ABSTRACT

A pilot commercial energy codes compliance support program was undertaken to establish a local precedent for utility-funded energy code compliance enhancement programs in a state with relatively low utility rates. Innovative aspects of the pilot program included either project-specific assistance to design teams or a project-specific design review service conducted on behalf of city code officials, both done with a targeted focus on a limited number of specific energy code requirements. For projects receiving design team support, the design reviews were conducted while the design was in process to help ensure that energy code items were addressed prior to the submittal of plans for a permit and/or bid. A summary of the individual measure compliance rates are reported for 24 buildings that did not receive any program services and compared to buildings that did receive program services. This analysis was based on a comparison of design documents at equivalent stages in the design process. For the targeted measures, low levels of compliance prior to program intervention showed a large potential for energy savings by simply bringing the designs up to code. The program interventions captured about three-fourths of the potential savings with favorable cost effectiveness. Recommendations for future code compliance programs are also presented based on the lessons learned from this pilot.

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 savings goals for Conservation Improvement Programs (CIP programs), no utilities in Minnesota currently offer such a program. Some barriers preventing this have been: 1) utility staff uncertainties about optimal utility program design, 2) concerns about cost-effectiveness in a state with relatively low utility rates, and 3) historical CIP program policies in the state that have not allowed these programs to claim savings against the state’s 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 has been relatively good (Hernick, Nelson, and Sivigny 2013), there is reason to believe that there is still the potential to achieve significant energy savings through increased compliance—especially as energy code updates occur. Studies in other states have shown that even where there is a high percentage of compliance with some requirements, substantial energy performance improvements can be accomplished by bringing the remaining items up to the code level of performance (Harper et al.
Moreover, Minnesota’s adoption of a more complex energy code in 2015 has led to confusion in the building industry,\(^1\) 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 city plan reviewers in a way that would improve compliance with the Minnesota Energy Code.\(^2\) 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 would be available for utility staff and CIP program regulators. The program development steps and some preliminary results were previously reported (Landry, Hoye, and Sui 2016), and more detail about the program effort and results can be found in the project’s final report (Landry, Hoye, and Sui 2018).

**Pilot Program Description**

CEE’s pilot program concept was to intervene at critical times in the building design and development process for individual building projects. With the relatively low utility rates in Minnesota — 19\(^{th}\) highest state for electricity and 32\(^{nd}\) highest for natural gas (EIA 2018) —, it was deemed important to minimize costs while capturing the most readily available energy savings associated with increased energy code compliance. Towards this end, instead of trying to achieve compliance with all energy code requirements, 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, shown in Figure 1, represent about one-sixth of the 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 strove for comprehensive compliance for every energy code line item.

The pilot offered two distinct services, design team support and city reviewer support. Design team support was limited to buildings that were smaller than 50,000 ft\(^2\), or had simple HVAC systems, using the prescriptive path to minimize program development and delivery costs. It included a kick-off meeting to provide early design phase guidance, a detailed one-page quick-reference guide for the program-targeted items, a checklist guiding clear design documentation of targeted items, on-call technical support, design review services that were available prior to the submission of construction drawings for city permit review, and on-site review/contractor direction for a limited number of projects. Restricting participants to a limited

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\(^2\) This project was 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, which is funded by Minnesota ratepayers.
building size and simple systems allowed for a simpler, easier to use quick-reference guide, and a minimization of plan review costs. Based on local recent construction history and reported trends, the buildings types targeted were: retail, restaurant, office, and multifamily/hospitality. A total participant incentive of $775 was split between the designer and the building owner. Candidates for the design team support pilot were identified mainly through Dodge Reports with about 20% of successfully recruited projects originated from previous long-standing relationships or from one of the partner cities referring the design team to the program.

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. Figure 1 shows an example of the summary table that appears in this report. The program target measures are listed, along with specific code references and color-coding indicating each item’s compliance status. The design review services were provided to three cities that had partnered on the pilot program proposal before it was funded, and on-site assistance with inspections for a limited number of buildings. The cities selected projects for our review with a general focus on buildings that were larger than 50,000 ft² and/or had complex HVAC systems that might stretch the technical/time availability limits of city staff. Both performance path and prescriptive path buildings were included.

Figure 1. Example city review report summary table
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 program design, the actual pilot program impact, and the expected cost-effectiveness of a full-scale program. Baseline code compliance rates and the baseline energy penalty for non-compliance were based on reviews of a set of 24 projects that received no program services prior to submission for a building permit. This set of 24 “control buildings” reviewed at time of permit plan set submission consisted of 16 buildings that received city plan review support only after submission of a permit plan set, plus 8 projects that received no program services. For these 24 projects, compliance with each measure was categorized and color-coded as:

- Compliant (green),
- Not applicable (gray),
- Clearly not compliant (red), or
- Not providing enough design detail to clearly demonstrate compliance (yellow).

The compliance rate for every targeted measure was noted, 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 simulations were based on DOE reference buildings that provide detailed baseline EnergyPlus models for a variety of common commercial buildings, with numerous design details tailored to specific energy code versions and climate zones (DOE 2017). For each targeted measure, a step change in energy performance was made (e.g. increasing window U-factor by 0.05) and the resulting energy use change evaluated. This change in energy use was then normalized by dividing by the change in numerical performance level (e.g. U-value) and by the quantity of the design element in the building (e.g. square feet of window area). This process was repeated for each building type and measure to generate normalized estimated savings tables for each combination of prototype building and targeted performance requirement. The building prototype simulation process was supplemented with engineering calculations for a limited number of items, including the assumption that commissioning saves 8% of HVAC system energy use following an approach used by PNNL (2016).

The normalized savings tables were used with each of the 24 control buildings’ non-compliant values and quantities to calculate and sum the energy penalty for each instance of non-compliance. Looking only at the clearly non-compliant items provided a lower bound estimate of impact while including the items without enough design detail to demonstrate compliance provided the upper bound (albeit with an assumed non-compliant value). These values based on the 24 control buildings provide estimates of the maximum potential impact of the pilot program (if the program intervention brought all projects into full compliance with the targeted measures).

The first step in evaluating the impact of design team support intervention was comparing individual measure compliance rates for 14 projects that received design team support to the
same values for the 24 control buildings. Then the 24 control buildings’ energy penalty was prorated based on the improved compliance rates observed among the participant buildings. The difference between the original average energy penalty for the 24 control buildings and the average prorated energy penalty was used as the best estimate of per building program impact for design team support.

We originally did not expect to be able to estimate the energy impact of the pilot’s city review support services; however, we were ultimately able to complete a quantitative estimate for 6 of the 16 buildings that received city review support. This was possible because, in addition to being reviewed in detail at the time of permit application, these 6 were reviewed again after the report to city staff led to design revisions and the resubmission of construction documents that partner cities passed along to CEE. The change in energy penalty for these 6 buildings’ clearly non-compliant items was compared between the two reviews, and the percent reduction in penalty determined. Then the potential larger-scale program impact per building was estimated by applying this percent savings to the average non-compliance energy penalty of the larger set of 24 control buildings.

Results

Recruitment efforts had mixed results. The recruitment of projects to receive design team support fell far short of participation goals, with one-third of that service’s total per-building costs used on recruitment efforts (46% if the incentive cost is included). On the other hand, recruitment for city reviewer support projects exceeded participation goals with 10% or less of the total per-building cost going towards recruitment. Other metrics of program performance, potential savings, and lessons learned are summarized in the subsections below.

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 2. Almost 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 the reviews were 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.
Table 1 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 84,700 square feet. The low estimate only includes instances of clear non-compliance, while the high estimate includes the clearly non-compliant items plus 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 1. Average building annual penalties for non-compliance with program measures (n=24, mean size=84,700 ft²)

<table>
<thead>
<tr>
<th>Savings Estimate Basis</th>
<th>Electric Penalty (kWh)</th>
<th>Gas Penalty (therms)</th>
<th>Cost Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Estimate (Clearly Non-Compliant)</td>
<td>35,402</td>
<td>545</td>
<td>$4,179</td>
</tr>
<tr>
<td>High Estimate (Clearly Non-Compliant + Not Defined)</td>
<td>71,501</td>
<td>1,476</td>
<td>$8,702</td>
</tr>
</tbody>
</table>

The measures that showed the highest potential savings among this group of buildings are shown in Table 2, listed in order of decreasing savings. Note that two top measures—HVAC commissioning and lighting system functional testing—are not design elements, but services that ensure systems and their controls operate correctly. It is also noteworthy that all of the top four gas measures address mechanical or special systems (e.g. pools). While the top two electric measures address system controls, the next two are both envelope measures.
Table 2. Top potential energy saving measures listed by fuel

<table>
<thead>
<tr>
<th>Electric measures</th>
<th>Gas measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC commissioning</td>
<td>HVAC commissioning</td>
</tr>
<tr>
<td>Lighting system testing</td>
<td>Duct sealing and testing</td>
</tr>
<tr>
<td>Roof insulation</td>
<td>Pool cover</td>
</tr>
<tr>
<td>Above grade wall insulation</td>
<td>Low leakage intake and exhaust dampers</td>
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</tbody>
</table>

**Pilot Program Impacts**

Each of the pilot program services cut the percentage of clearly non-compliant target measures in half, though the city review support approach had a much bigger impact on the percentage of items that were clearly compliant with a doubling of these instances. The changes in targeted measure compliance rates for each pilot service are shown in Figure 3.

![Figure 3. Pilot program impacts on targeted measure compliance](image)

The impact on energy savings was even more dramatic than the change in compliance rates, with low estimates of potential and actual program savings showing that both services captured about three-fourths of the potential savings associated with bringing all clearly non-compliant targeted measures into compliance. This is shown in Figure 4. The design team support and city reviewer support approaches were both successful, capturing 70% and 87% of the potential savings respectively. 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 savings by fuel type and total energy cost varied by less than 20% between the design team support and city plan reviewer support approaches.
Based on the pilot program experience, full-scale program delivery costs were estimated to be $4,610 per building for support of design teams, and $4,650 per building for support of city plan reviewers. A large fraction of the design team support 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 utility administrative cost for a program serving 50 buildings per year—both pilot program approaches are projected to be cost effective at both societal and utility levels, according to an industry standard utility program cost-effectiveness analysis (CEC 2012) as shown in Figure 5. 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.
Process Evaluation Findings

Process evaluation efforts included a focus group meeting part way through the program implementation period, and participant surveys. The focus group meeting identified the challenges and opportunities related to energy code compliance shown in Table 3.

Table 3. Key focus group findings

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

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. Even though this service was not a primary focus of the pilot program development and delivery efforts, its availability could be a strong incentive for city participation in future program offerings. The survey findings also suggest that, while CEE recruiters often found the financial 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. This suggests that a mature program would maximize participation by emphasizing participant testimonies about the value of the kick-off meeting and tools provided, with the financial incentives only highlighted during more “cold-call” situations (and perhaps reduced or eliminated over time as the program becomes established among designers in the area).

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 within key categories:

For Any Code Compliance Program

- Starting with a focus on a limited number of high impact items and carefully consider where the point of diminishing returns is reached (i.e. when adding requirements and complexity increases the savings per building, but at a high enough incremental increase in program delivery cost to reduce overall cost-effectiveness).
- Work with regulators to develop a methodology for counting savings appropriate for the type and scale of the program.
- Consider separate, specialized program design or recruitment of renovation projects. These represent a large volume of projects that may not be reached through the same channels as new construction-focused services and marketing.

For Similar Individual Commercial Project Assistance Programs

- Although the two services offered in the pilot are both viable models and are not mutually exclusive, we suggest placing a higher priority on partnering with cities to support their energy code review and inspection process (plus support for early design phase meetings), as opposed to supporting design teams directly. 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, and
update as new codes are adopted. Fine-tuning of the measure list should include the addition of HVAC system sizing based on the findings of Rosenberg et al. (2016) and the removal of lighting power density.

- Provide a high level of technical expertise, including building energy simulation, among program delivery personnel so that the participants will value the program as a resource.

**Relationship with Other Programs**

- 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 for participating in both types of programs.
- 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 in Minnesota demonstrated the potential to cost-effectively provide substantial savings. While we had originally anticipated greater overall efficiency in supporting design teams in their efforts to “get it right the first time”, recruitment of buildings for this approach proved to be more difficult and costly. On the other hand, once partnerships with participating cities were established, the city reviewer support approach had much lower recruitment costs, while also achieving a marginally higher level of savings per building served.

In addition to achieving energy savings toward conservation program savings goals, the pilot program services were perceived as valuable to the participants in both approaches. Even so, the program’s experience and participant survey results suggest that a number of program changes might further optimize its impact and cost effectiveness—most notably, an increased focus on early meeting(s) with the design teams. Some fine-tuning of the list of targeted measures is also recommended.

**References**


