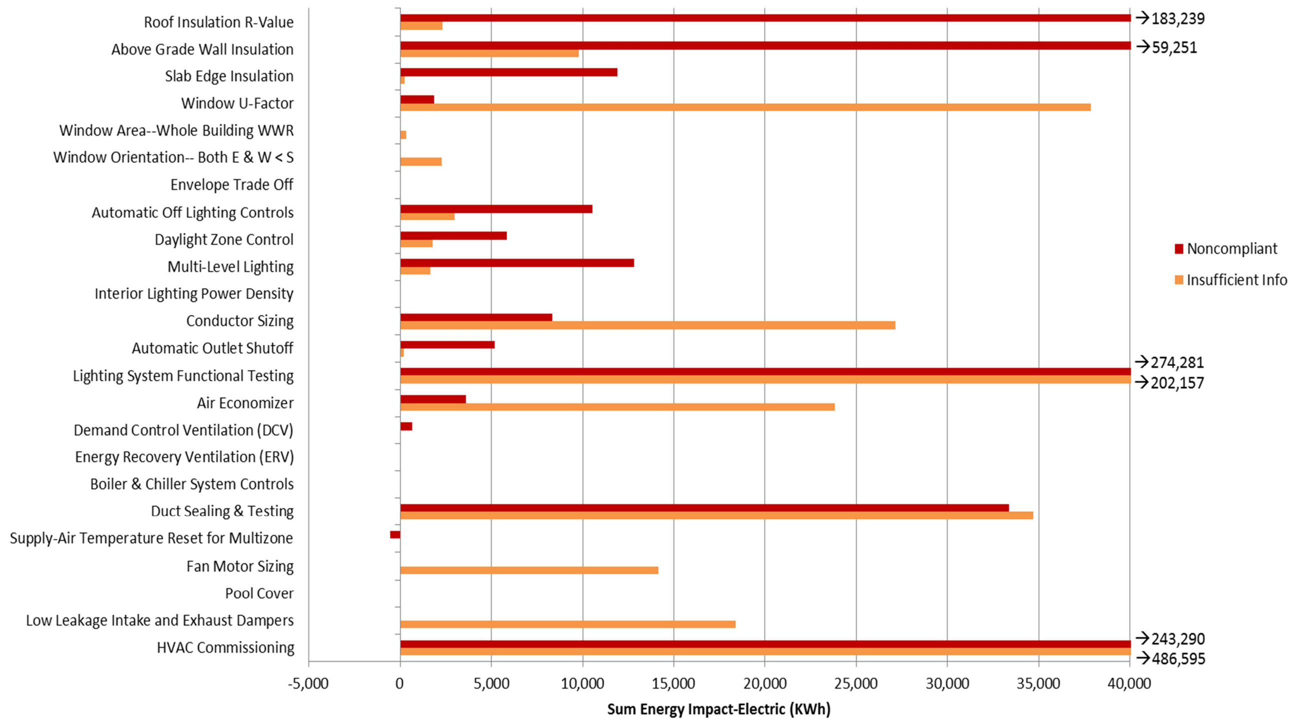
Building Type	Area (sf)	Electric Energy Penalty (KWh/sf)	Gas Energy Penalty (therms/sf)	Electric Cost Penalty per sf	Gas Cost Penalty per sf	Total Cost per sf
Hotel	43,202	3.27	0.20	$0.35	$0.14	$0.49
Office	53,628	3.90	0.05	$0.42	$.03	$0.45
Restaurant	5,502	8.45	0.31	$0.91	$0.22	$1.12
Retail	24,692	2.97	0.09	$0.32	$0.06	$0.38
Education	210,886	2.98	0.50	$0.32	$0.35	$0.67

The energy penalty can be interpreted as the energy saving potential for each building if its construction documents are updated to meet all the targeted code item requirements. The results of each individual building project are shown in Appendix x.

Targeted Code Item Energy Penalties

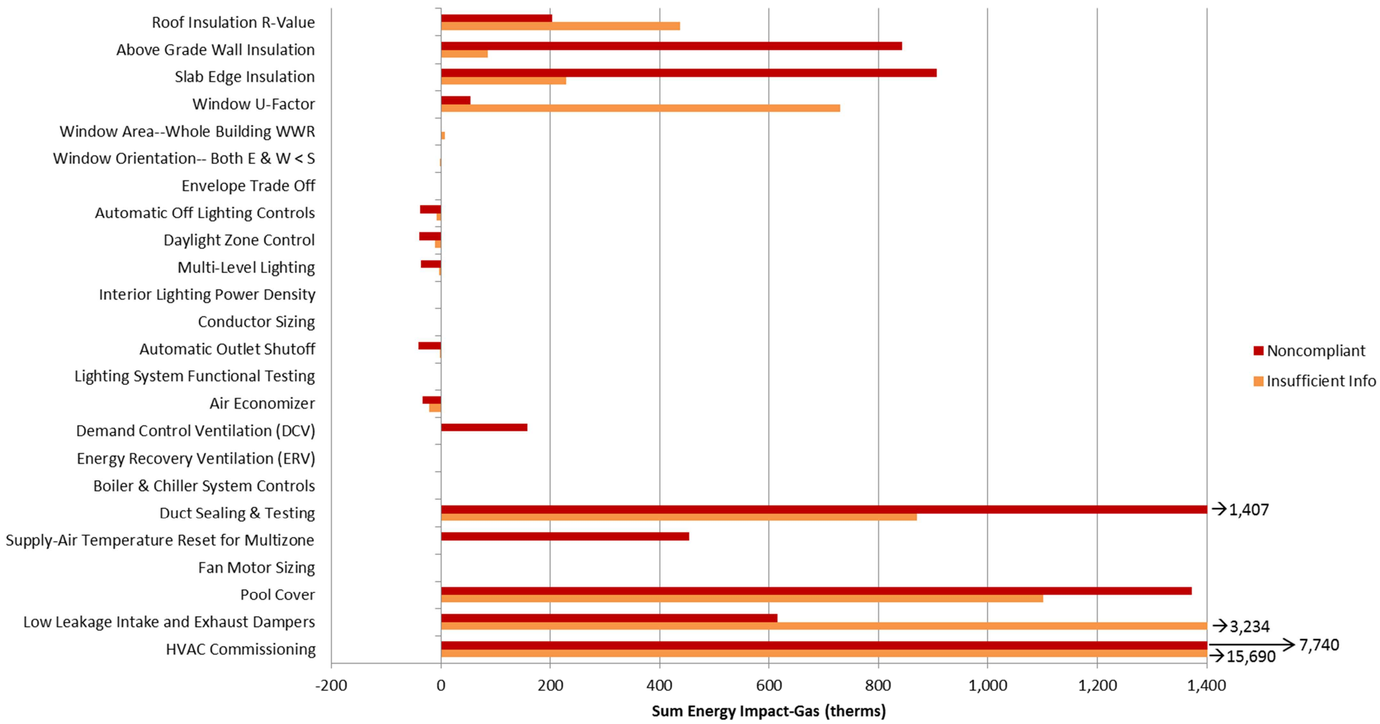
The total energy penalty for each item is illustrated in the Figure 17 (below) for No Support group. The impact of electric use and gas use are presented in separate charts. The penalty of each item was calculated by adding up the penalty of each review of a building for that item, so the result is the combinations of both compliance rate and the energy impact of not meeting the requirement. The comparison among all items illustrated in Figure 17 shows that item HVAC commissioning, Lighting Functional Testing, and Roof Insulation R-Value are the top three items that have significant high energy penalties. Besides those three, items also with significant impacts are Above Grade Wall Insulation, Window U factor, Conductor Sizing, Air Economizer, and Duct Sealing & Testing.

Figure 17 Sum Energy Impact of All Targeted Code Items for No Support Group – Electric



The gas usage penalties of the targeted items are shown in Figure 18. The top three items with highest energy penalties are Duct Sealing & Testing, Low Leakage Intake and Exhaust Damper and HVAC Commissioning. Besides those three, item Pool Cover and all items in Envelope division also have relatively high penalties.

Figure 18 Sum Energy Impact of Targeted Code Items for No Support Group – Gas



Pilot Program Energy Impact

The savings resulted from providing support to the design teams and the city code reviewers were calculated and presented in the tables below.

Table 17 shows the savings resulted from the support provided to the code officials. The savings are the difference between the first review (at initial permit application stage) and the final review (after city requested updates) of all buildings in the City Reviewer Support group. Based on the table, the support provided a per building savings range of 22,066 to 74,931 kWh and 433 to 1,301 therms. Those dramatic numbers shows a great potential of energy and cost savings that a program can brought of providing support to the city code reviewers.

Table 17 Savings per building by providing support to code reviewers

Penalty/Impact	Electric Penalty Low Estimation (KWh)	Electric Penalty High Estimation (KWh)	Gas Penalty Low Estimation (therms)	Gas Penalty High Estimation (therms)
Energy: At Initial Permit Application	22,066	74,931	433	1,301
Energy: After City Requested Updates	2,862	18,759	128	175
Energy: Savings	19,204	56,172	305	1,126
Cost: Savings	$2,061	$6,027	$213	$786
Savings/First Review Penalty	87%	75%	70%	87%

The 6 building subset of baseline buildings in Table 17 has a much lower per building potential than the larger group of baseline buildings. To better estimate the impact per building for the larger group of 24 baseline buildings, Table 18 (below) shows the projected impacts which are calculated based on the average penalties of the whole No Support group in Table 14 and the Savings/First Review Penalty in Table 17. Based on Table 18, the support can save a range of $3,305 to $5,754 by saving electric usage, and $266 to $896 by saving gas usage.

Table 18 Projected program energy and cost impact per building: City Review Support

Penalty/Impact	Electric Penalty Low Estimation (KWh)	Electric Penalty High Estimation (KWh)	Gas Penalty Low Estimation (therms)	Gas Penalty High Estimation (therms)
Energy: No Support Group Average	35,402	71,501	545	1,476
Savings/First Review Penalty	87%	75%	70%	87%
Energy: Projected Impact	30,800	53,626	382	1,284
Cost: Projected Impact	$3,305	$5,754	$266	$896

Table 19 shows the savings that resulted from the provided support to the design teams. To get the possible impact of the provided support, the estimated average Design Support Group energy penalty values per building were calculated based on the energy penalties of the No Support Group and the compliance rate difference between the two groups. The estimated penalties were calculated for each code item first, then summed up to get the total impacts, and finally averaged based on the total No Support Group building amount (24). The estimated Design Support Group values are shown Table 19 below.

Based on Table 19, for each building, supporting the design teams resulted in per buildings savings of 24,843 kWh and 545 therms by reducing the noncompliant rate in code reviews. Different from Table 17, the savings of the High Estimations groups are lower than those of Low Estimations groups. It is because of the apparent impact of the "Insufficient info" items, which are based on assumed levels of non-compliance (e.g. wall U-factor) that could have more energy impact than the actual non-compliant value observed in an instance of clear non-compliance. While the overall rate “Insufficient Information” instances in the Design Support Group is slightly lower than the No Support Group (32% vs 33%), the rates of some code items are still higher than the No Support Group, and those items have relatively high energy impacts compared to other items.

Table 19 Projected program energy and cost impact per building: Design Team Support

Penalty/Impact	Electric Penalty Low Estimation (KWh)	Electric Penalty High Estimation (KWh)	Gas Penalty Low Estimation (therms)	Gas Penalty High Estimation (therms)
Energy: No Support	35,402	71,501	545	1,476
Energy: Design Support Group	10,559	61,044	101	1,359
Energy: Savings	24,843	10,457	444	117
Cost: Savings	$2,666	$1,122	$310	$81

Program Costs

Based on the results of this pilot, our best estimate of future program costs are $4,220 per building for a similar design team support program and $4,520 per building for a similar city reviewer support program. Table 22 (below) shows how various indicators of pilot program costs were used to arrive at this estimate of future program costs. The first row of data shows the per-building pilot program staff time and costs (excluding initial development and evaluation) based on the entire length of the pilot program delivery. The second data row shows our best estimate of per-building costs for continuing the pilot program exactly as it operated over the last 9 months of active delivery. This latter period’s lower costs reflect more efficient plan review and report preparation due to a combination of process improvements and increased staff experience with the focused energy code reviews. Finally, the last row—our best estimate of future, similar program costs—is based on the expected labor reduction that would be achieved by omitting lighting power density calculations from the review process, and on the assumption that full-scale recruitment costs per building will be half of those in the pilot program.[5] Market transformation impacts on code compliance from long-term implementation of a city review support program would further reduce the per building cost of city review support (because of less effort to document and report on issues found during plan review), but this impact was not considered in our projections of program cost. This last row’s best estimate of future program costs provides the basis for the cost-effectiveness analysis reported in the next section.

[5] Our recommendation for omitting lighting power density from most reviews in future program iterations (because of a combination of very high compliance already, and high incremental costs to include this measure in the review process) is described further in the Discussion section.

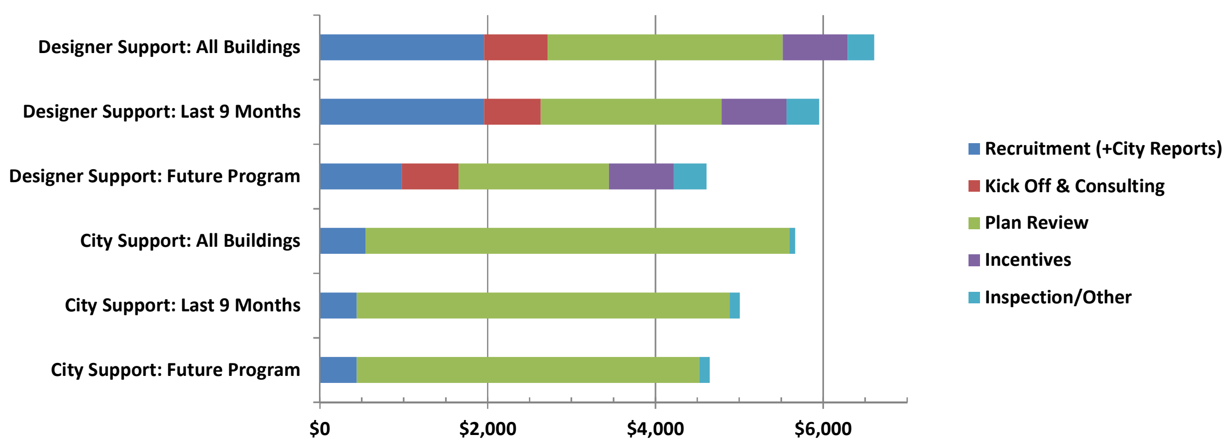
Table 20. Code compliance enhancement program costs per building

Cost Basis	Design Team Support Hours	Design Team Support Cost	City Review Support Hours	City Review Support Cost
Entire Pilot Program Delivery	57	$6,610	47.5	$5,670
Last 9 Months of Pilot Program	53	$5,950	43.5	$5,010
Last 9 Months Without Lighting Calcs	37.5	$4,610	39.5	$4,650

While the pilot program's vision was for the design team support efforts to be a much lower-cost, higher volume service compared to the city review support efforts, the pilot program experienced very similar per-building costs for each of the two approaches. This is primarily because of higher than anticipated recruitment costs, with the incentive costs also playing a role. Figure 19 shows how these factors contributed significantly to the costs for design team support, while neither had a dramatic influence on the city review support costs.

An alternative for achieving low costs in design team support efforts is to eliminate the detailed plan review portion of the program services and reduce the participation incentive. While this omits what was expected to be a key program component, omitting the plan review and cutting the incentive in half would save $2,180 per building and bring the total projected program cost per building down to $2,430.

Figure 19. Program delivery cost components



Program Cost-Effectiveness

Based on the previous sections' pilot program evaluation findings for the costs and savings for each of the two pilot program approaches, we looked at the projected cost-effectiveness of larger scale, similar programs. Both pilot program approaches were found to have the potential to be cost-effective; especially on a societal test basis. The analysis based on savings for Design Features only, still shows potential for cost-effectiveness if the savings for the pilot program's two largest energy impactful items—commissioning of HVAC systems and functional testing of lighting controls—were disregarded. The cost-effectiveness of the city reviewer support approach is much more reliably shown to be clearly cost-effective across a range of assumptions, and the cost-effectiveness is generally better for electric utilities than for natural gas utilities.

Table 21 displays the results of standard CIP program cost-effectiveness analysis with breakouts for various aspects of the pilot program and a range of assumptions for the energy impact. The Low Savings values are only based on instances of clear non-compliance with energy code requirements (and are considered to our best estimate of projected program impact), while what was expected to be High Savings estimates are based on the sum of measures that are not compliant or for which the construction documents did not have enough information to demonstrate compliance. However, the comparison between the building data sets, based on the average impact of individual line-items, actually modeled less impact of design team support when inadequately defined measures were included with clearly non-compliant measures (and even an increase in natural gas use). For projects receiving city review support, the cost-effectiveness increases dramatically when measures that were inadequately defined were assumed to have their full-energy impact included in program impacts.

Table 21. Projected utility program benefit-cost ratios

Pilot Program Aspect	Societal: Low Savings	Societal: High Savings	Electric Utility: Low Savings	Electric Utility: High Savings	Gas Utility: Low Savings	Gas Utility: High Savings
Design Team Support: All Measures	13.5	5.4	6.5	2.7	3.28	0.86
Design Team Support: Design Features*	5.4	1.64	2.5	0.81	1.41	0.3
City Support: All Measures	15.5	29.2	9.0	15.6	2.81	9.4
City Support: Design Features*	6.2	8.9	3.5	4.7	1.21	3.25

*Does not include savings from HVAC commissioning nor lighting system functional testing.

Process Evaluation

Code Official Focus Group

A formal group meeting of 7 code officials from 6 jurisdictions was held to find about early trends of issues with the 2015 Minnesota Energy Code and gain deeper insights into a number of other issues that could impact optimal program design and implementation. The key takeaways from this discussion are listed below.

Key Takeaways from Code Official Focus Group

- Contractors, manufacturers, and code officials all need more training and engagement opportunities around the energy code; all contribute to non-compliance

- Earlier and more frequent meetings with design teams around energy requirements is helpful, but a strain for some cities and it is challenging to get all relevant designers present for a meaningful conversation
- Energy code non-compliant projects are only being slowed in a minority of cases
- Deferred submittals are used as a way to permit a project and keep it on schedule, but there are questions as to the level of compliance of these projects as the submittals often happen too late in the process
- ComCheck is used sometimes as compliance documentation, but the reports do not always match the design and there is more need for education and clarification as to when it is an acceptable documentation tool
- There are concerns about design elements that aren't being reviewed by designers or code officials, particularly electrical contractors working on lighting and power design
- Code officials and design teams need more tools to help highlight commonly non-compliant issues, and best practices around design documentation
- Cities/Code officials are not well equipped to review projects that meet code via a performance based path. As codes trend in the direction of more performance based standards, there is need for new resources and technical assistance
- Code path selection appears to be leaning towards ASHRAE, with the performance path often being selected for larger projects.
- Non-compliant issues are most often seen in the following areas: air barriers, lighting controls, continuous above-grade wall insulation in wood-framed construction, ultra low-leakage dampers , and vestibules.

A detailed report of notes from the meeting can be found in Appendix G.

Participant Surveys

The purpose of administering qualitative surveys as part of the pilot was threefold:

1. To gather input about the observed value of the services—now and as a possible ongoing program/service.
2. To gather information about specific aspects of the program design.

The survey results are a way for us to study, from a user perspective, what attributes of the pilot design and delivery were most effective or could be added to increase the value of the services. Based on survey feedback, the most significant impacts for program participants were positive, such as increased project speed, increased convenience of applying the code, and hands-on education. From the project design team perspective, these benefits were significant because timely permitting and completion of a building project are key metrics of success. From the partner city perspective, the primary value was the increased ability to determine compliance at the time of plan review and inspections. As seen in the survey results, code officials saw benefit in the form of increased efficiency and confidence that projects were being designed and built in accordance with the Minnesota Energy Code.

The following discussion of survey results will focus on the two purposes enumerated above, including the value of continued program delivery, and the design of the program's services and tools. These are the primary streams of feedback that help us assess potential market acceptance as a scaled program or service offering. The discussion will incorporate the non-energy benefits of program services as observed by participants. While this value is not the principle interest of Minnesota utilities, it will help increase and maintain market interest and participation.

Design Team Support Feedback

The design team pilot is the arm of the pilot dedicated to providing services directly to project teams—those engaged in designing, documenting, and constructing as opposed to code enforcement. Eleven project team members responded to the post-participation survey, representing 8 (or 9, see methodology section) of the 15 participating projects.

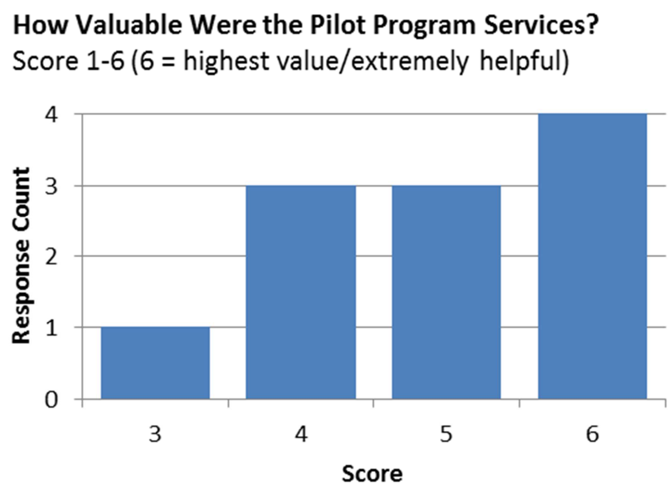
Value of Program Services

Overall, survey responses showed that most participants believe the pilot services to be highly valuable. On a scale of 1 to 6 (6 expressing the highest value), 11 responses provided an average value of 5.4. While the survey did not ask participants to describe why they selected this value, ongoing conversations and feedback from project teams over the 20 months of implementation provided insights into the high value ascribed to the pilot services. Among these were the no-cost experts that delivered project team code information customized to a given project, in a timely and relatively convenient and efficient manner. Furthermore, as stated previously, pilot participation helped project teams mitigate unforeseen project slowdowns during plan review—or more importantly, during inspection, when a project is looking to receive its Certificate of Occupancy so businesses can open. The benefits of optimal code compliant energy performance and sustainability was often emphasized by some clients for whom this was a driver. A survey participant mentioned, **"This is a great opportunity for design and construction teams to reduce their risk and improve compliance in their designs."**

We observed interest in the pilot services in all of the market segments we targeted, as well as segments beyond. The survey showed that project teams from all of the targeted building use types (office, retail, restaurant, and multifamily/hotel) were found to be valued. Additionally, projects teams that are design-driven—with architects and design engineers communicating with contractors—found the services helpful, as well as projects with contractor-driven teams where design was completed by installers. Furthermore, while the median project size in the design team support pilot was just over 29,000 square feet, projects of a wide range of sizes found value in these services; whether following performance or prescriptive compliance paths or even if they were participating in additional programs, such as utility programs like Energy Design Assistance (EDA) or Energy Efficient Buildings (EEB) (one Design Team Pilot project also participated in EDA, and one Code Official Pilot project).

Project teams did find that participation had educational benefits. By engaging in the pilot program, design team members became more knowledgeable about the energy code and how to apply it in a way that is hands-on rather than attending a stand-alone training.

Figure 20: Overall Value of the Pilot Program

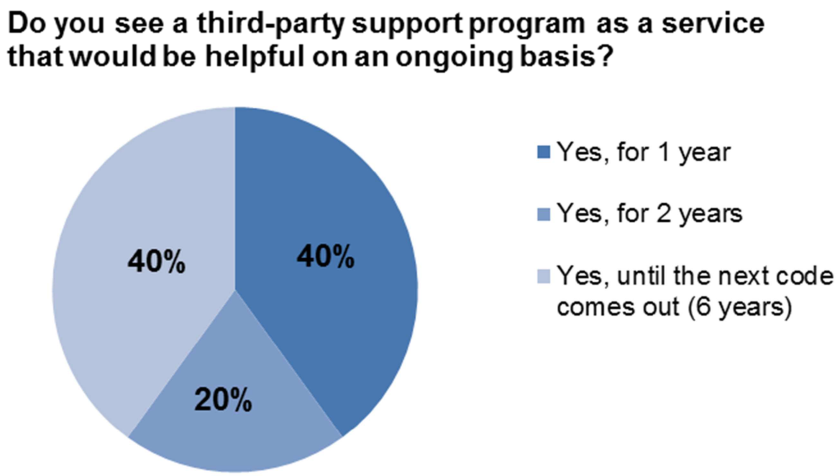


When asked if the support services provided during the pilot will improve individual team members' abilities to meet the energy code in the future, 30% reported that their future ability was improved *significantly* by the provided services and tools, while another 60% reported it as having *somewhat* of an impact. Beyond the educational benefits that might draw design teams to a scaled up service offering or program, the future benefits of these services highlight how they can further enhance the market transformation effects of code adoption in Minnesota.

When asked, participants said they would be interested in participating again. When given options, all respondents said they would be interested in program services beyond the pilot. Four out of ten respondents thought that a service such as this would be helpful in the first year of a new code cycle, while 6 out of 10 thought it would be valuable for two or more years—many showed interest in an ongoing program service (see Figure 21).[6]

[6] As of January 2018 a code cycle in Minnesota is 6 years. Those interested in an ongoing program service were interested in this service over the course of this 6-year code cycle.

Figure 21: Interest in Ongoing Services/Program



Program participants were offered an incentive to participate in the pilot – one for the firm managing the project and one for the client. On-the-ground recruitment experience shows that being able to offer a small incentive during recruitment was helpful for having an initial discussion about participation, and instills open-mindedness during cold calls. However, verbal feedback and survey responses show that this was not the primary impetus for participation and may not be necessary for a scaled or ongoing program.

Project team members most commonly rated the importance of an incentive for the firm managing the project as a 2 on a scale of 1 to 6 (6 being most important). Some project teams reported that this was true because it helped to start the conversation with their client and internally at their firms, allowing them to open up a discussion about the larger benefits of compliance, permitting timeliness, and long-term energy performance. Incentives for the client were on average rated as being slightly more important than the incentive for the project team. On that same scale, survey respondents rated the client incentive as a 2.5. With this being said, verbal input during implementation would reinforce that like the project team incentive, the client incentive was not a primary driver for pilot participation, but rather an easy way to help start the conversation.

Part of the non-energy benefits that this pilot was designed to deliver was expediting the permit review process for design teams. Our survey did not ask participants to comment on this specifically, but verbal feedback during implementation fell into two categories. The first is that the kick-off meeting, tools, and reviews helped reduce or eliminate the need for energy code revisions during code review. The second category was that design teams questioned if they would get called out to make these energy code adjustments during code review. The reasoning here is that pilot participation may cost them more time than is needed for receiving a building permit or certificate of occupancy because projects with some some non-compliant energy design features were not flagged and forced to be corrected—neither during plan review nor during on-site inspection. While expressed, most project teams saw avoiding the risk of the former as a desirable benefit.

When asked specifically if the program had any negative ramifications for the project, 7 of 8 responses (87.5%) said there were no negative project ramifications from participating in the pilot. The only ramification mentioned was that a project was delayed in submitting plans for plan review because an energy simulation was not ready (compliant) upon review from the pilot team and needed revision before submitting. Despite the slowdown, further comments from the same participant highlighted this as an overall project benefit.

Program Design

To gather feedback about the pilot design and specific services, the survey asked participants what services were most valued. The primary services that were made available to project teams during the pilot are listed in Figure 22. This figure also shows the distribution of how these pilot services were ranked by participants. Those ranks with the darkest shading received the most votes. The most votes that any service received at any given rank is 7. The services are listed in the order of highest ranked (those most valued) to those with the lowest ranking. Not all project teams experienced each of these services. However, kick-off meetings, access to tools, and at least one plan review, were services that all projects were required to receive.

Figure 22: The Ranked Value of Pilot Services

Rank	Service	Rank Distribution						
		1st	2nd	3rd	4th	5th	6th	7th
1	Kick-Off Meeting							
2	Documentation Checklist (late design tool)							
3	Applicability Guide (early design tool)							
4	First Plan Review							
5	Second Plan Review							
6	Conveying Tech. Requirements to Contractors							
7	On-demand Technical Support (phone)							

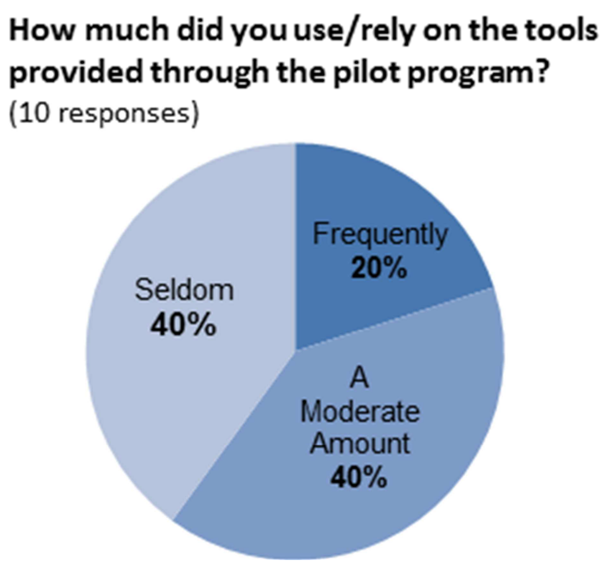
Kick-Off Meetings:

Verbal feedback during implementation demonstrated that the kick-off meetings were a highly valued part of the pilot and, according to survey results, the most valued part of the pilot services. At this meeting it was common to bring the whole project team together in early design to have a dedicated conversation about code requirements, compliance paths, and specific items that were likely to be a challenge for their project. This is a rare practice in the industry. During this meeting the pilot program providers would walk the team members through the Applicability Guide (an early design tool) and the Documentation Checklist (a late design tool). Inherently, some of the value of the kick-off meeting is tied to the value of being oriented to these tools as ongoing references. This likely increased the value of the kick-off as well as the tools, a link that is not distinguished in the ranking alone.

Design Team Tools: Documentation Checklist and Applicability Guide

For the small building pilot, two tools were provided to project teams as part of the services. To further evaluate from a user perspective what was valuable about the pilot design, the post-participation survey asked for feedback on these targeted tools. The Documentation Checklist was the late design tool that provided documentation best practices and a systematic way of tracking compliance during design. The Applicability Guide was the early design tool that outlined how and when each key code requirement applies in a building. Forty percent (40%) of respondents claimed that they used the tools *seldomly*, another 40% reported that they used them a *moderate amount*, and 20% stated that they used the tools *frequently* (see Figure 23). When asked for more detailed responses about what would have made them more helpful, 1 out of 10 respondents had no suggestions and four stated that the tools were very helpful. One respondent shared that, **"[T]he Applicability Guide has been passed around our office and used on other projects in other jurisdictions. I don't know if it can get any better."**

Figure 23: Project Team Tools - Usage



As seen in Figure 22, overall, the tools were a valued element of the services provided and seem to aid in offering requirement specific information and guidance about how to effectively communicate with contractors in the field, as well as mechanical and electrical contractors that might join the project team later (e.g. common in a design + build project scenario).

When asked what would make the tools more helpful, 5 respondents pointed to inclusion of options for how to meet each code requirement, beyond the provided what, where, and when guidance. This was reinforced by other responses that suggested including cost information so that project teams can compare compliance options. Early in program development, an interest in cost-related information was also mentioned, possibly conveying a broader interest in this type of information. A common request given during implementation, but only mentioned once in survey comments, was that the tools include special guidance for renovation projects regarding when requirements apply; as the boundaries of these requirements are often more challenging to discern.

Plan Review Comments: Verbal input during implementation suggested that plan review comments were among the most valuable service for project teams. However, survey responders most commonly ranked this provision as 4th or 5th in terms of value. The plan review services were commonly the most time intensive service provided by the pilot providers. This may be due to the fact that project teams believed the kick-off meeting and tools were helpful enough that the reviews were not as necessary. Project plans were often not provided for program review until a city submittal date was quickly approaching. This may have left teams feeling that they needed more time to integrate the recommended compliance comments. It is possible that in such cases, these drawings/plans may have been submitted to the city before the recommended revisions for energy code compliance could be incorporated, and may have been approved during the plan review as is. The mixed indications of the perceived value of the plan review service brings into question the original expectation that this service would be a critical cornerstone of the program.

As an ad hoc service provided at the time of need, we were highly attuned to the timeliness of the services being provided. The pilot team took a proactive role in scheduling a whole-team meeting as early in the design process as possible. The pilot team would also check in with the design team at intervals that were based on the project schedule (commonly this was every few weeks) to ensure that the window of time for a meaningful plan review did not expire. Acquiring documents for review, such as plans and specs, could be an iterative process. However, once all plans were received, the pilot team aimed to provide review comments within five to seven business days. However, when helpful or necessary, review comments may have been provided in as few as four days. The feedback provided by survey showed that 8 out of 9 respondents (89%) felt this was a sufficient turnaround time to be helpful to the project team. Individual conversations with project leads further support these results and highlight that the flexibility to move faster when needed is greatly valued.

On Demand Technical Assistance: The survey responses also show there is a wide spectrum of value derived from the access to ongoing technical assistance and communication support from the design professionals (e.g. architects and design engineers) and contractors in the field. For some projects, this was highly valued, while others did not use this service. For project teams where the mechanical and electrical contractors were responsible for design and installation, the survey showed this was a particularly valuable part of the service. If the pilot design was scaled, this communication service appears to offer value to the smaller projects segment of the market that are commonly structured as design + build projects (true for new construction and renovation).

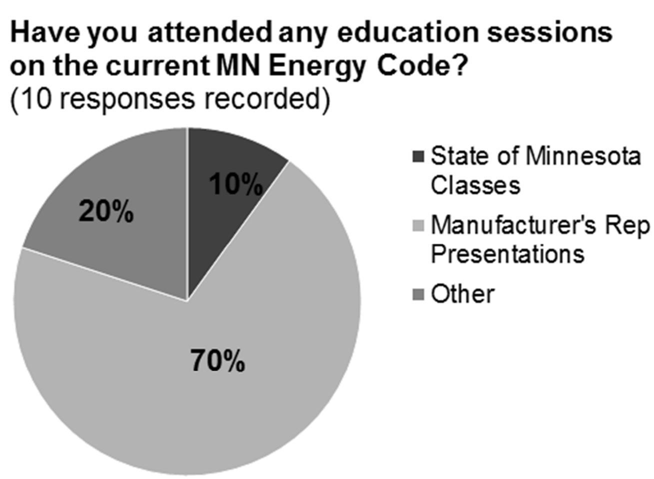
Selected Code Requirements: The survey asked participants for which specific measure line-items the support services were most helpful, or could the pilot have addressed other design measures to make the service more valuable. The answers provided are subject to being very specific to the nature of the current energy code and familiarity with previous code requirements. However, this feedback was helpful for validating the method used to identify the key code requirements the pilot services focused on.

Generally, survey responses commented that the pilot was helpful across challenging architectural, electrical, and mechanical requirements; although guidance on mechanical and electrical requirements were deemed most helpful. On multiple occasions, survey comments discussed the value of selecting a compliance path—International Energy Conservation Code (IECC) versus ASHRAE 90.1, and prescriptive versus a performance-based path. Furthermore, when asked about whether or not the pilot program helped the design team to clearly communicate energy code requirements to contractors in the field, all respondees answered affirmatively: 40% said *yes (somewhat)* and 60% said *yes (significantly)*.

Respondents' Energy Code Experience

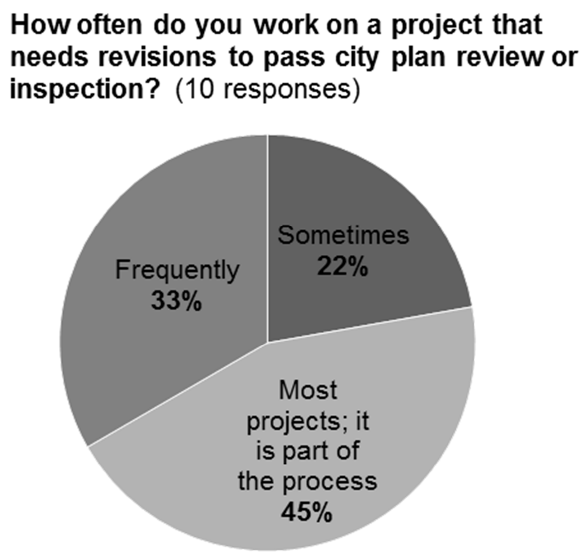
The level of knowledge about the energy code across the architectural, electrical, and mechanical professionals working on building design and construction varies. According to survey responses, only 1 in 10 design team members (10%) had received energy code training from the State of Minnesota at the time that their project started construction. One in five design team members stated that they received alternative energy code education. By far, the dominate source of code education came from manufacturer representatives. This is common in architectural, engineering, and contracting firms where manufacturers seek to educate designers and specifiers about how specific products will fulfill code requirements. Though practical, this is not formal code training and does not provide holistic strategies for applying the code, understanding code updates, code language, and various compliance path options. These survey responses aligned with the lack of code familiarity that we saw in the field prior to and during the pilot.

Figure 24. Energy Code Education Survey Response



The design team support pilot program was designed to offer services and tools to a targeted audience to test market acceptance and need. In an effort to test a high-value target market, the pilot was designed to serve building use types with the highest energy use and the highest current build volumes. At the time, this included restaurants, office spaces, and retail spaces less than or equal to 50,000 square feet, and multifamily and hotel buildings of any size. While efforts were made to focus only on the intended target audiences, it was clear during recruitment and from the survey responses, that the pilot services have value beyond the chosen targeted building types—such as schools, public assembly spaces, and religious facilities.

Figure 25: Plan Review Revisions



Survey participants were asked to comment on the frequency with which plan revisions are requested before they are issued the permits needed to move a project into construction. This provided a business as usual basis for how time intensive or laborious this process can be, and how it can be made easier or faster for the design team. According to the survey, project teams tend to see drawing revisions as part of the anticipated process. Eighty-eight percent (88%) of respondents reported that revisions are frequently requested or requested for most projects, after drawings are submitted for plan review *(*Figure 25*)*. The need for revisions is due to non-compliance and leads to a delay in receiving the earliest construction permits. While this is helpful information for a number of reasons, it infers that there is an opportunity to help remedy this slowdown by offering assistance and tools earlier in the design process.

City Staff Support Feedback

Separate from the services and tools provided to design teams, a parallel pilot was conducted providing services to city code officials. This pilot focused on medium to large projects, targeting large or complex building projects, or projects that the City felt would benefit from this technical support. The intent of the code official services pilot was to provide technical assistance on both prescriptive and performance-based compliance path projects. In practice, only one performance-based project participated in the pilot. This may have been due to the large volume of multifamily development taking place at the time; a building use type that tended to less frequently elect the performance-based path.

During the pilot, city code officials in the three partner cities were asked to complete a survey *mid-stream* during the project, and then again post-pilot. This survey was sent to six code officials anywhere from four to six months into implementation (starting dates varied by city based on available projects for review), and to eight city code officials at the end of the pilot. Both plan reviewers and inspectors completed the surveys and, because of their area of focus, could not always answer all of the questions asked in the survey. In all, there were five respondents to the *mid-stream survey* (one of which was a city planner that supported recruitment, and whose responses were excluded because they were partial). The second survey, conducted post-pilot, received three complete responses and one partial response. For both the first and second surveys, responders were asked to respond in regards to the projects that had participated in the pilot since the beginning of the pilot, or since the previous survey. This provides a more diverse set of responses, as code officials had different project experiences to report on in each survey.

While the mid-stream and *post-pilot survey* asked some of the same questions with the intention of capturing longitudinal data, the sample size was too small to make reliable conclusions. When available, the following discussion will call out questions that were asked at different points in time, and comment on how responses stayed the same or changed over time.

The Value of Pilot Services

Overall, code officials in partnering cities (and additional cities that participated in the second half of the pilot) expressed significant value in the program. According to the *mid-stream survey*, all four respondents[7] reported that the services had the highest value possible, on a scale of 1-6. Similarly, the *post-pilot survey* showed that three out of four respondents ranked the value and “helpful” nature of the pilot services as a 6. One respondee did report, in the second survey, that the value of the services was a 3. One of the four respondees was a city planner, who anecdotally stated the value of the pilot in terms of developing well-built buildings and the ability to offer services to those looking to develop or conduct business in their city.

The city staff receiving the technical support saw high value in the services they were provided, across multiple jurisdictions and individuals, and over the course of 18 months (starting five to seven months after the new code went into effect). Anecdotally, the value in the pilot was expressed by at least one jurisdiction inquiring about receiving services beyond the scope of the pilot for specific projects that may require a deeper review, more specialized knowledge of mechanical systems, or an energy simulation review. Additional interest was shown from more than one jurisdiction for being able to offer design team pre-plan review technical assistance services; usually in the form of an early design team meeting.

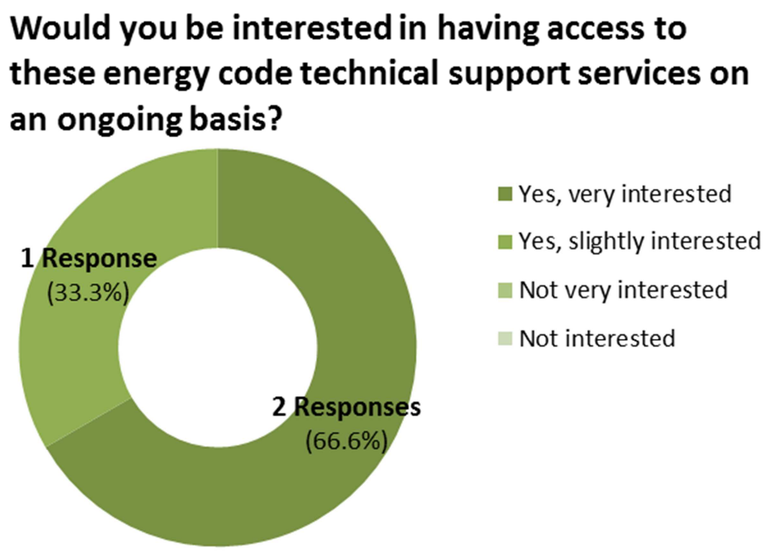
As stated by a respondent in the *post-pilot* survey, “Since the implementation of the new Energy Code in Minnesota, the trades haven't fully embraced it, if at all. CEE helped us [with] first understanding it ourselves as code officials and, secondly, enforcing it as it pertained to each individual project.”

Another respondee shared that, "[CEE's plan review comments were] very thorough and detailed, yet [they were] still straightforward and easy to understand – especially for team members that don't have a solid background in energy code training."

Near the end of the pilot, some jurisdictions inquired about participating in the pilot program. Although they did not receive firsthand experience, these city officials had heard from other participating cities about the benefits of participation. As explained through communication during pilot implementation, this was driven by interest in increased compliance, increased knowledge of the code by way of participation, and establishing a level of consistent code compliance documentation and interpretation across cities. This was found not only between adjacent cities, but also those with close networks; seemingly because they see themselves as having similar expectations for quality buildings and services provided to the public.

When asked if they had interest in participating in program services like these again in the future, all respondents (six total between the mid-stream and post-pilot surveys) responded that they would be "very likely" to participate again – they responded this way for receiving the services in regards to building use types they collaborated on in the pilot, and for those they had not (see Figure 26).

Figure 26: Interest in future services



Program Benefits

When asked to comment on unexpected benefits from the services provided during the pilot, multiple code officials offered commentary. One code official said, "It help[ed] reinforce to the contractors/designers that energy codes matter, and saved time in the field during inspections." Another code official said, "The program aided us as building inspectors in enforcing the new energy code because most of the trade hadn't been educated on the energy code. Your program educated me beyond [the] normal training we are provided with." All the code officials that provided complete survey responses stated some additional benefits from the pilot services; with the exception of one code official who indicated that the pilot was well described at the onset, so it delivered what they expected.

While the Applicability Guide was not a focal point of the services provided to cities, some reported this tool as being helpful and useful for basic design guidance.

Code officials were asked in both the *mid-stream survey* and the *post-pilot survey*, if the plan review services provided reduced the time burden during the review process. Across both the mid-stream and post-implementation surveys, three out of five responses indicated that the plan review support "significantly" reduced the time spent during the plan review process. [8] While some of these respondents were from the same city, their answers were not consistent across time, alluding to the fact that this benefit is subject to a per project situation. While a small sample size, respondees indicated more time savings in the *post-pilot survey* than the *mid-stream survey*. This may be an indicator that even as code officials become more familiar with the code in a given code cycle; there are still time savings benefits from receiving expert support.

Beyond saving time on some projects, city code officials reported that they have evidence that the pilot review comments were used to make plan corrections and improvements that would increase code compliance at the design stage. Of the eight responses received over the two surveys, three answered that "some" of the code items were addressed after the plan review comments were provided to the design teams, and one answered that "all" of the flagged code items were addressed (each response correlating to one or two specific projects).

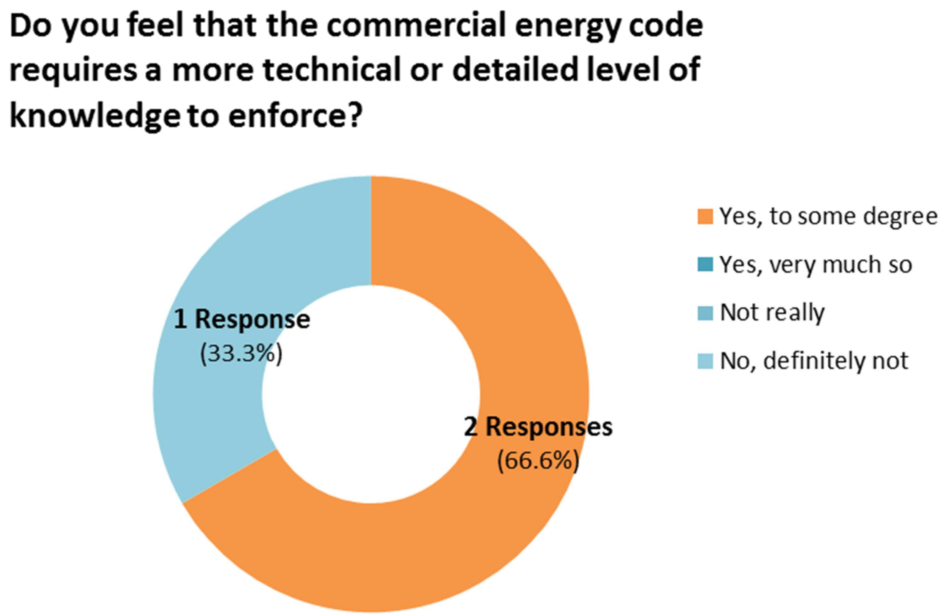
The highest ranked activities were generally those that happened earlier in the project life-cycle, including various services during plan review. When asked why these were most valuable, they shared insights such as, this is when design teams are still engaged and there is enough time to make changes to plans and specifications. It was also stated more than once that plan review is a time intensive activity, and the services reduced the burden of time spent.

Energy Code Enforcement Compared to Other Codes

When asked, in the *post-pilot survey*, if the energy code provides a different level of technical understanding or knowledge than the other codes they enforce, two out of three responders said *yes* when given a multiple choice answer (see **Error! Reference source not found.**). When asked about their answer, one code official who affirmed that the energy code required more technical or detailed knowledge, said this was because the energy code is still relatively new — at the time, in effect for 2.5 years — and because inspections require a great level of (or attention to) detail. The other code official who responded affirmatively stated it was because, "Not many [code officials] have background or formal training in HVAC, lighting, and energy code requirements."

[8] Respondees were given options of "no," "very slightly," "moderately," and "significantly" when asked if the plan review services reduced the time burden for the city code officials at the time of plan review.

Figure 27: Code official enforcement challenges



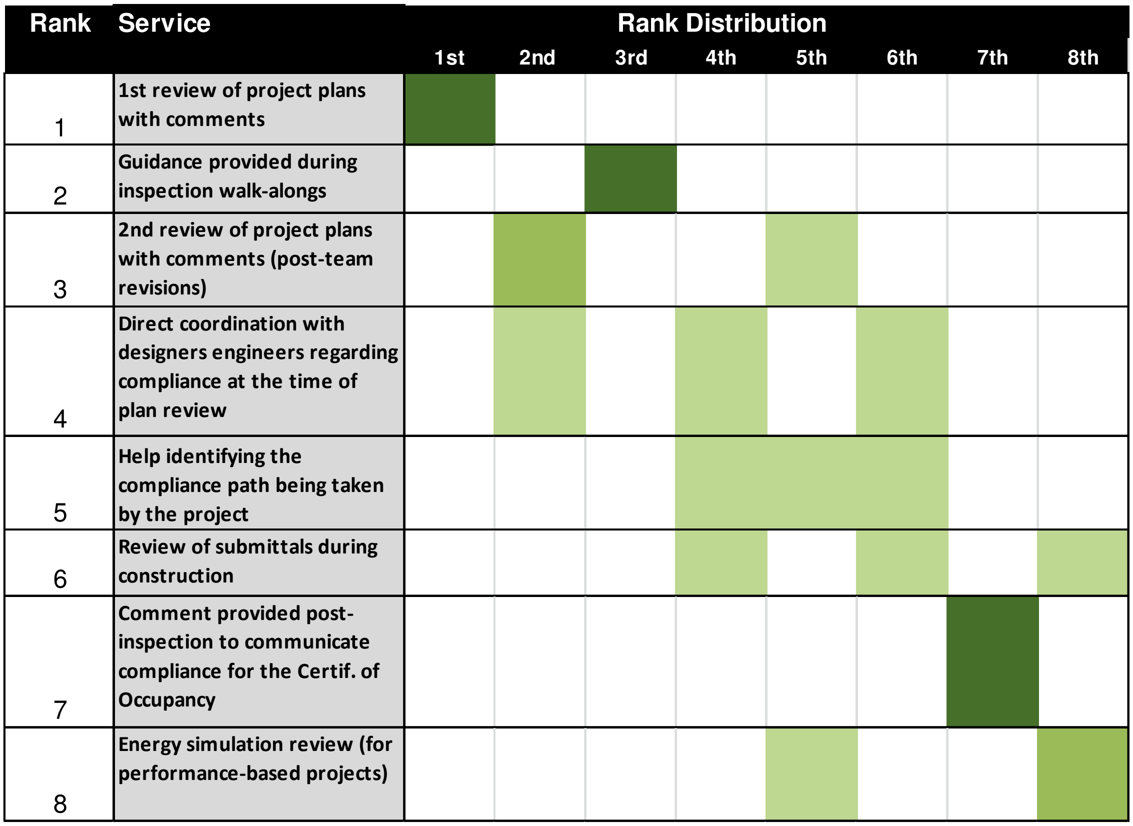
Program Services Design

Figure 28 shows the variety of services that code officials received as part of the pilot, and the comparative value of each service. Four different services were ranked by one or more survey respondents as having the greatest value or second greatest value to them. These were (in rank order):

- First Plan Review Comments
- Guidance Provided During Inspection Walk-Throughs
- Second Plan Review Comments
- Direct Design Team Coordination Regarding Compliance at the Time of Plan Review

These services were the most commonly received services of all those offered during the pilot, which may influence the rankings of the other services that they had less experience with. However, direct communication with participating code officials during implementation supports this ranking. While ranking high, *direct design team coordination at the time of plan review* and *review of submittals during construction* had the largest discrepancies in rankings across respondees. This is likely because not all cities called for direct engagement between the expert energy plan reviewer and the design team, resulting in different observed value. Similarly, not all project timelines allowed for projects to be inspected, or to receive submittal review and follow-up during construction. On the ground experience with the former indicates that submittal review, and support in requesting additional/specific information, was a helpful learning experience.

Figure 28: Ranked value of services provided



In the *mid-stream pilot survey*, 50% (2 of 4) respondents reported that participation in the program did not disrupt the plan review or inspection process. When given a multiple choice answer, respondents selected that the pilot services may have even helped expedite the process. In the *post-pilot survey*, 50% of respondents again reported that participation in the program did not disrupt the plan review or inspection process, 25% indicated that participation may have slightly disrupted the plan review process, but it was easy to work around, and 25% (1 respondent) did not provide an answer.

Services & Activities – Plan Review & Inspections

As we discussed earlier, code officials were asked to rank the value of each of the distinct services that they were provided with or had the opportunity to receive. By nature, this requires some services to have a higher ranking than others (see Figure 28). The three services that had the lowest ranking were energy simulation review for performance-based projects, comment and follow-up with contractors and designers post-inspection to clarify compliance before the Certificate of Occupancy, and review of submittals during construction. In large part, these were services that the cities saw fewer of, when compared with the other services, because they apply later in the life-cycle of projects – some participating projects never reached this stage during the pilot. Through less experience implementing these services and less experience receiving them, these could be opportunities for more detailed service refinement and evaluation if an ongoing program were developed.

As ranked by code officials across both the early and late survey, the review services and methods used to communicate during plan review ranked very high – between 5.3 and 6.0 on a 1-6 scale (6 = most helpful, streamlined, and valuable). Open-ended inquiry of how to improve these services resulted in no stated feedback. Table 22 summarizes these rankings.

Table 22. Code official rating of ease & value of pilot activities
(on a scale of 1-6, 6 representing the greatest value)

Evaluated Services & Activities	Average Rating
Providing or sending construction documents to expert reviewers for plan review	5.3
The format of the review comments	5.7
Receiving review comments	6.0

Across the first and second survey, code officials reported that they *always* shared the pilot plan review comments with the design teams. Most indicated that they integrated these comments in with their own, except one that communicated these comments separately, as third-party comments. With one exception in early implementation (input provided in survey one), the code officials reported that energy code review comments from pilot experts were integrated with their own comments on other code items and sent to the project team for response. Interactions with city staff over the course of the pilot would indicate that this was due to the fact that they were comfortable with the rigor of information being provided, and that they wanted to support these comments with the same authority as other code improvement requests. Overall, participating code officials saw great value in the plan review services provided.

When asked for input about how support for inspection services were helpful, or could have been improved, one code official stated the challenge of getting site visits coordinated between inspectors and pilot experts. Inspectors are often moving from site to site all day, so having dedicated staff that are out in the field would be helpful for scheduling flexibility. Even after 18 months of pilot support, one respondent out of three (in the *post-pilot survey*) stated that it would have been helpful to have a few more joint-site visits to do more learning on site, regarding a few more "certain details." It was also stated that it was helpful to have the inspection services because it helped create ways of verifying compliance in the field.

One code official explained that the design team often disengages in a project after the plans are turned over to the contracting team. For projects that fall into this category, there might be opportunities to better leverage design team engagement later in the project life-cycle. This change would likely require system-level change at the City permitting and inspection level. However, it may be a pain point that a future, scaled program could help remedy.

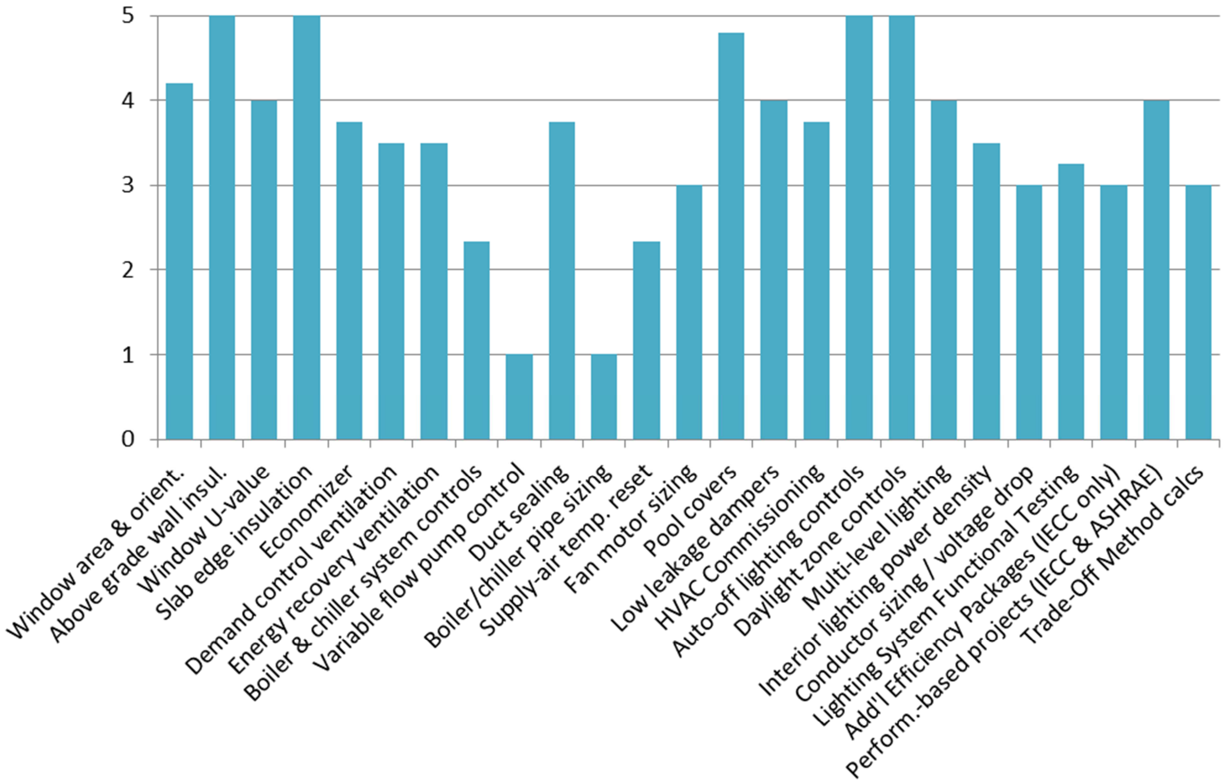
Evaluation of Targeted Code Requirements Used in the Pilot

Through the pilot, 24 potential code requirements were supported during review and inspection. Because of the scope of a given project, most projects are only subject to a portion of these requirements. Some requirements are relevant far more often than others, and some are more complex in nature. The participating code officials were asked to report, through ranking on a 1-5 scale, which code requirement support was most helpful. Overall, the code requirements selected for targeted support during the pilot, rated high. This seems to indicate that code officials felt their ability to review or inspect these requirements was weaker or less efficient than that of the pilot experts. It also seems to indicate that the selected code items were informed targets for the pilot; supporting the method used for evaluating and selecting key code requirements, and further, that the pilot experience might demonstrate relatively high utility for participating cities.

Anecdotal evidence from pilot implementation would note that the requirements with the lowest ratings were those that were applicable less frequently in the projects that participated in the pilot. In addition to this, or as a separate matter, due to less frequent encounters from the code officials, they may not have seen the value because they themselves did not learn enough about the requirement to observe what was needed to better enforce it. Additionally, 100% (6 of 6) respondees said they believed the program services provided would increase the participating project's energy code compliance.

Generally, the code officials saw high value across the board: envelope requirements, lighting requirements, and mechanical requirements (the pilot did not target any domestic hot water requirements). The requirements that received the highest scores likely did so because these were the hardest to document during plan review and on site (e.g. store window U-value), and because of their complexity and nuance (e.g. automatic-off lighting controls).

Figure 29: Ranking the benefit of support by code requirement
(rated on a 1-5 start rating, 5 = “very helpful and educational”)[9]



Improvement Opportunities

Both surveys asked code officials for their open-ended input on how the review services that the pilot provided could have been more useful. In the first survey, two code officials provided insights, stating that visual aids could be helpful and that more detailed design modification recommendations would be useful. The second survey returned fewer recommendations, two stating that the “process seemed perfect” or that they would do “nothing different.” Finally, one code official commented that it would be helpful to have guidance on other impactful requirements, but that it was understood that this was outside the scope of the pilot.

[9] The roof insulation requirement was not included in the survey, however, conversations with code officials indicate that support on this requirement was highly valued.

Discussion

Potential and Actual Program Impacts

Based on plan review findings that one-third of the targeted energy code line-items are not defined well enough to be able to determine compliance, there is a lot of uncertainty about the potential savings that can be achieved through improved compliance. In these cases, our high estimate of potential savings generally assumed that the design would match the previous Minnesota energy code requirements. However, a wide range of actual performance levels could actually occur in the construction. In some instances, performance may be below the current code, but at a level that is either below or above the previous code's performance level. In addition, contractors and equipment suppliers may still end up meeting the code requirement; either by chance or because of their own knowledge of the code requirement. Therefore, the estimates of energy impacts associated with inadequately defined items have greater uncertainty than energy impact evaluations of clearly non-compliant items, where the below-code condition could be quantified.

Due to the issues noted above, we consider the "Low Estimate" of savings reported to give the best representation of projected program impacts when comparing sets of buildings (or the same building at different stages), and only reported these values in the executive summary. This approach estimated the savings with the assumption that any reduction in instances of non-compliance represent a change to exact compliance with that line-items code requirement (i.e. anything other than clearly non-compliant items is assumed to be exactly compliant). The city review support tended to lead to more dramatic improvements in the percentages of clearly compliant instances than the reductions in clearly non-compliant instances, and this provided a fairly conservative estimate of actual program impact. For the design support participants, the impact on design was fairly consistent when looking at changes in rates for either clear compliance or clear non-compliance; especially for the measures with the largest energy impacts. In this case, the "High Estimate" actually gave a moderately lower savings estimate.

It should also be noted that future program savings from a program serving a large number of buildings less than 50,000 square feet could have significantly lower energy impacts, depending on industry trends regarding the compliance path options. This is because commissioning is by far the single largest energy impact item, and ASHRAE 90.1-2010 only requires this for buildings 50,000 square feet and larger, while IECC 2101 has a much lower threshold for requiring commissioning (~12,000 square feet with the actual threshold determined by HVAC equipment size rather than building square footage).

Other recent research (Rosenberg 2016) into the energy penalties for non-compliant commercial energy code line-items identified HVAC system oversizing as a top opportunity for achieving energy savings through increased compliance. These savings are primarily associated with higher fan energy use—especially in systems with constant fan speed. This tends to occur in smaller buildings or buildings with multiple, smaller HVAC systems.

The pilot program experiences with two performance based projects confirmed the expectations of numerous significant issues with the simulations and documentation submitted. While this is an area where there are opportunities for significant improvement in quality, the limited number of sites makes it difficult to reliably project the energy impact on a program level.

Future CIP Program Recommendations

The pilot program findings lead us to recommend that investor-owned utilities in Minnesota pursue the development and implementation of commercial energy code compliance enhancement programs. Key considerations in the development, planning, and implementation of the program are noted below:

- Work with regulators to develop a methodology for counting savings appropriate for the type and scale of the program. Minnesota's CIP regulators have signaled an openness to consider code compliance program proposals (beyond partially funding this pilot), and a companion policy brief provides more information about options. The findings of both this pilot program, and a CARD-funded commercial energy code compliance study that is underway, could provide a baseline for determining future program impacts.

- We suggest partnering with cities to support their energy code review and inspection process [instead of directly supporting design teams], and to increase early design-phase meetings. The pilot experience showed significant benefits in terms of lower participant building recruitment costs, while both approaches achieved a similar level of per-building savings. This approach also has more potential for large-scale market transformation. Once the design community begins to recognize that particular cities are more systematically addressing energy code items in their review and revision comments, they will be more likely to address these issues in initial building designs.

- If a design team support services program model is used, prioritize early design-phase meeting(s) and quick-reference tools, and consider reducing both incentives and plan review efforts relative to the pilot.

- Keep the pilot program's targeted focus on a short list of the most impactful and/or frequently missed energy code line-items, with some adjustments. Among the pilot program buildings, the most critical measures in a rapidly declining priority order were: HVAC commissioning, lighting control system functional testing, roof insulation, above-grade wall insulation, and duct sealing. Also, consider adding HVAC oversizing limits to the program's list of target energy code line-items, while removing lighting power density and fan motor oversizing from the targeted list.

- A code compliance enhancement program could strategically complement design assistance programs as a lower-cost, higher participation rate service. Participants could also benefit from both services, since a number of the mandatory measures targeted by the program are not commonly addressed by CIP-funded design assistance services.

- Provide a high level of technical expertise among program delivery personnel so that participants value the program as a resource. In addition to practical knowledge of multiple building systems, energy codes, and the design/development process; expertise in building energy simulation is critical for effective support of performance path projects that are more common as building size and complexity increases.
- Consider other program approaches to increase the frequency and quality of both HVAC commissioning and lighting control system testing.
- Consider a separate recruitment and/or program delivery approach to impact renovation projects, and refinement of recruitment and program delivery strategies.

Policies for Energy Code Compliance Programs

CIP program regulation policies regarding credit for energy code compliance enhancement energy impacts, both direct and via market transformation, will have an important impact on the funding incentive for such programs. This project funding also supported a companion document (Landry 2018) that addresses this issue. The findings of both this pilot program, and a CARD-funded commercial energy code compliance study that is underway, could provide a baseline for determining future program impacts.

Conclusions

Pilot testing of two commercial energy code compliance enhancement program approaches demonstrated the potential to cost-effectively provide substantial savings. Both of these pilot programs were targeted to a limited number of key energy code measures and provided a high level of technical assistance with individual building projects. One pilot program approach provided design team assistance beginning with a kick-off meeting and quick-reference tools early in the design process. The other pilot program approach provided city staff assistance with reviewing construction documents for energy code compliance at the time of building permit application, with services continuing through the construction and inspection process in some cases. Once partnerships with participating cities were established, the city reviewer support approach had much lower recruitment costs, while also achieving a higher level of savings per building served.

In addition to achieving energy savings toward Minnesota's 1.5% annual energy savings goal, the pilot program services were perceived as valuable to the participants in each pilot. Despite this, the program's experience and participant survey results suggest that a number of program changes might further optimize its impact and cost-effectiveness (an increased focus on early meeting(s) with the design team would be valuable for either pilot approach). Some fine-tuning of the list of targeted measures is also recommended.

One barrier to the development of code compliance enhancement programs in Minnesota is uncertainty in the ability and approach to count savings towards CIP program goals and/or cost-reclamation. A companion policy brief outlines a range of approaches that might be used for savings quantification, including precedents that have been established in other states.

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Appendix A. Design Team Support Tools

Figure 30. Page 1 of Applicability Guide

PILOT 2015-2017 The Commercial Energy Codes Support Program

cee Center for Energy and Environment

APPLICABILITY GUIDE For New Construction Projects

This tool is intended to be a quick reference for design and engineering professionals and includes new or challenging requirements in the new Minnesota Commercial Energy Code (2015). It is designed for small to mid-size buildings projects (usually 50,000 SF or less) to meet the code. Meeting the following pilot program requirements will earn clients and design teams a financial incentive.

The Commercial Energy Codes Support Program aims to support design and construction professionals on targeted requirements of the State Energy Code. However, this list of program requirements does not include all Code items.

Key:	
Gray	Indicates which code requirements are NOT common, by building use type.
Applicability Summaries:	Helps identify whether an item may apply before detailed designs are available

	TECHNOLOGY	TECHNOLOGY DESCRIPTION / ENERGY IMPACT & CODE REFERENCE	MEASURE REQUIREMENT	WHEN IT APPLIES	Targeted Building Use Types	APPLICABILITY SUMMARY
BUILDING ENVELOPE REQUIREMENTS	**Roof Insulation R-Value**	Provide adequate roof insulation between and/or above roof structure to reduce heat gain and loss.	IECC / ASHRAE All Above Deck: R-30 / R-20 Metal building: R-25 + 11ci / R-13 + 19ci Attic & Other: R-49 / R-38 *IECC References:* ***C303 & C402.2*** *ASHRAE References:* ***Table 5.5-6, Sections 5.5.3.1 & 5.8.1***	**IECC:** Required for ALL new roofs. Required for replacement roofs when all existing insulation is above the deck and the slope is < 2 inches per foot **ASHRAE:** Required for ALL new and replacement roofs.	Multifamily Offices Restaurants Retail Spaces	Applies to all buildings.
	Above Grade Wall Insulation	Provide adequate wall insulation between and/or outside of wall structural elements to reduce heat gain and loss.	Min R- (IECC / ASHRAE) OR Max U- (IECC / ASHRAE) Mass wall: 13.3ci* / 13.3ci* / 0.078* / 0.080* Metal building: 13 + 13ci / 13 + 5.6ci / 0.052 / 0.069 Steel-framed: 13 + 7.5ci / 13 + 7.5ci / 0.064* / 0.064 Wood-famed/other: 13 + 7.5ci - or R-20 + R-3.8ci / 13 + 7.5ci / 0.051 / 0.051 *Group R bldgs: mass wall R-15.2 ci/U-0.71; steel-framed IECC U-0.057. *IECC References:* ***C303 & C402.2.2.1*** *ASHRAE References:* ***Table 5.5-6, Sections 3.2, 5.5.3.1 & 5.8.1***	**IECC:** Exterior walls that are more than 15% above grade. **ASHRAE:** Exterior walls that are at least partially above grade. For partially below-grade walls: 1) If insulation is within the structural wall or outside of it, then these R-values only apply to the above-grade part of the wall. OR 2) If the insulation is inside of the supporting structure, then these R-values apply to the whole wall.	Multifamily Offices Restaurants Retail Spaces	Applies to all buildings.
	Slab Edge Insulation	Provide adequate insulation around the perimeter of floors on grade or below. This eliminates a potentially overlookd heat loss path.	IECC / ASHRAE Commercial (typical): R-10 for 24" / R-10 for 24" " w/in-floor heat: R-15 for 36" / R-15 for 24" Residential (typical): R-15 for 24" / R-15 for 24" " w/in-floor heat: R-20 for 48" / R-20 for 48" *IECC References:* ***Section 402.2.6 & Tables C402.1.2 and C402.2*** *ASHRAE References:* ***Table 5.5-6 and Sections 5.5.3.5 & 3.2 (def. Slab-on-grade floor)***	**IECC & ASHRAE:** For floor slabs in contact with the ground that aren't more than 2 feet below grade.	Multifamily Offices Restaurants Retail Spaces	Applies to buildings with slab on grade floors.
	Window U-Factor	Limits the U-value of windows, which saves energy by limiting the rate of heat gain or loss through windows.	**IECC:** Fixed Windows: 0.36; Operable: 0.43; Skylights: 0.50 (0.75 if automatic daylighting controls) **ASHRAE:** Non-metal windows: 0.35; Curtainwall/storefront windows: 0.45; Other metal-framed windows: 0.55; Skylights--glass 1.17; plastic with curb 0.87; plastic w/o curb 0.69 *IECC References:* ***Table C402.3, Sec: C303.3.1, C402.3.3 & C402.3.4*** *ASHRAE References:* ***Table 5.5-6, Sections 5.5.4.2 & 5.8.2***	**IECC & ASHRAE:** Applies to ALL exterior windows and skylights	Multifamily Offices Restaurants Retail Spaces	Applies to all buildings.
	***Window Area & Orientation**	Window area is limited to reduce heat gain and loss, which is much higher through windows than through opaque walls.	**IECC:** Window area must be ≤30% of the wall area. Up to 40% is allowed if at least half of the floor area is daylit AND visible transmissittance is ≥1.1 times SHGC. **ASHRAE:** Window area must be ≤40% of the wall area AND the window area on the south must be ≥ the window areas on each the east and west sides. *IECC References:* ***402.3.1*** *ASHRAE References:* ***5.5.4.2.1, 5.5.4.4.1 (exception c) & 5.5.4.5***	**IECC:** Applies to all buildings. **ASHRAE:** Street-side street-level wall/windows can be ignored (for area & orientation requirements) if it has permanent exterior shading (PF>0.5) and its window area is <75% of its wall area. The orientation requirement can also be ignored if there is significant shading on the south side (buildinging within 20 ft that is half the height of the building) or on the east or west side (75% of window area shaded by fixed object at 9am [east] or 3pm [west] on summer solstice).	Multifamily Offices Restaurants Retail Spaces	Applies to all buildings.

	TECHNOLOGY	TECHNOLOGY DESCRIPTION / ENERGY IMPACT & CODE REFERENCE	MEASURE REQUIREMENT	WHEN IT APPLIES	Targeted Building Use Types	APPLICABILITY SUMMARY
LIGHTING REQUIREMENTS	**Automatic Off Lighting Controls I,A**	Install controls to automatically turn lights off when spaces are unoccupied.	**IECC: & ASHRAE:** Occupancy sensors (ASHRAE only--or timer switch) must be used in certain spaces prone to intermittent occupancy to turn off lights within 30 minutes of when everyone leaves the space. A choice of occupancy sensor or automatic time-off control can be used in other spaces. Automatic time-off controls shall have a temporary manual override that will run lights for no more than 2 hours at a time. Automatic on controls (IECC--occupancy sensors only) must bring the lights on at ≤50% power in most spaces. *IECC References:* ***C405.2.2.2 & C405.2.2.1*** *ASHRAE References:* ***9.4.1 .1 & 9.4.1.2***	**IECC & ASHRAE:** All spaces except egress stairways/corridors, sleeping/dwelling units, patient care areas, security areas, emergency areas or other areas that need 24/7 lighting. Occupancy sensors (ASHRAE--or timer than shuts off lighting within 30 minutes of everyone leaving) required in any classrooms, private offices, break rooms, meeting rooms, restrooms, storage rooms, and janitor closets plus (IECC-any other room ≤300 sf; ASHRAE--copy, dressing locker and fitting rooms).	Multifamily Offices Restaurants Retail Spaces	Multifamily: Doesn't apply to dwelling units--only common spaces that don't need 24/7 operation. Offices, Restaurants, Retail Spaces: Applies to nearly all building spaces that don't require 24/7 operation
	***Daylight Zone Control I,A**	Controls that reduce the power needed to light areas close to dayliight sources.	**IECC & ASHRAE:** Daylit areas within larger spaces shall have separate lighting controls. If automatic control, it must have at least one step with ≤35% power and at least one step from 50% to 70% power with the setpoint and calibration readily accessible. *(IECC-Each daylighting control cannot serve more than 2,500 sf or daylight zones lit by windows facing more than two adjacent directions.)* *IECC References:* ***C405.2.2.3.1, C405.2.2.3.2 & C202 (def. Daylight Zone Definition)*** *ASHRAE References:* ***9.4.1.4, 9.4.1.5 & 3.2 (def. Daylight Area & Primary Sidelighted Area)***	**IECC:** Required in daylit zones with >2 light fixtures. Daylit zones are the rectangle extending 2 feet beyond each end of a window and 15 feet into the building. For skylights, it is the rectangle extending beyond each side of the skylight by 1/2 of the floor to ceiling height. **ASHRAE:** Required in daylit zones >250 sf by window(s) [>900 sf under skylight(s)] except in retail spaces or where a structure blocks the daylight. Daylit zones are defined as the rectangle extending 2 feet beyond each end of a window and as far into the building as the top of the window is above the floor. For skylights, it is the rectangular area extending beyond each side of the skylight by 70% of the floor to ceiling height.	Multifamily Offices Restaurants Retail Spaces	Multifamily: Doesn't apply to dwelling units. See below for other spaces. Offices, Restaurants: **IECC:** Spaces with windows (or skylights) that have 2 or more light fixtures. **ASHRAE:** Spaces >250 sf with windows (or >900 sf with skylights) Retail Spaces: **ASHRAE:** Doesn't apply to retail spaces. See above for other spaces & IECC
	***Multi-Level Lighting I,A**	Each space must have a lighting control that provides at least one step between on and off.	**IECC:** Each area must have a manual control that reduces lighting power to 1/2 of full power (or less) while providing uniform lighting, except for areas that have automatic daylighting control. **ASHRAE:** Each space must have a lighting control with at least one step that has power draw between 30% and 70% of full on. *IECC References:* ***C405.2.1.2*** *ASHRAE References:* ***9.4.1.2a***	**IECC & ASHARE:** Each area with more than one fixture (or one fixture ≥100W) that is not a stairway, corridor, equipment room, storeroom, restroom, public lobby, parking area, audience seating, electrical or mechanical room. **IECC Only:** Not required for spaces with occupancy sensors, lighting power density < 0.6 wsf, or sleeping rooms.	Multifamily Offices Restaurants Retail Spaces	Multifamily: Doesn't apply to dwelling units--common spaces only. Offices, Restaurants, Retail Spaces: Applies to most spaces within buildings.
	Interior Lighting Power Density I	The total connected lighting power is limited based on the building (or space) size and type of use (e.g. office vs retail).	**IECC & ASHRAE:** Specify and install lighting fixtures whose total power draw is less than allowed for the building. Total allowance may be calculated using building area type (building area method), or by using the sum of multiple space types and their respective areas (space by space method). The space by space method gives extra allowances for merchandise lighting (ASHRAE and for specific lighting controls in certain situations). *IECC References:* ***C405.5*** *ASHRAE References:* ***9.5 or 9.6***	**IECC & ASHRAE:** Applies to all spaces except dwelling units.	Multifamily Offices Restaurants Retail Spaces	Multifamily: Doesn't apply to dwelling units--common spaces only. Offices, Restaurants, Retail Spaces: Applies to all spaces within buildings.
	***Conductor Sizing I,A**	Provide large enough feeder and branch wiring to keep current (wiring heating) lossess to a minimum.	**IECC & ASHRAE:** Size feeder conductors for ≤2% voltage drop & branch conductors for ≤3% voltage drop *IECC References:* ***C405.8*** *ASHRAE References:* ***8.4.1***	**IECC & ASHRAE:** Required on all feeder conductors and branch circuits that are <u>not</u> dedicated to emergency lighting or services.	Multifamily Offices Restaurants Retail Spaces	Applies to all buildings.
	***Automatic Outlet Shutoff A**	Turn off power supply to at least half of outlets when spaces are unoccupied.	**ASHRAE Only**: At least half of receptacles must be automatically turned off by one of the following: 1) a time of day control serving no more than one floor nor more than 25,000 sf, 2), an occupancy sensor control with an off delay of no more than 30 minutes, or 2) another control or alarm signal that indicates that a space is unoccupied. *IECC References:* ***None*** *ASHRAE References:* ***9.4.2***	**IECC:** No Requirement **ASHRAE:** Office and computer classroom spaces. Applies to 125 volt 15 and 20 amp receptacles, except those specifically designed for equipment requiring 24 hour operation or where safety or security would be endangered.	Multifamily Offices Restaurants Retail Spaces	Multifamily, Offices: ASHRAE Only: Applies to office & computer classroom spaces only. Restaurants, Retail Spaces: ASHRAE Only: Applies to office & computer classroom spaces only.
	***Lighting System Functional Testing I,A**	Testing ensures that lighting system controls are installed and calibrated properly and according to construction documents and manufacturer's standards.	**IECC & ASHRAE**: Testing shall confirm proper control and sensor placement AND programmed controls are programmed for lights off AND that daylighting controls reduce electric light (lighting power).* *ASHRAE requires that this testing be performed by a third party (and IECC allows a code official to require third party testing). *IECC References:* ***C408.3*** *ASHRAE References:* ***9.4.4***	**IECC & ASHRAE:** Where automatic lighting controls are used.	Multifamily Offices Restaurants Retail Spaces	Multifamily: Doesn't apply to dwelling units--common spaces only. Offices, Restaurants, Retail Spaces: Applies wherever automatic lighting controls are used.

Figure 31. Page 2 of Applicability Guide.

BUILDING MECHANICAL SYSTEM REQUIREMENTS

TECHNOLOGY	TECHNOLOGY DESCRIPTION / ENERGY IMPACT & CODE REFERENCE	MEASURE REQUIREMENT	WHEN IT APPLIES	Targeted Building Use Types	APPLICABILITY SUMMARY
***Air Economizer**	Equipment that uses cool outside air to meet air conditioning needs (when possible) instead of running the AC compressor(s). This reduces compressor energy use and wear.	**IECC & ASHRAE:** Specify and install air economizer system capable of providing up to 100% of design supply air as outdoor air (for cooling). *IECC References:* ***C403.3.1 & C403.4.1*** *ASHRAE References:* ***6.5.1***	**IECC:** When a fan cooling unit has a cooling capacity of ≥33,000 Btu/hour (>2.75 tons); Residential spaces: ≥165,000 Btu/hr (13.75 tons) **ASHRAE:** When a fan cooling unit has a capacity ≥54,000 Btu/hr (≥4.5 tons) [Residential spaces: ≥270,000 Btu/hr (≥22.5 tons); Computer Rooms: ≥135,000 Btu/h (≥11.25 tons)]	Multifamily	Common spaces; seldom applies to dwelling units.
				Offices Restaurants Retail Spaces	Applies to most systems serving floor areas large than listed (or smaller areas with high cooling loads): IECC ≥~1,100 sf ASHRAE ≥~1,800 sf
Demand Control Ventilation (DCV)$_{I,A}$	A control that automatically reduces the amount of fresh outside air being brought in through the ventilation system when few or no people are in a space. This reduces the energy use for heating and cooling outside air.	**IECC & ASHRAE:** Specify and install a demand control ventilation system (or exhaust air energy recovery ventilation) for high occupancy spaces (Occupant Density is based on the MN 2015 Mechanical Code, Table 403.3 *Minimum Ventilation Rates.*) *IECC References:* ***C403.2.5.1*** *ASHRAE References:* ***6.4.3.9***	**IECC & ASHRAE:** When design occupancy is: **IECC** ≥25 people/1,000 sf **ASHRAE** >40 people/1,000 sf for a space >500 sf with ≥1,200 cfm of supply air flow AND there is an economizer, automatic modulating outdoor air damper control, OR outdoor airflow is >3,000 cfm AND the hvac system has ≥1,200 cfm of outdoor air AND the hvac system does NOT have exhaust air ventilation recovery with an effectiveness of at least 50%	Multifamily	May apply to common spaces
				Offices	Often if large meeting room, reception area or phone/data entry.
				Restaurants	Almost always applies unless very small
				Retail Spaces	Seldom applies (except mall commons or other gathering space)
Energy Recovery Ventilation (ERV)	Equipment that uses the air being exhausted to preheat (and precool) fresh outdoor air that is brought into the building for ventilation. This reduces the amount of heating and cooling that must be done by the primary heating and cooling equipment.	**IECC & ASHRAE:** Specify and install ERV that reduces the outdoor air heating or cooling load by at least 50% without unduly impacting fan energy or economizer operation. *IECC References:* ***C403.2.6*** *ASHRAE References: 6.5.6.1*	**IECC & ASHRAE:** Any hvac system that runs at least 20 hours a week at a combinations of high % outdoor air (OA) and supply flow starting at 5,500+ cfm for 30-40% OA and going down to any flow rate for ≥80% OA {see code between} **Unless:** 1) More that 1/4 of the system's exhaust is somewhere other than the primary exhaust location, **OR** 2) Required humidity control is via reclaimed heat, **OR** 3) ≥60% of heating is from renewables or recovered heat	Multifamily	Sometimes for central ventilation or common spaces--especially dining rooms.
				Offices Restaurants Retail Spaces	This requirement is generally relevant only for mid to large size hvac systems that primarily serve high-occupancy spaces (e.g. conferences room or dining room)
Boiler & Chiller System Control	Adjust water system flow rate and/or temperature at reduced loads. This saves energy by reducing the pump load, reducing heating and cooling loads, and/or increasing boiler or chiller efficiency.	**IECC & ASHRAE:** Specify and install part load controls that reset the supply-water temperature (IECC--by ≥25% of design temperature drop) OR reduce system pump flow to ≤ ½ of design flow rate. **ASHRAE:** ...and reduce power to ≤ 30% . If DDC at each zone and reducing system pump flow, reduce flow until one valve is nearly wide open. If total pump power > 10 hp, must reduce system pump flow. *IECC References: C403.4.3.4* *ASHRAE References:* ***6.5.4.1 & 6.5.4.3***	**IECC & ASHRAE:** When hydronic system design output (heating or chilling) >300,000 Btu/hr (25 cooling tons). **ASHRAE:** When system pump power> 10 hp, variable flow must be used (and water temperature reset is optional).	Multifamily Offices	This will generally apply to buildings >~6,000 sf with a boiler, which is more common in office buildings and older mutlifamily bulidings.
				Restaurants Retail Spaces	Seldom applies--only if there is a boiler system (and the building is >~6,000 sf)
***Duct Sealing & Testing$_{I,A}$**	All ductwork connections shall be sealed, and high pressure ductwork shall be tested. Savings is realized through reduced fan power and heating/cooling loads.	**IECC & ASHRAE:** All ducts need to be sealed to *Seal Class* A using mastics, tapes, gaskets, and welds. [ASHRAE only allows tape if per UL-181A or UL-181B certification and IECC does not require sealing of longitudinal joints that are continuously welded and locking at pressures below 2 inches water column.] Sealing of high pressure ducts (>3 inches water column) shall be verified by testing . *IECC References:* ***C403.2.7*** *ASHRAE References:* ***6.4.4.2.1***	**IECC & ASHRAE:** Sealing to class A applies to all ducts and plenums with a pressure class rating. Leakage testing is required in systems with static pressures above 3 inches water column (750 Pa).	Multifamily Offices Restaurants Retail Spaces	Sealing applies to all buildings Testing seldom applies--only if high pressure ductwork.
Supply-Air Temperature Reset for Multizone Systems	Control that raises the cooling supply air temperature when the weather is not real hot. This saves energy by reducing overcooling and reheating that occurs when different zones have unbalanced cooling loads.	**IECC & ASHRAE:** HVAC systems controls should be specified and installed to automatically reset the supply air temperature by at least 25% of the difference between design supply and design room temperatures. Zones with relatively constant heat loads (e.g. server room) must be sized based on the maximum reset temperature (i.e. 25%+ higher cfm). *IECC References:* ***C403.4.5.4*** *ASHRAE References:* ***6.5.3.4***	**IECC:** This applies to multizone HVAC systems EXCEPT zones with <300 cfm air flow. Is not required if reheat is via site recovered heat or site **ASHRAE:** This applies to multizone HVAC systems EXCEPT when total system fan nameplate hp ≤ 5 hp (including exhaust fans). Is not required if reheat is via site recovered heat or site solar.	Multifamily	Seldom applies--only if multizone hvac system with reheat.
				Offices	Applies to multizone systems with reheat.
				Restaurants Retail Spaces	Seldom applies--only if multizone hvac system with reheat.
***Fan Motor Sizing$_{I}$**	Fan motor oversizing is limited. This saves energy (and first cost) by reducing part-load inefficiencies.	**IECC & ASHRAE:** Each fan motor shall be no larger than the smallest available motor size that provides enough power for the fan at design conditions EXCEPT that the next largest size may be used if the smallest available size is within 30% of the calculated requirement (within 50% for fans with calculated fan requirements less than 6 hp). *IECC References:* ***C403.2.10.2 (& C403.2.10)*** *ASHRAE References:* ***6.5.3.1.2 (& 6.5.3)***	**IECC & ASHRAE:** When the total fan motor nameplate horsepower for an hvac system (including exhaust fans) is >5 hp.	Multifamily Offices Restaurants Retail Spaces	Typically applies to systems serving >~4,500 sf
***Pool Cover$_{I,A}$**	Provide a pool cover for the surface of any pool.	**IECC:** Specify and install a vapor retardant pool cover. For pools heated above 90ºF, the cover shall have a minimum R-12 insulating value. *IECC References:* ***C404.7.3*** *ASHRAE References:* ***7.4.5.2***	**IECC & ASHRAE:** Required for all heated pools.	Multifamily	When there is a heated pool.
				Offices Restaurants Retail Spaces	Doesn't apply
Low Leakage Intake & Exhaust Dampers$_{I,A}$	Provide dampers meeting specific low leakage testing requirements, with motorized dampers required in many situations.	**IECC: & ASHRAE:** Leakage Rates Based on AMCA 500D @ 1 inch wg 1) Motorized Dampers: ≤4 cfm/sf (≤6 cfm/sf @ 4 in wg is better); 2) Gravity Dampers ≥2 ft in both directions: ≤20 cfm/sf; 3) Gravity Dampers < 2 ft in one direction: ≤40 cfm/sf. *IECC References:* ***C402.4.5.2 & C403.2.4.4*** *ASHRAE References:* ***6.4.3.4.2 & 6.4.3.4.3***	**IECC & ASHRAE:** Low Leakage Motorized Dampers--System outdoor air intakes >300 cfm; and system exhausts >300 cfm in buildings over 2 stories. Low Leakage Gravity Dampers--Other outdoor air intakes & exhausts. **IECC Option: (in Lieu of Rating)** Gravity Exhaust Dampers < 8 inch diameter--Must be spring-loaded with a weather hood (no testing requirement).	Multifamily Offices Restaurants Retail Spaces	**Virtually all outdoor air intakes and exhausts.**
HVAC Commissioning & Documentation$_{I,A}$	Verification that equipment and controls are installed, balanced, adjusted and functioning properly, and mechanical system documetnation.	**IECC: & ASHRAE:** 1) Provide O&M manuals and record all setpoints; 2) HVAC systems are to be balanced to first reduce throttling losses, and then reduce fan/pump speed; 3) Controls shall be tested to ensure they are calibrated, adjusted and working properly; 4) Detailed instructions for commissioning must be in the construction documents. *IECC References:* ***C408.2*** *ASHRAE References:* ***6.7.2.2, 6.7.2.3 & 6.7.2.4***	**IECC:** Buildings with cooling capacity ≥480,000 Btu/hr (40 tons) OR heating capacity ≥600,000 Btu/hr, except for systems serving dwelling or sleeping units. **ASHRAE:** All hvac systems need balancing and controls testing; Written balancing report is only needed for systems serving >5,000 sf; Commissioning instructions only needed in design documents for buildings >50,000 sf.	Multifamily Offices Restaurants Retail Spaces	**IECC:** -NOT required for dwelling/sleeping unit systems -NOT required for projects <~12,000 sf (unless high heating or cooling loads) **ASHRAE:** -Balancing and controls testing for all -Balancing reports: systems >5,000 sf -Commissioning: buildings >50,000 sf

ADDITIONAL EFFICIENCY PACKAGE REQUIREMENTS (IECC only)

* All *new construction* building projects shall comply with at least one of the following requirements. Tenant spaces should comply with C406.2 or C406.3, unless the entire building meets C406.4.

TECHNOLOGY	TECHNOLOGY DESCRIPTION / ENERGY IMPACT & CODE REFERENCE	MEASURE REQUIREMENT	WHEN IT APPLIES	Targeted Building Use Types	APPLICABILITY SUMMARY Only for Projects Following IECC
***Efficient HVAC Performance**	Increase heating and cooling efficiencies above the base energy code requirements. This save significantly on heating energy, and moderately on cooling energy.	*Gas-fired heating equipment (except steam boilers) must be condensing with efficiencies at least:* Furnaces: *< 225 MBH 92% / ≥225 MBH 90%* Hot water boilers: 97% Unit heaters & duct furnaces: 90% Air conditioner efficiency must be at least: ≤ 5 tons 14 SEER 5.5 to 19.5 tons 11.3 EER & 11.8 IEER ≥20 tons 10.3 EER & IEER	**IECC:** All building types have the option of choosing this (*Efficient HVAC Performance*) or either *Efficient Lighting Power* or *On-Site Renewables* for it's additional efficiency package.	Multifamily Offices Restaurants Retail Spaces	**IECC Only:** 1 of 3 Options. This has medium to large impact if base hvac system design doesn't lend itself to high efficiency condensing heating equipment. Small impact for many buidings.
***Efficient Lighting Power**	Reduce the total connected lighting power to levels below the base energy code requirements.	Connected interior lighting must be at or below a lower whole-building method value (space by space method is not an option). The percentage power reductions are much larger for retail and multifamily than for office Building Area Method Only with the required values being: Mutlifamily 0.6 wsf Office 0.85 wsf Restaurant 0.89 wsf - 0.99 wsf Retail 1.3 wsf *IECC References:* ***C406.3***	**IECC:** All building types have the option of choosing this (*Efficient Lighting Power*) or either *Efficient HVAC Performance* or *On-Site Renewables* for it's additional efficiency package.	Multifamily	**IECC Only:** 1 of 3 options. NOT in dwelling units. Medium energy impact.
				Offices	**IECC Only:** 1 of 3 options. Small energy impact
				Restaurants	**IECC Only:** 1 of 3 options. Large energy impact
				Retail Spaces	**IECC Only:** 1 of 3 options. Small energy impact
***On-Site Renewables**	Reduce energy impacts through on-site renewables.	On-site renewable production must be at least one of the following: 1) 1.75 Btu/sf peak rate 2) 0.50 Watts/sf peak rate 3) 3% of the sum of energy for hvac, service hot water and lighting *IECC References:* ***C406.4***	**IECC:** 1 of 3 options. Small energy impact	Multifamily Offices Restaurants Retail Spaces	**IECC Only:** 1 of 3 options. Small energy impact

IMPORTANT: All measures require that design compliance is documented in construction documents and/or in submitted specifications so that compliance can be reviewed and documented at Plan Review stage.

*These measures are completely new commercial energy code requirements within the State of Minnesota (as of the effective date: June 2, 2015) or dramatically tighter than previously.

$_{I}$ and/or $_{A}$ indicates measures that are required under both prescriptive and performance options for the IECC 2012 path ($_{I\ and/or\ A}$) and/or ASHRAE 90.1-2010 path ($_{A}$).

ci = Continuous Insulation, meaning that any breaks in insulation are properly sealed

This pilot program is a research program administered by the Center for Energy and Environment and is supported in part by a grant from the Minnesota Department of Commerce, Division of Energy Resources through the Conservation Applied Research and Development (CARD) program.

Figure 32. Documentation Checklist: First 2 of 4 Sections

PILOT 2015-2017 | The Commercial Energy Codes Support Program | cee Center for Energy and Environment

DOCUMENTATION CHECKLIST: Project X

This tool is intended to help design and engineering professionals verify that all code requirements included as measures in this program are documented properly and provides best practices as to how to

HOW TO USE THIS CHECKLIST

1. Reference: Reference this tool as a guide for what documentation is needed and best
2. Dynamic Checklist--Initial Design: As program requirements are met, use this document as a checklist by picking from the drop-down list. Add notes for each measure
3. Dynamic Checklist--After Pre-Plan Review: Refer back to this tool to see notes from your CEE Energy Reviewer. CEE reviewers will use color coding to give an "at a glance" indication, change designer column to XXXXX for items needing attention, and add notes to give more project-specific information that will aid in achieving program compliance.

KEY

CEE Review	Design Team Checklist
GRAY: Meausure doesn't apply to a project	- - no entry yet by design team
GREEN: Measure is deemed to be fulfilled and docmented properly	NR - not required for this project
YELLOW: Not enough information to ensure compliance	X - meets it & documented in design
RED: Design does not meet program requirement	Pending - will meet but not in design docs yet
	TBD - design details not yet clear
	XXXXX - design update or more info needed

HOW TO FULFILL PROGRAM REQUIREMENTS

The Commercial Energy Codes Support Program supports design professionsla early on in design to make sure that relevant energy code requirements are documented for Plan Review and constructed or installed properly. This program requires only a specific subset of all of Minnesota's commercial energy code requirments be met, because they are where the greatest energy savings potential is. To receive the incentive(s), a building project must meet three requirements

A. provide sufficient documentation to verify during plan review that all of the below requirements are included in the design and design documentation

B. that these requirements are constructed or installed properly, which CEE will field verify late in construction

C. that the building project team complete a post-program participation survey.

This project is supported in part by a grant from the Minnesota Department of Commerce, Division of Energy Resources through the Conservation Applied Research and Dvelopment (CARD) program.

PROJECT SCOPE & REQUIREMENT APPLICABILITY

Projects will need to meet the documentation and construction/installation requirements of the program only for those program measures that will be included in the scope of the building project. If the project includes a change of occupancy that requires an increase in the demand for fossil fuel energy (i.e. natural gas or electricity for increased heating, cooling, lighting, etc.), the project must meet the affected parts of the design. This is true for renovations, alternations, and repair projects (see MN Energy Code Chapter 1323.0100 Subparts 3-7).

CODE REFERENCES REGARDING DOCUMENTATION

According to the MN Energy Code Chapter 1300.0130, Subpart 2 and Chapter 1323.0100 Subpart 8, 9 and 10, all requirements below are to be documented in the construction documents or the submittals (which ever is deemed most appropriate by industry standard, city preference, or company best practice) so that enforcement professionals can complete a full Plan Review.

Which compliance path is being used for this project?	Pick from List

	Designer	CEE	2/12/2018 22:02:30
Most Recent Update (Date)	none	none	(copy from above cell, then 'Paste special--values only' into the yellow cell @ right)

ENVELOPE REQUIREMENTS

MEASURE	REQUIRED INFORMATION	DOCUMENTATION BEST PRACTICE	Design	CEE	PROJECT TEAM NOTES	CEE REVIEW NOTES
Roof Insulation R-Value	1. The R-value of all insulating roof assembly components (at least the min. & max.).	1. In addition to insulation thickness, clearly note the minimum R value on the drawings. Also clearly note the minimum thickness for tapered insulation.	-			
Above Grade Wall Insulation	1. Indicate the R-value for all wall/wall assembly components for which any part of the wall is above grade.	1. Include the R-vaklue of the wall assembly or assembly component in the an Assembly Schedule.	-			
Slab Edge Insulation	1. Indicate the slab material, thickness, and total R-value of the slab OR the depth below grade at the top of the slab.	1. Include this information on the architectural drawings.	-			
Window U-Factor	1. All window assembly U-factors.	1.In addition to sample products, list window assembly maximum assembly U-factors, including those for storefront window systems.	-			
Window Area & Orientation	1. Indicate the total wall area and the total window area for each side/orientation of the building.	1. Include this information in the architectural drawings or in a portion of the window schedule dedicated to wall and window area ratios.	-			

ELECTRICAL REQUIREMENTS

MEASURE	REQUIRED INFORMATION	DOCUMENTATION BEST PRACTICE	Design	CEE	PROJECT TEAM NOTES	CEE REVIEW NOTES
Automatic Off Lighting Controls	1. Indicate controls meeting requirments or exemption for all lights.	1.Include a Lighting Controls Schedule that notes the type of control by room (or space type). This would include note of occupancy sensors, mutiple light level controls, and if a space needs 24 hour lighting.	-			
Daylight Zone Control	1. Document daylight zone control locations and the fixtures controlled by each controller. 2. Document the power level steps that each daylight zone control will use.	1. Include a Daylight Zone Control section in the Specifications. 2. Besides noting daylighting sensors and fixtures controlled by each on drawings, include a Lighting Controls Schedule that includes notations about lighting control by room.	-			
Multi-Level Lighting	1. Indicate lighting fixtures are controlled by the same switch.	1. Show this information in the Drawings.	-			
Interior Lighting Power Density	1. Include all information needed to determine lighting fixture wattage and count.	1. In the Lighting Schedule, include a dedicated column that lists the maximum allowable wattage for the fixture as a whole. 2. If using space by space calculation method, indicate this and include table of assumed space types and areas.	-			
Conductor Sizing	1. Include information needed to determine voltage drops for feeders and branches.	1. In addition to showing the expected amperage load and conductor sizing for each panel and hardwired load on the drawings, include a note giving clear direction regarding branch circuit wire sizing.	-			
Automatic Outlet Shutoff	1. Document shutoff controller and outlets controlled.	1. For occupancy sensors, clearly note the maximum allowable delay before outlets are powered off (no more than 30 minutes).	-			
Lighting System Functional Testing	1. A Lighting System Functional Testing Plan (as part of the Commissioning Plan or separately) or specifications requesting the completion of this plan before construction. 2. The party to complete the testing should be called out.	1. Provide within the specifications and/or as a stand-alone submittal. 2. Call out this party in the specifications or Lighting General Notes.	-			

Figure 33. Documentation Checklist: Last 2 of 4 Sections

MECHANICAL REQUIREMENTS

MEASURE	REQUIRED INFORMATION (when applicable)	DOCUMENTATION BEST PRACTICE	Design Team	CEE Review	PROJECT TEAM NOTES	CEE REVIEW NOTES
Air Economizer	1. Air economizer is specified and indicates the capability to provide up to 100% outdoor air supply air.	1. Clearly note the use of air-side economizers in the Mechanical Schedule and include 100% OA capability in schedule Notes column.	-			0
Demand Control Ventilation (DCV)	1. Note the occupant density assumed for ventilation design for all spaces or building area types (according to Mechanical Code). 2. Specify sensors and controls that automatically modulate outdoor air flow per the requirement.	1. Document occupant density for ventilation design on drawings, in HVAC schedules, or in a separately provided ventilation design calculations summary. 2. In addition to showing sensors on drawings, indicate which zones or units have DCV on the HVAC schedules.	-			
Energy Recovery Ventilation (ERV)	1. Document design supply, outdoor and exhaust air flow rates for each HVAC unit. 2. Clearly document that the ERV is designed & specified for 50% total energy recovery at design conditions.	1. Clearly note supply, outdoor and relief air flow rate (or percentage) for each HVAC unit on the schedule. 2. For separate exhaust fans, include a note on the schedules indicating the correspondence between HVAC supply air units and exhaust fans. 3. Clearly note the minimum ERV effectiveness at design conditions and/or entering and leaving enthalpy conditions for both air streams).	-			
Boiler & Chiller System Controls	1.Document hydronic heating and/or cooling design output. 2. Controls are specified to automatically reset supply-water temperature OR reduce pump flow by 50% of design flow rate.	1. Clearly document the total hydronic system design capacity on the drawings or the schedule. 2. In addition to inclusion in the Sequence of Operations, note key hydronic system control features and setpoints on the schedules. 3. When VFD used, clearly called out minimum target flow in the Mechanical Schedule under Pumps, and the sequence of operations should clearly note the control method and settings used to reach 50% or lower flow rate.	-			
Duct Sealing & Testing	1. SMACNA class A duct sealing needs to be specified for all ducts and plenums with a apressure class rating. 2. The material(s) to be used for duct sealing need to be specified. 3. Call out that all High-Pressure duct systems require duct leakage testing in accordance with SMACNA requirements.	1. Note duct sealing requirements within the mechanical drawings. 2. Clearly note duct pressure classifications for each hvac unit on the mechanical drawings.	-			
Supply-Air Temperature Reset for Multizone Controls*	1. Document the use of automatic supply air temperautre reset, the design supply air tempeature, and maximum reset temperature. 2. Document the design room air temperature.	1. Clearly note in sequence of operations, and include any necessary sensors in drawings 2. For VAV boxes serving constant loads (e.g. data closet), clearly note that the maximum reset temperature is used as the design temperature for airflow sizing purposes.	-			
Fan Motor Sizing	1. Document the nameplate horsepower for all air-side HVAC motors. When the total nameplate horsepower for a system (including separate exhaust fans serving the space served by an hvac unit) is >5 hp, also document the brake horsepower of each motor.	1. Include brake horsepower information on hvac unit schedules in drawings. 2. Include a general note about fan motor sizing on the mechanical drawings.	-			
Pool Cover	1. Document pool cover existence and R-value. 2. Document pool temperature to be maintained.	1. Clearly document on drawings, and/or list pool cover properties in a schedule. 2. Note pool temperature setpoint range and intended operating temperature with pool heating equipment schedule.	-			
Low Leakage Intake and Exhaust Dampers	1. Document damper location and type. 2. Document damper maximum leakage rates per the required test standard.	1. Note ultra low leakage damper requirement on drawings (on page notes or schedule). 2. Provide detailed air leakage limit and testing requirements in specifications.	-			
HVAC Commissioning	1. A Commissioning Plan or specifications requesting the creation of a Commissioning Plan before construction. 2. The parties that will complete the Commissioning and Balancing should be called out (e.g. commissioning agent or design professional).	1. Include detailed commissioning plan in the design specifications. 2. Call out the party to perform commissioning in the Specifications or the Mechanical Drawing General Notes.	-			

ADDITIONAL EFFICIENCY PACKAGE REQUIREMENTS (IECC Path Only)

MEASURE	REQUIRED INFORMATION (when applicable)	DOCUMENTATION BEST PRACTICE	Design Team	CEE Review	PROJECT TEAM NOTES	CEE REVIEW NOTES
Efficient HVAC Performance	1. Call out the increased performance or efficiency requirements.	1. Clearly note which additional efficiency package option is chosen in the code analysis section of the drawings. 2. When this option is selected, include this as General Note in the Mechanical Drawings, beisdes having the design details address this.	-			
Efficient Lighting Power	1. Call out the reduced Lighting Power Density as required.	1. Clearly note which additional efficiency package option is chosen in the code analysis section of the drawings. 2. When this option is selected, include this as General Note in the Electrical Drawings, besides having the design details address this.	-			
On-Site Renewables	1. Indiacate the additional Efficiency Package option that was selected for this project.	1. Clearly note which additional efficiency package option is chosen in the code analysis section of the drawings. 2. When this option is selected, include as a General Note in the Drawings or in the Special Equip. Section of the Specifications.	-			

Appendix B. Sample City Plan Review Report

.Figure 34. Page 1 of Plan Review Report to City

cee
Center for Energy and Environment

PILOT
2015-2017
The Commercial Energy Codes
Support Program

PLAN REVIEW COMMENTS For City Code Officials

Project: Learning Place School
Building Type(s): Addition
City: Suburbia
ICC Certified Energy Code Plan Reviewers: Di Sui, Kirk Kolehma, Russ Landry, PE
July 00, 2017

This report summarizes the findings of a non-exhaustive energy code review that was focused on the most problematic and energy-impactful items in the 2015 Minnesota Energy Code. Since the compliance path was not clearly indicated in the provided construction documents, the review was still done based on both IECC 2012 with MN addendum and ASHRAE 90.1-2010, with a presumption that the intent is to follow the prescriptive path. Although the provided COMcheck report was generated based on ASHRAE 90.1-2010, the report is not considered as part of the construction drawings. The comments and summary below are based on the construction documents dated 12/25/2016 and the three COMcheck reports dated 4/01/17. This review addresses the addition of the cafateria, classroom and corridor. CEE's recommendation is that the project team follow the IECC compliance path, primarily because of the need to change the amount and/or placement of windows to meet the ASHRAE 90.1 requirements.

REVIEW SUMMARY

	REQUIREMENTS	STATUS	
		IECC	ASHRAE
ENVELOPE REQUIREMENTS	Roof Insulation R Value IECC: C402.2.2; ASHRAE: 5.5.3.1 (5.8.1)		
ENVELOPE REQUIREMENTS	Above Grade Wall Insulation IECC: C402.2.3; ASHRAE: 5.5.3.2 (5.8.1)		
ENVELOPE REQUIREMENTS	Window U value IECC : Table C402.3, Sec C402.3.3 & C402.3.4, (C503.1.3) ASHRAE: Table 5.5-6, Sections 5.5.4.3, (5.8.2)		
ENVELOPE REQUIREMENTS	Window Area & Orientation IECC: C402.3.1; ASHRAE: 5.5.4.2.1 & 5.5.4.5		
ENVELOPE REQUIREMENTS	Slab Edge Insulation IECC: C402.2.6; ASHRAE: 5.5.3.5		
ELECTRICAL REQUIREMENTS	Automatic Lighting Shutoff IECC: C405.2.2.2 & C405.2.2.1; ASHRAE: 9.4.1.1 & 9.4.1.2		
ELECTRICAL REQUIREMENTS	Daylight Zone Control IECC: C405.2.2.3.1, C405.2.2.3.2 & C202; ASHRAE: 9.4.1.4, 9.4.1.5 & 5.2		
ELECTRICAL REQUIREMENTS	Multilevel Lighting Control IECC: C405.2.2.2; ASHRAE: 9.4.1.2a & 9.4.1.6g		
ELECTRICAL REQUIREMENTS	Interior Lighting Power Density IECC: C405.5; ASHRAE: 9.5 or 9.6		
ELECTRICAL REQUIREMENTS	Conductor Sizing IECC: C405.8; ASHRAE: 8.4.1		
ELECTRICAL REQUIREMENTS	Automatic Outlet Shutoff IECC: no requirement; ASHRAE: 8.4.2		
ELECTRICAL REQUIREMENTS	Lighting System Functional Testing IECC: C405.3; ASHRAE: 9.4.4		

	REQUIREMENTS	STATUS	
		IECC	ASHRAE
MECH	Economizer IECC: C403.3.1; ASHRAE: 6.5.1		
MECH	Demand Controlled Ventilation IECC: C403.2.5.1; ASHRAE: 6.4.3.9		
MECH	Energy Recovery Ventilation IECC: C403.2.6; ASHRAE: 6.5.6.1		
MECH	Boiler & Chiller System Control IECC: C403.4.3.4; ASHRAE: 6.5.4.5		
MECH	Variable Flow Pump Control IECC: C403.4.3.4; ASHRAE: 6.5.4.1 & 6.5.4.4.2		
MECH	Duct Sealing IECC: C403.2.7; ASHRAE: 6.4.4.2.1		
MECH	Supply Air Temperature Reset IECC: C403.4.3.4; ASHRAE: 6.5.3.4		
MECH	Fan Motor Sizing vs bhp IECC: C403.2.10.2 & C403.2.10); ASHRAE: 6.5.3.1.2 & 6.5.5		
MECH	Pool Cover IECC: C404.7.3; ASHRAE: 7.4.5.2		
MECH	Low Leakage Intake and Exhaust Dampers IECC: C402.4.5.2 & C403.2.4.4; ASHRAE: 6.4.3.4.2 & 6.4.3.4.5		
MECH	HVAC Commissioning IECC: C408.2; ASHRAE: 6.7.2.2, 6.7.2.3 & 6.7.2.4		
Add. EE	Additional Energy Efficiency Package (3 Options) IECC: C406.2 - C406.4; ASHRAE: no requirement		

Status legend:
- Code requirement met
- Not enough information to determine/ensure
- Code requirement not met
- Not required for this project
- No requirement

Page 1 Commercial Energy Codes Support Pilot Program

Figure 35. Page 2 of Plan Review Report to City

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SECTION 1 – ENVELOPE

Roof Insulation (compliant)

Above Grade Wall Insulation (compliant)

Slab Edge Insulation (compliant)

Window U-Value (need additional information: both ASHRAE & IECC)
ASHRAE 90.1 2010 requires assembly U values for metal framed windows not to exceed U-0.55 and storefront assemblies not to exceed U-0.45. IECC requires fixed windows not to exceed assembly U-0.35. The Specification 08 41 13 refer to the glazing U value of 0.25 winter, but does not indicate the assembly U-value. Please include the exact or maximum window assembly U values in the specifications.

Window Area/Orientation (not compliant: ASHRAE)
ASHRAE requires the area of the east and west windows each have less area than the south facing glazing. The east window area exceeds the south area by approximately 110 square feet. IECC has no related requirement.

SECTION 2 – ELECTRICAL

Automatic Lighting Shutoff Controls (need additional information: both ASHRAE & IECC)
ASHRAE and IECC both require automatic lighting shutoffs with exceptions. General Lighting Notes, E1 refer to specification section 26 09 23 for occupancy and daylight sensors and that manufacturer shall furnish drawings showing quantity and location of sensors. Section 26 09 23 was not included in the provided specifications. There are notes in the drawings referencing auto off controls for the gym (103) and classroom (105) but no reference for storage (104) and office (105). Please provide more information regarding locations and number of sensors for all required areas.

Daylight Zone Control (not compliant: ASHRAE)
Again, specification section 26 09 23 was not provided and the drawings appear to indicate manual dimmers for each row of light fixtures. ASHRE 90.1 requires automatic daylight controls with the daylight zone defined as a rectangle extending two feet beyond each end of a window and as far into the building as the top of window is above the floor. This zone would extend to the second bank of lights at the north gym wall and would need to be addressed in the design. IECC defines the zone as extending fifteen feet into the area with manual controls allowed. This area would meet IECC standards.

Lighting Power Density (compliant)

Multilevel Lighting Control (need additional information: both ASHRAE & IECC)
ASHRAE/IECC both require multilevel lighting controls with exceptions. The gym (103) and classroom (102) meet both standards. ASHRAE would also require the office (105) to have multilevel lighting while IECC requires that this area has either multilevel lighting or a vacancy sensor.

Conductor Sizing (need additional information: both ASHRAE & IECC)
ASHRAE/IECC requires feeder conductors not to exceed 2% voltage drop and branch conductors not to exceed 3% voltage drop. Please include this on drawings or in specifications.

Page 2 Commercial Energy Codes Support Pilot Program

Figure 36. Page 3 of Plan Review Report to City

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Automatic Outlet Shutoff (not compliant: ASHRAE)
ASHRAE requires at least one half of the outlets in offices and computer classrooms to be automatically shutoff by either a time of day control, an occupancy sensor control or another control that would signal this space is unoccupied. The office would be required to meet this standard and the classroom dependent on usage. IECC has no requirement for automatic outlet shutoff.

Lighting System Functional Testing (not compliant: ASHRAE)
ASHRAE and IECC both require lighting system function testing. Specification 26 00 00 is adequate except that 3rd party testing is required by ASHRAE and may be requested by a code official when following IECC.

<u>SECTION 3 – MECHANICAL</u>

Economizer (need additional information: both ASHRAE & IECC)
No Economizer information was provided. ASHRAE requires Economizers capable of providing up to 100% of design supply air as outdoor air when a fan cooling unit has a capacity of 54 MBH or greater, and the threshold for IECC is 33 MBH. The cooling capacity of RTU-1 exceeds both thresholds, but no economizer information was found either in the mechanical drawings or the specification. To meet the requirement, we recommend asking the project team to add economizer to RTU-1, update mechanical drawings to include clear indication that the unit shall have an economizer, and update specifications to include the operation sequence of the economizer.

Demand Controlled Ventilation (compliant)
Meets both ASHRAE and IECC

Energy Recovery Ventilation (not compliant: both ASHRAE & IECC)
Based on both ASHARE and IECC requirements, system RTU-1 shall be equipped with energy recovery ventilation. The provided COMcheck report indicates that this requirement can be exempted since "the system services spaces that are not cooled and only heated to less than 60F", however, the mechanical schedule of RTU-1 shows that the system has the capability of cooling. Energy recovery ventilation should be added to RTU-1 (unless additional clarifying comments and documentation of a valid exemption are provided).

Boiler & Chiller System Control (need additional information: both ASHRAE & IECC)
The hot water heating loop is large enough (estimated higher than the threshold: 300,000 Btu/h) that it is required to have controls that automatically provide specific reductions in either the supply water temperature or the water flow rate (and pump power if following ASHRAE) when conditions allow. Although the construction documents indicate the presence of both an outdoor reset control (23 09 93, 3.01) and variable speed drive control of the pump motors (page M9 and 23 09 93, 3.02), the drawing notes or sequence specifications didn't provide enough detail to adequately document that either of the specific reductions will be achieved (i.e. resetting supply water temperature by at least 7.5°F based on outdoor air temperature, or reducing pump flow rate to 50% or less of design value). We recommend requiring that the construction documents be updated to clearly show that one or both of the reduction options will be achieved.

Variable Flow Pump Control (not required)
Not required by either ASHRAE or IECC—pumps are smaller than the threshold.

Duct Sealing (not compliant: both ASHRAE and IECC)

Page 3 Commercial Energy Codes Support Pilot Program

Figure 37. Page 4 of Plan Review Report to City

Specification indicated that all ductworks will be sealed to Class B, while both ASHRAE and IECC require all ductwork with pressure class shall be sealed to seal Class A. We recommend asking the project team to revise the duct sealing to meet the ASHRAE requirement.

Supply Air Temperature Reset (not applicable)

Fan Motor Sizing (need additional information)
The 2015 Minnesota Energy Code requires that for systems with total fan power larger than 5hp, the all selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp), with the exception that the next available size maybe selected if the difference between the bhp and the first available size is smaller than 30% of the design bhp. In this case, the supply and exhaust fan in RTU-1 both need to meet this requirement, and based on the fan information, both fans meet the requirement. However, COMcheck reports are not considered as part of the construction drawings. We recommend asking the project team to add bhp to the mechanical schedules in the drawings. Alternatively, notes could be added to the mechanical schedule (and/or the specifications) to clearly describe the requirement and make it clear that submittals must clearly document the design brake and nominal horsepowers of the supply and return fans in the rooftop unit.

Pool Cover (not applicable)

Low Leakage Intake and Exhaust Dampers (need additional information: both ASHRAE & IECC)
Both ASHRAE and IECC require that the motorized dampers have leakage values of less than 4 cfm/sf. However, we didn't find any information on the damper leakage in either the mechanical drawings or the specifications. We recommend asking the project team to clearly document this requirement in the construction documents.

HVAC Commissioning (compliant: required by IECC only)

SECTION 4 – ADDITIONAL EFFICIENCY PACKAGE (required by IECC only)

One of 3 Options (compliant)
While the construction documents gave no explicit indication of the choice of the options available, the design performance is much better than the minimum threshold for the Efficient Lighting Power option.

Page 4 Commercial Energy Codes Support Pilot Program

Appendix C. Sample Survey Instruments

Design Team Survey:
Commercial Energy Codes Support Pilot

1) What was your project type? (i.e. office building, restaurant & retail mixed-use, etc.)*
____

2) In what city or town is your project being constructed?
____

3) Which best describes the make-up of the design project team?
( ) Architectural + Mechanical engineers + Electrical engineers + GC
( ) Architectural + Mechanical engineer + field contractors
( ) Architectural + Mechanical and electrical contractors
( ) Architectural (design-build)
( ) Other - Write In (Required): ____*

4) Do you believe that the program services provided will increase this project's energy performance?*
( ) Yes
( ) No

5) How valuable was the Commercial Energy Codes Support Program for this project? (Rank: 1 = Not Helpful, 6 = Extremely Helpful).
1 ________________________[__]_____________________________ 6

____
(untitled)

6) What Energy Code compliance path are you most familiar with?*
( ) IECC Prescriptive
( ) IECC Performance
( ) ASHRAE Prescriptive
( ) ASHRAE Performance

7) Have you attended an education session on the 2015 Minnesota Energy Code?*
[ ] State of Minnesota Classes
[ ] Manufacturer's Rep Presentations
[ ] Other

8) How often do you work on a project that needs revisions to pass City Plan Review or Inspection?*
( ) Almost never
( ) Sometimes
( ) Frequently

( ) Most projects -- it is just part of the process

9) Select the building types that you see having the greatest challenges to being built in accordance with the 2015 Minnesota Commercial Energy Code?
[ ] Office
[ ] Schools
[ ] Restaurant
[ ] Retail
[ ] Multifamily
[ ] Assembly
[ ] Public buildings
[ ] Other - Write In (Required): ____*

10) How much did you use/rely on the tools provided through the Commercial Energy Codes Support Program pilot?
( ) Seldom
( ) A Moderate Amount
( ) Frequently

11) Rank how helpful each of the following were:
________Kick-off meeting & discussion
________Applicability Guide (1 page front & back reference)
________Documentation Checklist (not including review comments provided on the checklist document)
________First project-specific review
________Second project-specific review
________On-demand technical support over the phone
________Conveying technical requirements to contractors in the field

12) How could the tools have been more helpful? Are there other tools that would have been more helpful? Describe:*
____
____
____
____

13) Typical pre-plan review turnaround times were 5-7 business days. How quickly do the design reviews need to be turned around to be of maximum benefit to the design team?
____

14) Do you feel the support provided on this project will improve the ability of your team to meet the energy code more easily in the future?
( ) Yes, significantly
( ) Yes, somewhat

( ) Not sure
( ) No

15) Were the program services helpful for communicating code requirements to the contracting team?
( ) Yes, significantly
( ) Yes, somewhat
( ) Not sure
( ) No

16) Do you believe your project team partners found the support and tools helpful? (1=no, 2=minimally, 3=a modest amount, 4=highly valued it)
( ) 1
( ) 2
( ) 3
( ) 4

17) For which energy code measures or systems was the program most helpful?
____
____
____
____

18) For which energy code measures or systems was the program least helpful?
____
____
____
____

19) Are there other energy code measures that would have been valuable to have addressed by the program?
____
____
____
____

20) How important was it that an incentive was available for your client? Considerations may include: getting the client or team onboard to participate, to spend time learning through the program, and also considerations for filing out formwork to receive the incentive. (Rank: 1 = Not Important, 6 = Extremely Important).
1 _________________________[__]______________________________ 6

21) How important was it that an incentive was available for the design team? Considerations may include: getting the client or team onboard to participate, to spend time learning through the program,

and also considerations for filing out formwork to receive the incentive. (Rank: 1 = Not Important, 6 = Extremely Important).
1 ________________________[__]_____________________________ 6

22) Were there any negative ramifications for utilizing the program services on this project?
____
____
____
____

23) Were there any additional benefits of the program services beyond what you anticipated?
____
____
____
____

24) Do you see third-party program support as a service that would be helpful on an ongoing basis?
( ) No
( ) Yes, for 1 year
( ) Yes, for 2 years
( ) Yes, for 3 years
( ) Yes, until the next code comes out (6 years)

25) What didn't you get out of the process or review that would be helpful? What would improve the quality or timing of the services?
____
____
____
____

26) Are there any other comments that you would like to share?
____
____
____
____

27) What is/was your role in this project?*
( ) Architect
( ) Electrical Engineer
( ) Mechanical Engineer
( ) Mechanical Contractor
( ) General Contractor

Code Officials Survey 1: Mid-Stream
Commercial Energy Codes Support Pilot

1) What is your email?*
____

2) What is the name of the participating building project?
If you are responding regarding more than one project, list all that have participated since the last survey you took.
____

3) On a scale of 1-6, how valuable was the Commercial Energy Codes Support Program for this project?
(1 = not helpful, 6 = extremely helpful)*

4) Did program participation disrupt the plan review or inspection process?*
( ) No, it may have even helped expedite the process
( ) No affect
( ) Slightly, but something we easily worked around
( ) Substantially, CEE's review slowed down or comment turnaround substantially

5) Have you let the project team know a 3rd-party would be conducting supplemental energy code plan review?*
( ) Yes
( ) No
( ) Not Yet (may at the time of inspection)

6) On a scale of 1-6, rate the following. Select only 1 score per row:
(1 = burdensome/time consuming/obscure & over detailed, 6 = simple/streamlined/helpful & clear)*

	1	2	3	4	5	6
Sending/providing construction documents to CEE for review	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Receiving renew comments	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
The format of the review comments	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

7) Did the review comments reduce the time burden for you or your colleagues during review?*
( ) Yes, very slightly
( ) Yes, moderately
( ) Yes, significantly
( ) No

8) Did you share CEE's plan review comments with the project team?*
( ) Yes, we integrated them with comments from the City before sharing
( ) Yes, we provided the comments from CEE independantly
( ) No
( ) Other - Write In (Required): ____*

9) For you, what would have made CEE's review comments more helpful?*
( ) Shorter in length and detail
( ) More standardized feeback
( ) Visual aids
( ) More detailed design modification recommendations
( ) Other - Write In: ____

10) For each of the following requirements, which were most helpful to have CEE's review support? Describe by giving each requirement a rating. (1 star = little to no help, 5 stars = very helpful & educational)*

Degree to which CEE plan review comments were helpful/educational

Window area & orientation ____
Above grade wall insulation ____
Window U-value ____
Slab edge insulation ____
Economizer ____
Demand control ventilation ____
Energy recovery ventilation ____
Boiler & chiller system controls ____
Variable flow pump control ____
Duct sealing ____
Boiler/chiller pipe sizing____
Supply-air temperature reset ____
Fan motor sizing ____
Pool covers ____
Low leakage dampers ____
HVAC Commissioning ____
Automatic-off lighting controls ____
Daylight zone controls ____
Multi-level lighting ____
Interior lighting power density ____
Conductor sizing for voltage drops ____
Lighting System Functional Testing ____
Additional Efficiency Package options (IECC only)

____

Performance-based projects (IECC or ASHRAE)

____

Trade-off method calculations ____

11) What evidence do you have, if any, that the project team took steps to correct construction documents and specifications to comply with the code at the time of permitting?*

( ) We received revised construction documents and/or specifications addressing ALL OF the requirements flagged in CEE's review
( ) We received revised construction documents and/or specifications addressing SOME OF the requirements flagged in CEE's review
( ) The design team provided written responses to CEE's review comments (not within the construction documents)
( ) No physical evidence for this project
( ) Other - Write In (Required): ____*

12) Do you believe that the program services provided (to date) will increase this project's energy code compliance?*
( ) Yes
( ) No

____

(untitled)

13) Were there any negative ramifications for utilizing the program services on this project? Answer "No", "Some", or "Many" and provide brief notes that support your response.*

____
____
____
____

14) Were there any additional benefits of the program services beyond what you anticipated? Answer "No", "Some", or "Many" and provide brief notes that support your response.*

____
____
____
____

15) If available in the future, how interested would you be to use these program services again for a similar building project?*
( ) Not at all likely
( ) Moderately likley
( ) Somewhat likely
( ) Very likely
( ) Other - Write In: ____

16) If available in the future, how likely would you be to use this program services again for a different building type?
( ) Not likely at all
( ) Marginally likley
( ) Somewhat likley

( ) Very likely
( ) Other - Write In: ____

17) If you have any additional comments you would like to share, please do so here:

____
____
____
____

Code Officials Post-Pilot Survey 2: Post-Pilot
Commercial Energy Codes Support Program

1) What is the name of the participating building project?
If you are responding regarding more than one project, list all that have participated since the last survey you took.
____

2) On a scale of 1-6, how valuable was the Commercial Energy Codes Support Program for this project? (1 = not helpful, 6 = extremely helpful)*

3) Regarding Question #2, why did you give the pilot program this rank? *
____
____
____
____

4) Did program participation disrupt the plan review or inspection process?*
( ) No, it may have even helped expedite the process
( ) No affect
( ) Slightly, but something we easily worked around
( ) Substantially, CEE's review slowed down or comment turnaround substantially

5) Have you let the project team know a 3rd-party would be conducting supplemental energy code plan review?*
( ) Yes
( ) No
( ) Not Yet (may at the time of inspection)

6) On a scale of 1-6, rate the following. Select only 1 score per row:
(1 = burdensome/time consuming/obscure & over detailed, 6 = simple/streamlined/helpful & clear)*

	1	2	3	4	5	6
Sending/providing construction documents to CEE for review	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Receiving renew comments	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
The format of the review comments	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

7) Did the review comments reduce the time burden for you or your colleagues during review?*
( ) Yes, very slightly
( ) Yes, moderately
( ) Yes, significantly
( ) No

8) Did you share CEE's plan review comments with the project team?*

( ) Yes, we integrated them with comments from the City before sharing
( ) Yes, we provided the comments from CEE independantly
( ) No
( ) Other - Write In (Required): ____*

9) For you, what would have made CEE's review comments more helpful?*
( ) Shorter in length and detail
( ) More standardized feeback
( ) Visual aids
( ) More detailed design modification recommendations
( ) Other - Write In: ____

10) For each of the following requirements, which were most helpful to have CEE's review/support? Describe by giving each requirement a rating. (1 star = little to no help, 5 stars = very helpful & educational) Feel free to skip those with which you haven't had direct experience.

Degree to which CEE plan review comments were helpful/educational
Window area & orientation ____
Above grade wall insulation ____
Window U-value ____
Slab edge insulation ____
Economizer ____
Demand control ventilation ____
Energy recovery ventilation ____
Boiler & chiller system controls ____
Variable flow pump control ____
Duct sealing ____
Boiler/chiller pipe sizing____
Supply-air temperature reset ____
Fan motor sizing ____
Pool covers ____
Low leakage dampers ____
HVAC Commissioning ____
Automatic-off lighting controls ____
Daylight zone controls ____
Multi-level lighting ____
Interior lighting power density ____
Conductor sizing for voltage drops ____
Lighting System Functional Testing ____
Additional Efficiency Package options (IECC only) _______________________________________
Performance-based projects (IECC or ASHRAE) ____
Trade-off method calculations ____

11) What evidence do you have, if any, that the project team took steps to correct construction documents and specifications to comply with the code at the time of permitting?*
( ) We received revised construction documents and/or specifications addressing ALL OF the requirements flagged in CEE's review
( ) We received revised construction documents and/or specifications addressing SOME OF the requirements flagged in CEE's review
( ) The design team provided written responses to CEE's review comments (not within the construction documents)
( ) No physical evidence for this project
( ) Other - Write In (Required): ____*

12) Do you believe that the program services provided to participating building projects has or will increase their energy code compliance?*
( ) Yes
( ) No

13) Which of the following pilot program services provided by CEE did you see as most beneficial? Please rank in order which you found most helpful/valuable (Rank position #1 = most helpful).*
________1st review of project plans with comments
________2nd review of project plans with comments (post team revisions)
________Energy simulation review (for performance based projects)
________Direct coordination with designers engineers regarding compliance at the time of plan review
________Guidance provided during Inspection walk-alongs
________Comment provided post-inspection to help communicate compliance in preparation for the Certificate of Occupancy
________Review of submittals during construction
________Other
________Help identifying the compliance path being taken by the project

14) Regarding question #13, why was support at the time of plan review helpful? What could have made it more helpful? Please answer both below:*
____
____
____
____

15) Regarding question #13, why was support at the time of inspection helpful? What could have made it more helpful? Please answer both below:*
____
____
____
____

16) Do you feel that the commercial energy code requires a more technical or detailed level of knowledge to enforce than other codes you are responsible for enforcing? *

( ) Yes, very much so
( ) Yes, to some degree
( ) Not really
( ) No, definitely not

17) Regarding question #17, please describe why?*

____
____
____
____

18) Would you be interested in having access to these energy code technical support services on an ongoing basis?*

( ) Yes, very interested
( ) Yes, slightly interested
( ) Not very interested
( ) Not interested

____

(untitled)

19) Were there any negative ramifications for utilizing the program services on this project? Answer "No", "Some", or "Many" and provide brief notes that support your response.*

____
____
____
____

20) Were there any additional benefits of the program services beyond what you anticipated? Answer "No", "Some", or "Many" and provide brief notes that support your response.*

____
____
____
____

21) If available in the future, how interested would you be to use these program services again for a similar building project?*

( ) Not at all likely
( ) Moderately likley
( ) Somewhat likely
( ) Very likely
( ) Other - Write In: ____

22) If available in the future, how likely would you be to use this program services again for a different building type?
( ) Not likely at all
( ) Marginally likley
( ) Somewhat likley
( ) Very likely
( ) Other - Write In: ____

23) If you have any additional comments you would like to share, please do so here:
____
____
____
____

____
Thank You!

Thank you for taking our survey. Your response is very important to us, as it will help us evaluate the impact of the Commercial Energy Codes Support Pilot Program, in regards to energy savings and professional education. We look forward to sharing what we learn from this survey and other analysis via our final report.

Center for Energy & Environment, Research & Engagement Teams

Appendix D. Detailed Compliance Results

Table 23 No Support group compliance results for all targeted code items

Targeted Code Item	Compliant	Insufficient Info	Not Compliant	Not Required
Roof Insulation R-Value	77%	5%	14%	5%
Above Grade Wall Insulation	36%	18%	41%	5%
Slab Edge Insulation	41%	18%	32%	9%
Window U-Factor	22%	70%	4%	4%
Window Area--Whole Building WWR	96%	4%	0%	0%
Window Orientation-- Both E & W < S	65%	13%	17%	4%
Envelope Trade Off	9%	0%	0%	91%
Automatic Off Lighting Controls	16%	47%	37%	0%
Daylight Zone Control	0%	26%	32%	42%
Multi-Level Lighting	26%	21%	53%	0%
Interior Lighting Power Density	65%	35%	0%	0%
Conductor Sizing	28%	50%	17%	6%
Automatic Outlet Shutoff	5%	11%	63%	21%
Lighting System Functional Testing	0%	58%	42%	0%
Air Economizer	47%	24%	6%	24%
Demand Control Ventilation (DCV)	12%	18%	12%	59%
Energy Recovery Ventilation (ERV)	12%	12%	0%	76%
Boiler & Chiller System Controls	6%	6%	0%	88%
Duct Sealing & Testing	0%	59%	35%	6%
Supply-Air Temperature Reset for Multizone	12%	6%	6%	76%
Fan Motor Sizing	12%	59%	0%	29%
Pool Cover	0%	15%	10%	75%
Low Leakage Intake and Exhaust Dampers	0%	71%	24%	6%
HVAC Commissioning	24%	41%	18%	18%

Table 24 Design Team Support group compliance results for all targeted code items

Targeted Code Item	Compliant	Insufficient Info	Not Compliant	Not Required
Roof Insulation R-Value	64%	29%	0%	7%
Above Grade Wall Insulation	43%	43%	7%	7%
Slab Edge Insulation	43%	7%	14%	36%
Window U-Factor	43%	36%	14%	7%
Window Area--Whole Building WWR	93%	0%	0%	7%
Window Orientation-- Both E & W < S	36%	7%	0%	57%
Envelope Trade Off	25%	0%	0%	75%
Automatic Off Lighting Controls	18%	45%	36%	0%
Daylight Zone Control	9%	55%	27%	9%
Multi-Level Lighting	36%	27%	27%	9%
Interior Lighting Power Density	64%	36%	0%	0%
Conductor Sizing	27%	64%	9%	0%
Automatic Outlet Shutoff	18%	9%	18%	55%
Lighting System Functional Testing	0%	73%	27%	0%
Air Economizer	27%	45%	18%	9%
Demand Control Ventilation (DCV)	18%	27%	0%	55%
Energy Recovery Ventilation (ERV)	18%	27%	0%	55%
Boiler & Chiller System Controls	9%	27%	0%	64%
Duct Sealing & Testing	18%	64%	18%	0%
Supply-Air Temperature Reset for Multizone	9%	27%	0%	64%
Fan Motor Sizing	9%	45%	0%	45%
Pool Cover	9%	0%	9%	82%
Low Leakage Intake and Exhaust Dampers	45%	36%	9%	9%
HVAC Commissioning	36%	64%	0%	0%

Table 25 City Reviewer Support group compliance results for all targeted code items

Targeted Code Item	Compliant	Insufficient Info	Not Compliant	Not Required
Roof Insulation R-Value	83%	0%	0%	0%
Above Grade Wall Insulation	50%	17%	17%	0%
Slab Edge Insulation	67%	0%	0%	17%
Window U-Factor	50%	33%	0%	0%
Window Area--Whole Building WWR	83%	0%	0%	0%
Window Orientation-- Both E & W < S	83%	0%	0%	0%
Envelope Trade Off	0%	0%	0%	17%
Automatic Off Lighting Controls	50%	50%	0%	0%
Daylight Zone Control	17%	0%	50%	33%
Multi-Level Lighting	50%	33%	17%	0%
Interior Lighting Power Density	100%	0%	0%	0%
Conductor Sizing	33%	50%	17%	0%
Automatic Outlet Shutoff	50%	0%	17%	33%
Lighting System Functional Testing	67%	33%	0%	0%
Air Economizer	50%	33%	0%	17%
Demand Control Ventilation (DCV)	33%	0%	33%	33%
Energy Recovery Ventilation (ERV)	17%	17%	0%	67%
Boiler & Chiller System Controls	17%	17%	0%	67%
Duct Sealing & Testing	67%	17%	17%	0%
Supply-Air Temperature Reset for Multizone	33%	0%	0%	67%
Fan Motor Sizing	83%	17%	0%	0%
Pool Cover	17%	0%	0%	83%
Low Leakage Intake and Exhaust Dampers	50%	33%	17%	0%
HVAC Commissioning	67%	17%	0%	17%

Appendix E. Normalized Energy Impact Tables

Table 26 Normalized electric energy impact for targeted code items

Targeted Code Item	Unit	Multifamily	Office	Restaurant	Retail	Education
Roof Insulation R-Value	kwh/delta U/roof sf	38.51	22.94	1.36	4.69	3.29
Above Grade Wall Insulation	kwh/delta U/wall sf	20.41	16.15	0.27	1.20	0.67
Slab Edge Insulation	kwh/delta R/perimeter ft	0.78	1.58	0.01	0.42	0.65
Window U-Factor	kwh/delta U/window sf	31.49	7.06	0.73	4.85	-0.03
Window Area--Whole Building WWR	kwh/delta WWR/wall sf	8.23	14.02	0.89	3.68	3.42
Window Orientation-- Both E & W < S	Kwh/delta sf/window sf	-	-	-	4.25E-04	-
Envelope Trade Off	-	-	-	-	-	-
Automatic Off Lighting Controls	kwh/missed watt	0.37	0.19	0.36	0.03	0.41
Daylight Zone Control	kwh/missed watt	0.66	1.09	0.85	0.04	0.61
Multi-Level Lighting	kwh/missed watt	1.12	0.09	0.18	0.01	0.26
Interior Lighting Power Density	kwh/wattage difference	0.86	2.09	4.68	4.13	2.96
Conductor Sizing	kwh/extra %drop change/sf	0.02	0.02	0.14	0.03	0.02
Automatic Outlet Shutoff	kwh/office area sf	0.50	0.22	-	-	0.14
Lighting System Functional Testing	kwh/total floor area sf	0.25	0.20	0.44	0.48	0.24
Air Economizer	kwh/applied area sf	0.28	0.13	0.27	0.47	0.41
Demand Control Ventilation (DCV)	kwh/applied area sf	0.10	0.05	-	-	0.18
Energy Recovery Ventilation (ERV)	Kwh/ton	-	-	-	-	-64.33
Boiler & Chiller System Controls	-	-	-	-	-	-
Duct Sealing & Testing	kwh/SA cfm	0.51	0.27	0.31	0.16	0.01
Supply-Air Temperature Reset for Multizone	kwh/applied area sf	-0.05	0.75	-	-	0.01
Fan Motor Sizing	kwh/fan counts	5hp: 1023 10hp: 426 15hp: 328 50hp: -427	5hp: 1051 10hp: 438 15hp: 337	5hp: 1051 10hp: 548 15hp: 423	5hp: 827 10hp: 344 15hp: 265	5hp: 888 7.5hp: -87 10hp: 370 15hp: 285

Targeted Code Item	Unit	Multifamily	Office	Restaurant	Retail	Education
						20hp: 0 25hp: -28 30: -351
Pool Cover	-	-	-	-	-	-
Low Leakage Intake and Exhaust Dampers	kwh/OA cfm/leakage%	0.05	0.12	0.00	2.23	20.23
HVAC Commissioning	kwh/total floor area sf	0.45	0.27	1.36	0.31	0.32

Table 27 Normalized gas energy impact for targeted code items

Targeted Code Item	Unit	Multifamily	Office	Restaurant	Retail	Education
Roof Insulation R-Value	therms/delta U/roof sf	0.01	0.22	0.45	0.89	1.11
Above Grade Wall Insulation	therms/delta U/wall sf	0.15	0.22	0.14	0.52	0.59
Slab Edge Insulation	therms/delta R/perimeter ft	0.03	0.02	0.07	0.10	0.57
Window U-Factor	therms/delta U/window sf	0.31	0.09	0.85	0.20	0.52
Window Area--Whole Building WWR	therms/delta WWR/wall sf	0.05	0.10	0.02	0.20	0.31
Window Orientation-- Both E & W < S	Therms/delta sf/window sf	-	-	-	-8.49E-08	-
Envelope Trade Off	-	-	-	-	-	-
Automatic Off Lighting Controls	therms/missed watt	-6.79E-04	-6.70E-04	-7.14E-04	-2.59E-04	-4.95E-03
Daylight Zone Control	therms/missed watt	-0.01	-0.01	-0.01	1.93E-04	-6.02E-06
Multi-Level Lighting	therms/missed watt	-2.08E-03	-3.35E-04	-3.57E-04	-1.29E-04	-3.20E-03
Interior Lighting Power Density	therms/wattage difference	-2.70E-03	-0.03	-0.08	-0.04	-0.01
Conductor Sizing	-	-	-	-	-	-
Automatic Outlet Shutoff	therms/office area sf	-4.05E-03	-1.15E-03	-	-	-1.51E-03
Lighting System Functional Testing	therms/total floor area sf	-	-	-	-	-
Air Economizer	therms/applied space area sf	-2.00E-03	-1.77E-06	-1.72E-05	-3.07E-05	-2.64E-03
Demand Control Ventilation (DCV)	therms/applied area	0.02	0.05	-	-	0.02
Energy Recovery Ventilation (ERV)	Therms/ton	-	-	-	-	101.25
Boiler & Chiller System Controls	-	-	-	-	-	-
Duct Sealing & Testing	therms/SA cfm	0.01	0.02	0.09	0.01	0.01
Supply-Air Temperature Reset for Multizone	therms/sf	0.04	-0.03	-	-	0.04

Targeted Code Item	Unit	Multifamily	Office	Restaurant	Retail	Education
Fan Motor Sizing	-	-	-	-	-	-
Pool Cover	therms/sf	1.125	-	-	-	1.125
Low Leakage Intake and Exhaust Dampers	therms/OA cfm/leakage %	0.97	0.61	0.16	0.03	0.25
HVAC Commissioning	therms/total floor area sf	0.01	0.01	0.19	0.01	0.01

Table 28 Normalize parameters for targeted code items

Targeted Code Item	Normalize parameter 1	Unit	Normalize Parameter 2	unit 2
Roof Insulation R-Value	Roof area	sf	Delta U-Factor	BTU/(h·ft²·°F)
Above Grade Wall Insulation	Wall area	sf	Delta U-Factor	BTU/(h·ft²·°F)
Slab Edge Insulation	Floor parameter	ft	Delta R-Value	(h·ft²·°F)/ BTU
Window U-Factor	Window area	sf	Delta U-Factor	BTU/(h·ft²·°F)
Window Area--Whole Building WWR	Wall area	sf	Delta WWR	%
Window Orientation-- Both E & W < S	Sum of $A_E - A_S$ (if above 0) and $A_W - A_S$ (if above 0)	sf	Total window area	sf
Envelope Trade Off	-	-	-	-
Automatic Off Lighting Controls	Missed control wattage	watt	-	-
Daylight Zone Control	Missed control wattage (lighting for the space that has daylight control)	watt	-	-
Multi-Level Lighting	Missed control wattage	watt	-	-
Interior Lighting Power Density	Lighting power density difference between designed and required values	watt	-	-
Conductor Sizing	Extra %drop change	%	Building total area	sf
Automatic Outlet Shutoff	Office area	sf	-	-
Lighting System Functional Testing	Floor area	sf	-	-
Air Economizer	Applied space area	sf	Cooling unit capacity	ton
Demand Control Ventilation	Area applied dcv	sf	-	-

Targeted Code Item	Normalize parameter 1	Unit	Normalize Parameter 2	unit 2
(DCV)				
Energy Recovery Ventilation (ERV)	cooling capacity	ton	-	-
Boiler & Chiller System Controls	Not Calculated. Measure either not required or met by all participated projects	-	-	-
Duct Sealing & Testing	Supply air flow rate	cfm		
Supply-Air Temperature Reset For Multizone	Applied space area	sf	Cooling unit capacity	ton
Fan Motor Sizing	Count of fan of each motor size	-	-	-
Pool Cover	Pool area	sf	-	-
Low Leakage Intake And Exhaust Dampers	OA flow rate	cfm	Leakage%	
HVAC Commissioning	Floor area	sf	-	-

Appendix F. Modeled Energy Penalty for Each Building

Table 29 No Support Group Reviewed Project Energy Penalty

Project	Building Type	Floor Area (sf)	Electric Penalty Low Estimation (KWh)	Electric Penalty High Estimation (KWh)	Gas Penalty Low Estimation (therms)	Gas Penalty High Estimation (therms)	If fully reviewed
LHS1	Hospitality	117,583	72,620	87,027	1,815	1,956	N
LHS2	Hospitality	64,773	22,075	75,792	537	2,005	Y
LHS3	Hospitality	81,662	20,982	38,808	804	908	Y
LHS4	Hospitality	73,150	1,970	60,266	118	1,792	N
LMT1	Multifamily	278,095	139,390	214,214	4,534	5,152	N
LMT2	Multifamily	283,924	16,065	221,257	1,013	5,501	Y
LMT3	Multifamily	139,579	82,915	86,896	2,112	2,110	Y
CMT1	Multifamily	613,960	370,290	662,368	695	11,954	Y
LOT1	Office/Other	71,991	82,236	93,786	86	90	Y
COF1	Office	9,023	1,806	1,821	-	0	N
CRR1	Restaurant	2,412	-	310	-	7	N
CRR3	Restaurant	4,352	39	5,396	13	43	N
LRT1	Retail	3,503	51	4,133	0	22	Y
LRT2	Retail	3,440	15	2,780	6	45	Y
LRT3	Retail	41,560	15,495	18,518	(0)	466	Y
LRT4	Retail	29,167	-	29,655	-	127	N
LRT5	Retail	27,198	780	2,622	337	413	N
CRT1	Retail	17,031	8,709	20,754	-	405	Y
CRT2	Retail	33,329	1,015	19,279	234	975	N
LED1	Education	89,281	9,382	56,601	636	818	Y
LED2	Education	8,909	3,729	9,482	60	365	Y
LED3	Education	10,153	44	43	38	66	N
CED1	Education	17,760	-	4,179	-	158	N
CED2	Education	10,512	42	42	36	36	N

Table 30 Design Support Group Reviewed Project Energy Penalty

Project	Building Type	Floor Area (sf)	Electric Penalty Low Estimation (KWh)	Electric Penalty High Estimation (KWh)	Gas Penalty Low Estimation (therms)	Gas Penalty High Estimation (therms)	If fully reviewed
SHS1	Hospitality	88,364	27,183	101,476	11	2,595	Y
SMT1	Multifamily	86,983	2,055	67,546	(10)	1,267	Y
SMT2	Multifamily	260,300	133	190,546	(1)	4,033	Y
SMT3	Multifamily	62,807	-	24,108	-	85	N
SOF1	Office	41,234	3,121	17,568	(13)	(18)	Y
SOF2	Office	11,288	3,407	7,958	71	145	Y
SOF3	Office	5,906	6	4,747	(0)	186	Y
SOT1	Office/Other	44,344	-	23,815	-	853	Y
SRR1	Restaurant	11,167	-	21,752	-	2,138	N
SRR2	Restaurant	7,347	-	14,250	-	1,387	N
SRT1	Retail	13,946	16,580	18,775	396	676	Y
SRT2	Retail	3,088	-	464	-	60	N

Table 31 City Reviewer Support Reviewed Project Energy Penalty

Project	Building Type	Floor Area (sf)	Electric Penalty Low Estimation (KWh)	Electric Penalty High Estimation (KWh)	Gas Penalty Low Estimation (therms)	Gas Penalty High Estimation (therms)	If fully reviewed
LMT2	Multifamily	283,924	-	-	-	-	Y
LOT1	Office/Other	71,991	6,336	(38)	56,489	(29)	Y
LHS3	Hospitality	81,662	645	171	5,736	(8)	Y
LED1	Education	89,281	9,382	636	14,774	182	Y
LED2	Education	8,909	807	(0)	8,414	135	Y
LRT4	Retail	29,167	-	-	9,972	(1)	Y

Appendix G. Focus Group Report

Commercial Energy Codes Implementation Discussion Session

April 27, 2016 | Center for Energy and Environment

OBJECTIVES

The purpose of this discussion is to gage the extent to which the market is successfully implementing (designing & constructing) the new commercial energy code. We expect this conversation to share valuable knowledge about market acceptance that:

a) helps us determine the ongoing need for access to technical assistance
b) highlights challenges across jurisdictions to help elevate awareness and future tools for success.

The conversation asked participants to talk about what the issues are, drill in to the why they exist, and think through how they know these issues exist (what are the indicators).

PARTICIPANTS

- City of St. Louis Park – Dave Skallet
- City of Blaine – Tim Manz
- City of Minneapolis – Dan Callahan
- State of Minnesota, Dept. of Labor & Industry – Don Sivigny*
- City of Minnetonka – Kevin McDermott
- City of Minnetonka – Lenny Rutledge
- City of Moorhead – Jack Nyberg*

*Denotes those that participated remotely

DISCUSSION SEGMENTS & MAJOR TAKEAWAYS

The discussion session was divided into *three segments*, with some spare time to hear from the partner cities about the value of participating in the Commercial Energy Codes Support Program. Some notable takeaways include:

- Contractors, manufacturers, and code officials all need more training and engagement opportunities around the energy code; all contribute to non-compliance
- Earlier and more frequent meetings with design teams around energy requirements is helpful, but a strain for some cities & it is challenging to get all relevant designers present for a meaningful conversation
- Energy code non-compliant projects are most often not being slowed from development
- Deferred submittals are used as a way to permit a project and keep it on schedule, but there is question as to how compliant these projects are as the submittals often happen too late in the process

- ComCheck is used sometimes as compliance documentation, but it is not always accurate and there is more need for education and clarification as to when it is an acceptable documentation tool
- Concern about design elements that don't need to be reviewed by designers or code officials, particularly electrical contractors working on lighting and power design
- Code officials and design teams need more tools to help highlight commonly non-compliant requirements, common issues, and best practices around design documentations (i.e. drawings & specs)
- Cities/Code officials not well equipped to review projects that meet code via a performance based path. As codes trend in the direction of more performance based standards, there is need for new resources and technical assistance

Based on the discussion session, the table below summarizes the types of compliance resources that can improve energy code compliance in Minnesota cities. In response to the questions asked, participating cities identified specific either tools that would be helpful or highlighted compliance problem leverage points. Together, these opportunities for improvement feel into three types of compliance resources: Tools & Training, Assistance, or Improved Processes.

Compliance resources table

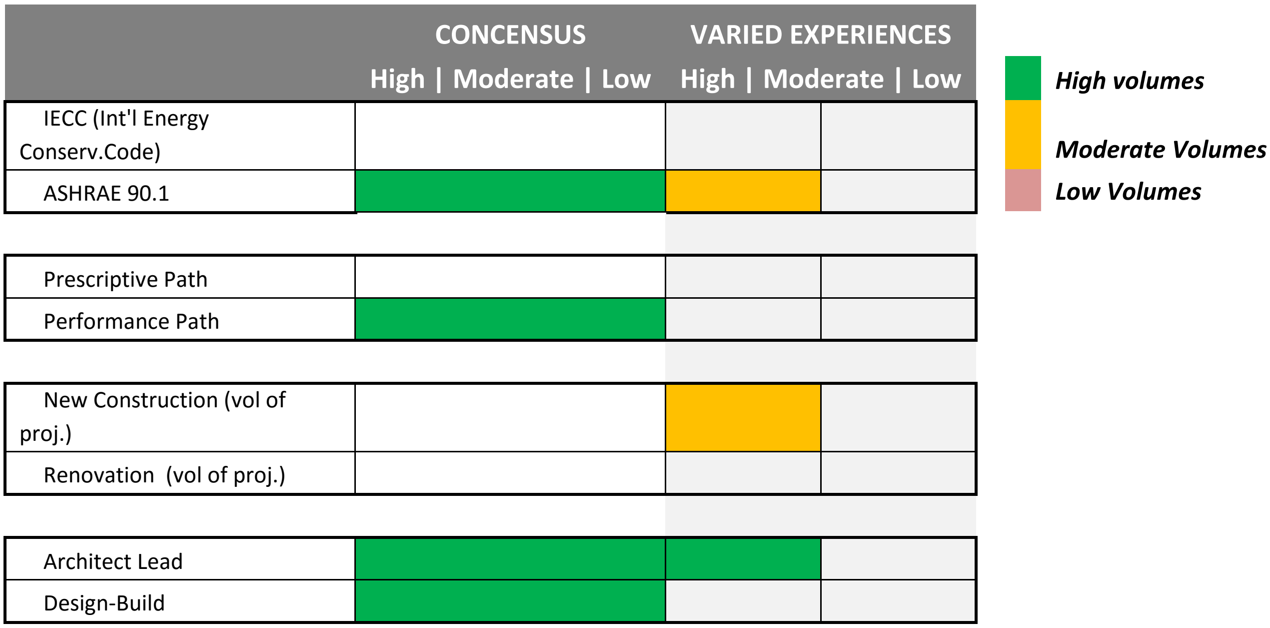
POINTS OF ENTRY	Tools & Training	Assistance	Improved Processes
Compliance Path			
Review			
Inspection			

DISCUSSION NOTES

1| Market Trends & Compliance Paths

1. What general trends are you seeing in the market place (greatest volumes of commercial construction; project team composition, etc.)?

Project volume trends table.



- Multiple cities see projects moving in the direction of a performance path because of particularly challenging requirements (e.g. auto shutoff lighting, timed controls, continuous insulation, and window-to-wall ratios)
- To some extent earlier meetings between designers and code officials are moving projects towards a performance path because of the challenging prescriptive requirements listed above.
- Tenant improvement work is challenging to hold accountable; have to push to get lighting specs on these projects (are working to do this)
- Getting project teams to pick a path is a barrier in and of itself (and knowing that multiple aspects of the design all need to follow the same path) Getting the necessary team members involved in this decision is challenging or not done well in the industry.
- Contractors and designers see ASHRAE standard as more familiar.
- A big challenge lies with enforcing the electrical and lighting requirements. This work is often done by a master electrician and isn't seen in the form of drawings or complete specifications until the work is being done on-site. Thus, inspection is the first and only time to enforce this work, which is likely too late.
- Could we incorporate energy conservation into the NEC? Generally, could the energy code be adopted into other respective codes?
- Need more electrical contractor training around the energy code.
- Many requirements are waved at the time of permitting and become contingent on deferred submittals. This allows the project to move ahead without delay, while frequently delaying approval so late that there is little opportunity to enforce some code requirements.

- There is interest and need for commercial checklists that can be applied to prescriptive projects. (This could be a version of what CEE has created for the Commercial Energy Codes Support Program pilot.)
- ComCheck is being used with some frequently (less than 50%).
- There is some lack of clarity about which compliance paths ComCheck is a viable piece of documentation (prescriptive versus performance and mandatory requirements versus non-mandatory requirements.
- When ComCheck documentation is submitted, the information may not align with what is on the plans.

2. Why do you think you see this lack of compliance?

- Lack of code understanding by contractors as well as manufacturers (reps).
- Design engineers and architects need more education.
- Code officials don't understand the energy code sufficiently, particularly considering the emphasis on health and life safety focused codes.

2| Reviews

3. How many projects have you now reviewed for the new energy code?

- There is a project lag because of grandfathering and rush to get projects in under old code. Most projects under the new energy code have submitted for building permits just recently (late Jan./early Feb or since).

4. Which requirements/sections tend to have the most non-compliance at the time of review (envelope, mechanical, lighting, domestic hot water, additional EE packages)?

- Air barriers
- Lighting controls – getting the details documented and installed
- Continuous insulation in stick construction walls; seeing examples of projects where more insulation is installed in the walls to compensate for the roof knowing that they aren't meeting the roof requirement
- Dampers on roof-top units aren't meeting the leakage requirement & manufacturers aren't stocking locally making for extended lead times which requires more planning ahead
- Too much reliance on passive ventilation in R-2 multifamily buildings; more often need to move in the direction of mechanical ventilation to meet <5 ACH requirement
- Vestibules – when requirement applies

**The challenges come from all sections of the energy code*

5. How often is ComCheck Submitted as (partial or complete) compliance documentation?

- All cities agree that they see it used on <50% of projects; some cities only see it for a small fraction of projects.
- Need to cross-reference ComCheck documentation with the plans (often times not consistent)
- Unsure if ComCheck is a helpful compliance tool; most cities in the discussion haven't seen enough ComCheck documentation to have a conclusion

6. What pre-design meetings do Cities currently require?

Current variety of practices shared table

Minority of project teams come in for pre-design meetings	Pre-design meetings are not required; most come in for at least one	Moving towards pre-design meetings	90% design meetings are fairly common; don't get the whole team, rarely includes the architect

7. Are you seeing an increase in the number of pre-submittal plan reviews?

- Project teams are not requesting earlier meetings
- Some cities are recommending earlier meetings and more frequent meetings with code officials before drawings are submitted for building & other permits

3| Inspections

8. Which requirements/sections tend to have the most non-compliance at the time of review (envelope, mechanical, lighting, domestic hot water, additional EE packages)?

   None of the participating cities have projects that are meeting the new energy code that have completed construction and inspections.

9. Which requirements/sections tend to have the most non-compliance at the time of review (envelope, mechanical, lighting, domestic hot water, additional EE packages)?

- HVAC balancing & system capacity design is correct and installed properly
- Continuous insulation in above grade walls
- Ventilation system installation is correct or not installed at all
- Controls for unoccupied rooms are not installed

**Non-compliance falls across all code sections, including domestic hot water.*

**This question was answered specifically by building inspectors speaking from field experience since the new energy code was put in place.*

10. Are projects being delayed because of non-compliance with the energy code?

- Based on the DLI 2012/2013 Code Compliance Study, energy code non-compliant projects were not being delayed or halted.
- In Minneapolis there are some examples of projects being delayed when energy models are involved (extra time needed by the design team to get the design to meet the requirements)
    - If projects move in the direction of energy modeling, cities don't necessarily have people to review the models
- No other cities had examples of project delays, even if projects weren't compliant

Partner City Feedback & Comments: *Commercial Energy Codes Support Pilot Program*

- Pilot program summary of challenging requirements is a very helpful "cheat sheet"
- Detailed comments have been a real eye opener as to what is not compliant; helpful for upcoming inspections
- Helping cities better understand where they are seeing non-compliance and to think through tools they need as solutions (e.g. Pre-construction meetings with construction teams; focused energy code training plumber and electrical contractor trainings)
- Helpful to have checklists and detailed documentation at the time of review so that it can be used during inspection

Other Discussion

- At the national code-making level the trend is to move towards more performance-based requirements
- Some code officials expressed interest in more prescriptive based codes because the performance-based codes are too hard to enforce
- Hard to delay projects because it is not a health or life-safety based code, but this doesn't mean the projects are compliant
- May non-compliance issues come from not needing to permit the electrical and lighting work at the time of the plan review; the design and installation are done late and with little to no oversight until after they are installed

Appendix H. Survey Open Ended Responses

Design Team Survey

Comments Summary

Other - Write In (Required):Select the building types that you see having the greatest challenges to being built in accordance with the 2015 Minnesota Commercial Energy Code?

- I don 't know - we don 't work on all of these types
- speculative warehouses

How could the tools have been more helpful? Are there other tools that would have been more helpful? Describe:

- I thought it was helpful as is
- There was seemingly very little room to incorporate the suggested upgrades, other than from an electrical standpoint. Maybe additional tools that are geared to better address renovations in existing buildings?
- Budget items or options
- No suggestions.

For which energy code measures or systems was the program most helpful?

- helpful in determining which path was a best fit for the project (iecc versus ashrae, performance versus prescriptive), plus some details of review such as related to relief air
- Electrical.
- Above grade wall insulation & window U-values Fan schedule & Power Fan coils HVAC cooling & heating efficiency Pump power Ventilation rates

For which energy code measures or systems was the program least helpful?

- basic prescriptive requirements
- Mechanical, building envelope were the two biggest; in an existing building, there was little we could do to adjust those.

Were there any negative ramifications for utilizing the program services on this project?

- no
- No.
- The multiple reviews of our consultant's energy code compliance work contributed to a delayed submission of the report to the city.

Were there any additional benefits of the program services beyond what you anticipated?

- It was helpful to have another set of eyes on the project throughout the design/construction process
- Not that we are presently aware.
- It is reassuring to know and was beneficial to be able to tell the city plans examiner that the final energy code compliance report has been reviewed by program staff.
- general awareness of current energy code requirements by our HVAC engineer
- Knowledge and confidence in how it works.

- Access to the Applicability Guide
- Good to have 3rd party communication to use for the contractor to remove the typical VE elements that come up

<u>What didn't you get out of the process or review that would be helpful? What would improve the quality or timing of the services?</u>

- Quality was fine; the type of project did not seem to apply very well.
- Starting earlier in the design process so that it's not rushed.
- nothing I can think of
- I don't think there was anything I can think of.
- Project didn't go through whole program, can't say.
- I think it was good

<u>Are there any other comments that you would like to share?</u>

- We really appreciated having program staff as a resource leading up to the decision of which compliance method to use and during their detailed reviews of the energy model created by our consultant.
- This is a great opportunity for design and construction teams to reduce thier risk and improve compliance in their designs.
- We appreciate the opportunity to try to participate and the information we did get even though we didn't complete the program.
- Clarity of information was really good.

Code Officials Survey 1: Mid-Stream

Comments Summary

Other - Write In (Required):What evidence do you have, if any, that the project team took steps to correct construction documents and specifications to comply with the code at the time of permitting?

- The contractor revised the specificcode items on site.

Were there any additional benefits of the program services beyond what you anticipated? Answer "No", "Some", or "Many" and provide brief notes that support your response.

- Many. It helps reinforce to the contractors/designers that energy codes matter and saved time in the field during inspections.
- Yes, the program aided us as building inspectors in enforcing the new energy code because most of the trades hadn't been educated on the energy code.

If you have any additional comments you would like to share, please do so here:

- Your program educated me beyond the normal training we are provided with.

Code Officials Survey 2: Post-Pilot

Comments Summary

Regarding Question #2, why did you give the pilot program this rank?

- Since the implementation of the new Energy Code in Minnesota, the trades haven't fully embraced it, if at all. CEE helped us in first understanding it ourselves as code officials and secondly enforcing it as it pertained to each individual project.
- Helpful for both plan review and inspections
- It was very thorough and detailed, yet it was still straightforward and easy to understand--especially for team members that don't have a solid background in energy code training.
- 4800 was a project that required several reviews

Other - Write In: For you, what would have made CEE's review comments more helpful?

- Process seemed perfect.
- nothing different
- For certain projects, other impactful requirements could have been addressed, although I realize they were beyond the scope of the program.

Regarding question #13, why was support at the time of plan review helpful? What could have made it more helpful? Please answer both below:

- Energy code is a big part of our plan review process so the support was extremely helpful to have so we could concentrate on other aspects of the review- architecturals, structurals....
- Saved the City time doing plan review and was more accurate
- Because the designers are still engaged and can easily make changes to plans/specs.

Regarding question #13, why was support at the time of inspection helpful? What could have made it more helpful? Please answer both below:

- It helped us look for certain specific details during our walk through which may have been a little gray before. It would have been more helpful to do a couple more site inspections to visit with certain details at certain times. Coordination of this schedule was next to impossible.
- Point out specific code issues and ways to determine verify on-site compliance
- The design/build projects where the architect or engineer turns over their final plans prior to issuance of building permit are the the most challenging because it is difficult to get them re-engaged in the project once construction starts. If there was some leverage to keep them involved in the design during construction that would be helpful.

Regarding question #17, please describe why?

- The energy code is a different level of inspection because of it's newness.
- All of the codes require a high level of technical and detailed level of knowledge
- Because not many people have the background or formal training in HVAC, lighting and energy code requirements.