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Codes Market Characterization

for the MN Advanced Energy Codes Partnership and Center for Energy and Environment

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Executive Summary

This project was designed to build understanding of the current state of commercial energy code compliance in Minnesota, the typical process involved in plan development and compliance review, and the tools and trainings that would best reach different market actors. This research was designed to collect nuance and detail via qualitative interviews, as opposed to statistically representative sample sizes. The research team prepared for data collection by reviewing existing literature on Minnesota codes and interviewing eight Minnesota energy code subject matter experts. The team conducted primary research with three key groups of market actors involved in the overall codes "market" in Minnesota, which included:

- in-depth interviews with 14 code officials,
- in-depth interviews with 15 mechanical designers/design engineers, and
- a survey of 17 HVAC contractors

The overarching research objectives for this project included:

- Documenting the experiences and roles of energy code market actors as they relate to ensuring energy code compliance for commercial buildings: who is responsible for which aspects, and how do the market actors work together?
- Assessing market actor familiarity with existing code
- Identifying training opportunities and tools used by various market actors to learn about changes to commercial energy code and compliance strategies: what types of professional development and/or training tools are likely to be most useful?
- Identifying the most challenging aspects of energy code compliance and documentation
- Investigating standard inspection or correction processes

Key Findings and Opportunities

Energy code is often subordinated to other building codes and sometimes conflicts.

The energy code competes with other building codes and requirements for the resources of code officials and design professionals. Code officials are time constrained and prioritize health and safety code compliance over the energy code. The electrical code compliance verification is typically handled by state inspectors or certified third-party inspectors. Misalignment between the energy code and other building codes, such as mechanical and plumbing codes, causes confusion amongst all market actor groups.

Opportunity:

- Provide solutions for how to navigate conflicts between energy code and other building code. Solutions could include a centralized, searchable, online research tool for code information and interpretation and standardized checklists and templates to streamline compliance review

Gaps in training and tools limit shared understanding of code requirements.

Market actors believe they are on their own when it comes to staying up to date on the energy code. This research confirmed a fragmented understanding of existing energy codes and uneven enforcement across the State. Code offices rarely have staff with specific energy code expertise, which can undermine consistency. Staying up to date on new energy code requirements is a challenge for all market actors. Code officials and designers in particular voiced frustration with not having access to the new energy code guidance when it was released in January 2024. Additional details on training and education by market actor role can be found in 5.2, Table A-1.

Opportunities:

- Develop a unified training platform with comprehensive, multi-format training options that meet the needs of all stakeholder groups. This platform should include in-person workshops, on-demand webinars, and hands-on technical sessions.
- Consider hosting training opportunities for contractors during slower months (winter for new construction, spring/fall for those involved in repair/replacement).

The Advanced Energy Codes Partnership would benefit from additional trusted messengers.

The number and diversity of entities involved in delivering code compliant new buildings and major renovations indicates the Partnership will need help carrying messages deep into firms and professional networks. Code adoption follows a typical adoption curve, with experts and early adopters aware and adjusting quickly while others must be pulled along through enforcement actions. To prepare the market, Minnesota should provide timely access to new code books and related tools prior to the energy code implementation date.

Opportunities:

- To effectively engage with these market actors over the long term, the Partnership should identify trusted messengers throughout the system and provide them with training, information, and resources to represent code best practices throughout the market.
- Leverage the relationship equipment suppliers have with designers and encourage them to host trainings and electronic libraries of resources.

Poor documentation quality creates challenges for enforcement and implementation.

Code officials and HVAC contractors report marginal quality in design documentation. The lack of details included in documentation (plan sets, energy code compliance documentation, and build specifications) requires on-going communication with designers to complete necessary documentation submissions. Contractors also struggled with the quality of design documentation and control sequences.

Opportunities:

- Develop and promote standardized templates for design documentation and control sequences to improve detail and consistency across projects.
- Encourage preconstruction meetings that engage design engineers early in the process, particularly for large, complex projects.

As performance path becomes more common, code officials are less able to verify code compliance and expected building performance.

Market actors indicate that energy modeling to support performance path compliance is becoming increasingly prevalent, particularly in new construction. This allows for a more holistic approach that incorporates envelope, building systems, and interactive effects and encourages finding cost-effective solutions to achieve energy efficiency and code compliance targets.

However, there are a variety of energy modeling packages, and code officials are not trained to review model assumptions. Code officials report focusing on the end value from the COM*check*™ or energy model report, and if the model indicates the building passes, they do not investigate further. Code officials indicated the need for better methods to confirm model accuracy and verify that buildings are performing as designed.

MEP design firms report having in-house energy modeling, which ensures the models meet the timeline requirements of the design team and streamlines analysis of equipment options. Design engineers either prepare the model or work directly with energy modelers to inform the design.

Opportunities:

- Market actors need specialized resources and training on the benefits and challenges of performance-based compliance path.
- Work with designers to promote solutions that allow code officials to verify reasonableness of energy models
- Code officials would benefit from information on energy modeling best practices and straightforward verification methods. Provide training and resources to code officials on how to review energy models
- Third party energy modeling consultants can be helpful but must meet the timeline required by the design team.

- Ensure training materials clarify the difference between envelope trade-offs and performance path.

Renovation/retrofit projects tend to follow prescriptive path

There is often little opportunity to modify or improve the building envelope on existing buildings; therefore, renovations tend to focus more on mechanical system modifications to comply with the energy code. The constraints associated with mechanical room space, shaft runs, existing ductwork, heating fuel, and electrical load push designers towards the prescriptive code path.

Design-build projects are more likely to use prescriptive approaches for energy code compliance as these projects tend to be more straightforward, lower cost, and face constraints on mechanical system modifications.

Opportunities:

- Investigate codes associated with renovation and retrofit projects to confirm prescriptive approaches are encouraging optimal energy savings.
- Identify utility programs or other subsidies to encourage investment in high-performance upgrades for existing buildings so these projects do not fall in a program gap.

Commissioning is inconsistently understood and implemented.

The odds that energy code related commissioning is happening as intended by code are low. Commissioning most commonly occurs on public projects, where the owners insist on it, and in large buildings with complex systems. Code official knowledge regarding commissioning is inconsistent, and their perspectives on enforcement likely affect project level commissioning.

For projects constructed in phases, designers said commissioning could get delayed until the end, with the first phases operating for years without commissioning.

Opportunities:

- Develop the workforce of commissioning professionals to improve access and quality.
- Provide education for code officials on commissioning requirements and their role.

As the Partnership works on additional code updates, addressing technical challenges with energy code implementation and areas of non-compliance could demonstrate a commitment to reducing pain points.

Market actors shared concern that rapid code advancements could outpace manufacturers' ability to develop products that meet their needs.

Code officials identified common areas of concern with technical energy code compliance including:

- Building envelope and insulation requirements, particularly air barriers and continuous insulation
- Mechanical system components, including economizers, horsepower limitations, and vestibule requirements

Designers and contractors expressed frustration with several mechanical challenges:

- Challenges with meeting fan power limitations
- Lack of affordable product availability for heat/energy recovery for dwelling units
- Vestibule air tempering control
- Difficult to program controls for systems with integrated ventilation and conditioning

Opportunities:

- Work with equipment suppliers to promote product or system upgrades that make it easier for market actors to meet advanced code requirements.
- Solicit ideas and solutions from market actors for areas that represent chronic challenges.

Baseline control strategy templates could perpetuate outdated methods

Designers often use baseline control sequence templates and modify them for the specific project needs. While this may be efficient, it can also lead to proliferation of outdated methods.

Designers emphasized the importance of aligning control strategies with owner/occupant expectations for building use and operation, particularly considering maintenance capabilities when specifying controls.

Opportunities:

- Provide updated tools and templates that encourage mechanical design consultants to update control strategies
- Encourage the use of energy modeling as a tool for identifying optimal control strategies for energy efficiency and operational benefits.

Value engineering (VE) does not lead to noncompliance but does reduce energy efficiency

Designers and contractors agree that VE processes do not significantly contribute to noncompliance, as there are collaborative efforts to ensure equipment and systems meet energy code minimums; however, both groups reported that VE leads to reduced energy efficiency overall.

Opportunities:

- Encourage the use of energy modeling as a tool for highlighting and quantifying tradeoffs in operational costs or long-term energy savings during VE.

- Mechanical costs can be reduced initially by increasing the envelope air tightness and therefore reducing the effect of the VE process on mechanical systems.

Section 1 Introduction & Background

The Minnesota Advanced Energy Codes Partnership was formed in 2023 to help achieve the rapid increase in the efficiency of Minnesota buildings needed over the next 15 years to help meet the State's aggressive climate goals. The Partnership is focused on expanding several existing efforts and activities related to adopting more advanced codes in Minnesota, enhancing code compliance, and exploring strategies for existing buildings, including building performance standards.

1.1 This Project

This project was designed to build understanding of the current state of commercial code compliance in Minnesota, the barriers to code advancement, the typical process involved in plan development and compliance review, and the tools and trainings that would best reach different market actors.

The overarching research objectives for this project included:

- Documenting the experience of and role of various respondents as it relates to ensuring energy code compliance for commercial buildings: who is responsible for which aspects, and how do the market actors work together?
- Assessing market actor familiarity with existing code
- Identifying training opportunities and tools used by various market actors to learn about changes to commercial energy code and compliance strategies: what types of professional development and/or training tools are likely to be most useful?
- Identifying the most challenging aspects of energy code compliance and documentation
- Investigate standard inspection or correction processes

1.2 Literature Review and SME Interviews

To inform subsequent tasks and ensure current market intelligence guided our work, the Cadeo team began this project by reviewing literature and research on energy code adoption, compliance and barriers, and by interviewing several energy code subject matter experts in code advancement and compliance. Minnesota stakeholders have supported several recent research projects to understand opportunities for advancement in energy codes and appliance standards, and to provide recommendations for how the state could proceed. These documents tended to center on the perspective of stakeholders and building level calculations of code compliance and opportunity. As the Cadeo team prepared to interview market actors, we sought to leverage this work and reviewed a set of core sources, documented in Table 1.

Table 1: Minnesota Codes and Standards Literature Reviewed

Source	Summary
Minnesota Advanced Energy Codes Partnership: A Path to Net Zero. Technical Volume. Center for Energy and Environment, Minneapolis, MN. 2023	Provides an overview and technical description of several core project activities as identified by the Minnesota Advanced Energy Codes Partnership. Includes a discussion on challenges with compliance and a path toward net zero energy code.
Minnesota Codes and Standards Program: Concept to Realization Roadmap. Prepared for the Minnesota Department of Commerce, Division of Energy Resources by 2050 Partners, Slipstream, Midwest Energy Efficiency Alliance, and LHB. Contract Number 157674. 2021	Summarizes efforts of a Technical Advisory Group and input of a variety of stakeholders to identify policy and program ideas to support a new Minnesota Codes & Standards Program. Provides a range of detailed recommendations for MN stakeholders and utilities.
Minnesota Code Program Development Report. Prepared for Xcel Energy, CenterPoint Energy and Minnesota Energy Resources by TRC. 2023	Informed by stakeholder interviews and analysis, this report evaluates the potential energy savings that could be claimed by MN utilities from a coordinated building codes program in MN. Provides an initial program design.
Minnesota Codes and Standards Evaluation. Prepared for Xcel Energy by Michaels Energy and Guidehouse. Report Number GF-521BAN. 2023.	An impact and process evaluation of the utility-funded Minnesota Community Code Support Program, which operated from 2021-2022 and provided technical support for code officials during the plan review stage of commercial new construction permitting.
Minnesota Commercial Energy Baseline and Market Characterization Study. Prepared for Minnesota Department of Commerce, Division of Energy Resources by Slipstream, LHB, Franklin Energy and Institute for Market Transformation. Contract 156123. 2020.	Examines the characteristics and energy savings opportunities associated with energy code in MN. Collected data for 78 building projects in four major building segments and calculated lost energy and cost savings.

This process included interviews with eight subject matter experts, including contacts from MN Department of Labor and Industry (DLI), CEE, NORESCO, University of Minnesota, and City of St Louis Park. Interviews focused on understanding their perspectives on code compliance in Minnesota, barriers to improved compliance, and opportunities to support market actors in both compliance and advancement challenges.

1.2.1 Code Advancement

The literature identified seven core barriers to code advancement:

1. Perceptions that codes increase first costs for builders and consumers, which creates resistance to changes.

2. Securing buy-in from affected industries like builders, contractors, and design professionals who must learn about and execute code changes.
3. Negative associations between code advancement and enforcement.
4. Lack of resources and staffing to support code activities at state organizations.
5. Lack of urgency or overall complacency with the status quo (including utility program design).
6. Limitations associated with code advancement that requires modifications to existing buildings.
7. Equity concerns, especially for rural areas with fewer construction or code resources.

An important foundational source for the team's understanding of how Minnesota might approach overall code advancement is the Minnesota Code Roadmap, which discussed historical and potential pace of acceleration and established a core set of initial tasks for the state, including:

- Establishing a goal of achieving **net zero energy for new commercial buildings** by 2036, starting with adopting ASHRAE 90.1-2019 and advancing the code every three years.
- Creating a working group to collaborate on **launching and administering a statewide codes and standards program**.
- Focusing efforts on building energy code advancement, including **providing technical support** for the adoption of more stringent codes.
- **Improving building code compliance** through activities like training, circuit riders, and enhanced code official resources.
- Conducting additional **market research and analysis** to enable future updates to the residential building code and extending this to existing buildings.
- **Coordinating with stakeholder groups**, including contractors, designers, labor unions, and local governments to get input on codes program design.

1.2.2 Code Compliance

To prepare for data collection on code compliance challenges and the overall status of code compliance in Minnesota, we identified both existing, documented challenges and ideas for improving the overall rate of compliance. The literature indicated that code officials lack the time to thoroughly review energy code requirements, particularly for complex performance path projects. The Community Code Support program evaluation specifically noted that the complexity of the commercial energy code leads to low understanding among code officials and design teams and that this affects the level of enforcement, and costs associated with corrections.

Ideas for improving code compliance, both the overall rate of compliance and the ease with which the market can deliver it, fall into three main categories: augmenting the knowledge, skills, and awareness of key market actors, streamlining the process, and building enthusiasm.

To **augment the knowledge, skills, and awareness** of key market actors, (including code officials, mechanical designers, and contractors) the literature suggests Minnesota advocates develop and provide specialized training, establish a collaborative group for peer engagement, develop clear guidance documents, and offer third party plan review and inspection services.

To **streamline the compliance and review process**, the reviewed literature (Table 1) suggests Minnesota advocates develop customized checklists and sample compliance forms, provide updates on latest technologies and design strategies, and implement a circuit rider program to support code officials.

Building enthusiasm or support for compliance with existing code could involve providing robust data on building costs and performance, conducting pilot demonstrations to showcase and support compliance best practices, and recognizing those who provide leadership in compliance and advancement work.

Overall, the literature indicates the need to keep code advancement goals reasonable and adopt them incrementally to allow the market to adjust and achieve high compliance before additional changes are required.

1.3 This Report

This report includes five additional sections. Section 2 summarizes the findings from in-depth interviews with Minnesota code officials. Section 3 provides a detailed discussion of the findings from in-depth interviews with design engineers and mechanical designers. Section 4 provides the results of a survey with HVAC contractors working in Minnesota. Finally, Section 5 provides a summary of the findings and opportunities for the Minnesota Advanced Energy Codes Partnership.

Appendix B provides detailed descriptions of the methodology and outreach approach that informed the data collection efforts. Appendix C contains the data collection instruments.

Section 2 Code Officials

2.1 Summary

This section is based on interviews with 14 code officials responsible for commercial building plan reviews and inspections in Minnesota. These officials experience challenges enforcing energy code compliance, including challenges staying current with new code requirements, educating contractors and designers about code changes, and verifying compliance for complex systems. Code officials report a lack of timely access to new code books, difficulties in balancing increased compliance costs with long-term benefits, and challenges in enforcing commissioning requirements. One of the most common issues mentioned for compliance centered on missing information and the lack of detail in documentation provided by the design team, such as plan sets, energy code compliance, and project specifications.

Interview data indicates interest in user-friendly tools and resources, including standardized checklists, clear documentation requirements, and practical guides for energy code enforcement. More comprehensive training and additional tools will be valuable for verifying performance path compliance moving forward. Code officials expressed a preference for in-person training that provides in-depth, practical knowledge of energy code requirements.

2.2 Methodology

The team sought to better understand the experiences and perspectives of code officials through in-depth interviews.

To determine potential interviewees, the team used a publicly available list from MN DLI of licensed Certified Building Officials, a list of ICC credentialed contacts, and known contacts from CEE and NORESCO. The team leveraged an existing relationship with a contact at DLI who sent outreach emails to contacts with active CBO licensure. This DLI outreach yielded 14 completed interviews.

For a more detailed description of population frame development and outreach, see Appendix B.

2.3 Experience & Responsibilities

We asked code officials about their primary responsibilities, the types of projects they work on, and the portion of their time dedicated to energy code enforcement. All code officials interviewed work on commercial buildings, with 10 of 14 reporting that 50-100% of their projects are commercial. Most respondents (12 of 14) confirmed they are responsible for plan review. Over half (8 of 14) reported they conduct inspections. A similar portion (8 of 14) said

they are the Building Official for their jurisdiction, with six of those individuals reporting that they are in a supervisory role.

Five contacts specifically mentioned that they are responsible for all commercial buildings in their jurisdiction. Two of these officials spontaneously flagged the nuance associated with state delegated projects, which are public buildings that are either paid for by the state, or school buildings where the cost of the project is over $100,000.[1] One of these officials has a state delegation agreement, which means they can inspect state delegated projects but not review plans. The other official does not have a state delegation agreement and noted that without it he is unable to inspect state-delegated projects.

> *"There lies the problem...it's like you almost need somebody who's an energy code specialist to try and figure it out and to do a thorough energy code plan review"*
>
> -Code official

Of the 14 interviewed code officials, only two reported having staff with specific energy code expertise. While jurisdictions may have staff with energy code expertise, it is rare to have personnel dedicated solely to energy code enforcement. Instead, this responsibility is commonly distributed among the plan review and inspection staff. Several respondents noted the challenge this presents, especially with the increasing complexity of the energy code.

Code officials estimated the portion of their time dedicated to energy code compliance verification, which ranged from almost none (5-10%) to more than half of their plan review and/or building inspection time focused on energy code review.

2.3.1 Plan Review Process

We asked code official contacts to describe their typical process for reviewing a project for energy code compliance. Contacts provided a step-by-step description of how this process typically works.

1. Plan submission: Designers submit plans electronically, through an online portal or via email. Every respondent said that their jurisdiction accepts plans electronically (including via online portals), with only two saying that they accept hard copies as well.
2. Initial review: The building official or plan reviewer downloads the submitted documents and begins reviewing them, often using software like Bluebeam for markup. Six contacts mentioned using the PDF software Bluebeam in their plan review process.
3. Energy code documentation review:
    a. Determine if the project is using prescriptive or performance path, and review accordingly.

[1] (MN Department of Labor and Industry , n.d.)

   b. Check if all required energy code documentation is provided and complete, such as COM*check*™ reports (if submitted).
   c. For energy code compliance, reviewers compare the documentation to code requirements to verify that the proposed design meets or exceeds minimum code requirements. Specific energy code related items reviewers look for include:
      i. Insulation values for walls, roofs, foundations
      ii. Window and door U-factors
      iii. Air barrier and weather-resistive barrier details
      iv. HVAC system specifications. Some code officials did note that they do not investigate too closely at mechanical systems due to their complexity.
      v. Lighting controls and power density
4. Comment compilation: Reviewers compile a list of comments, questions, or required corrections related to energy code compliance. Comments are typically sent back to the architect or designer, often through an electronic system or via email.
5. Revisions and resubmission: Designers address comments and resubmit plans if necessary.
6. Final approval: Once all energy code requirements are met, this portion of the plan review is approved.

2.3.2 Building Inspection Process

Code officials who perform building inspections described their typical process for inspecting a project for energy code compliance. Contacts provided a step-by-step description of how this process typically works.

1. Preparation: Inspectors review approved plans and previous inspection notes before site visits. There's variation in approach, with some relying on digital methods and others preferring paper-based approaches. Five contacts reported downloading plans to tablets or phones for easy reference on-site. Three contacts said they expect a printed plan set on-site and available for them to review during inspections.
2. On-site inspection: Energy code inspections are typically integrated into overall building inspections. Two contacts specified that they typically spend less than an hour per inspection. Inspectors may visit the site several times over the course of construction, to inspect specific features as they are installed. Several inspectors mentioned the challenge of balancing the time required for thorough inspections that also focus on energy code items. Contacts verify that installed systems and materials match the approved plans, typically electronic devices (tablets, phones) to document and make notes regarding the building inspection. Contacts noted that better checklists or guidance specific to energy code inspections would be helpful.
3. Communication with contractors and follow-up: Code staff discuss any issues or non-compliant elements found during the inspection and provide guidance on necessary

corrections. Re-inspections are scheduled if needed. Once all requirements are met, a final certificate of occupancy is issued.

2.3.3 Typical Process for Review or Inspection

While they described a general process for plan review, code officials face challenges in consistently applying the energy code due to lack of training, incomplete submissions, project-specific details, and the time required to go back and forth with designers. The interviews reveal several components of this process where the ideal case might not occur.

Code officials acknowledge that they are not always equipped to review the energy code in detail. This could be because of lack of information provided by design teams or due to working with staff and design teams that are not up to date on energy code requirements. This challenge can affect the completeness of the submitted permit set and require more time for the project to pass through plan review due to additional clarifications, review comments, and corrections needed for a complete application. As one respondent noted, *"The majority (of time) for energy code is getting them to declare the path they are using and then providing proper documents, which a lot of times they don't give us right away."*

Issues around documentation emerged throughout the process and one mitigation suggestion by code officials was to have a preconstruction meeting, at least for large projects. More commonly documentation issues are addressed through lists, review comments, and passing documents back and forth. Comments are recorded on a plan review letter and submitted back to *"whoever submitted the plans."*

- *"The bigger projects always have a preconstruction meeting, but we have a lot of non-licensed non-commercial type contractors doing some of these projects."*
- *"I forward [comments] to the architect or engineer for corrections that need to be made, and then I'll look through the notes first and sit down and go through it, have them explain some stuff to me."*

Code officials said that they may not review equipment efficiencies or other energy code components in detail due to lack of education, experience, or time. At several points interviewees noted a lack of standardized inspection process or checklist, reflecting that energy code is woven into the rest of the building code. During the interview period (Q1 2024) code officials reported that they did not have a checklist for the new ASHRAE with Minnesota amendments code. Enforcing new energy code requirements emerged as a general and significant challenge.

Electrical code review is a unique situation. Code officials confirmed electrical code, including energy code measures related to electrical such as lighting controls, are handled by specialized individuals, including State inspectors or certified third-party inspectors. One code official reported that *"if the electrical COMcheck™ is supplied to me I'll review it;"* however, none of the

code officials interviewed were responsible for any electrical energy code inspection items. Two code officials reported that they contract out the electrical inspection, *"We contract TOKLE Electrical Inspectors. They serve something like 25 cities around the metro area. I don't know if they review plans or if they just do everything on site."* The remaining code officials reported that the state is fully responsible for electrical inspection.

2.3.4 Common Areas of Non-Compliance

When asked about areas with the most non-compliance found during plan review or building inspection, respondents identified several common issues. The most common issue mentioned for compliance centered on missing information and the lack of detail in documentation provided by design teams, such as plan sets, energy code compliance, and project specifications. A few specific areas emerged as common challenges or areas of non-compliance. Building envelope and insulation requirements can cause problems, particularly air barriers and continuous insulation. One code official described often seeing the air barrier/weather resistant barrier being confused or conflated and noted that contractors often miss the air barrier. Several other code officials highlighted challenges resolving discrepancies between mechanical/plumbing and energy code requirements, particularly regarding insulation. Code officials mentioned challenges with a few mechanical system components, including economizers, horsepower limitations, and vestibule requirements.

2.4 Challenges with Energy Code Compliance

Respondents described a variety of challenges enforcing energy code compliance, from keeping up with new requirements to educating the industry and balancing costs and benefits. Many of these challenges stem from the increasing complexity of the energy code and the need for better training and communication among all stakeholders. The following sections highlight several common challenges.

2.4.1 New Code Requirements

Code officials reported that **staying up to date on new energy code requirements** is a challenge for them both directly and indirectly, as they are often educating building designers and contractors. The timing of the interviews likely affected the prevalence of this challenge, as code officials were in the process of understanding and adopting the 2024 MN Commercial Energy Code based on ASHRAE 90.1-2019. Code official interviewees reported they did not have access to the new code book. Five contacts specifically mentioned this frustration.

> *"I can't enforce something when I don't even have the code book. How can you enforce something that you don't know anything about?"*
>
> *-Code Official*

On top of staying on top of their own education, code officials expressed challenges with educating building designers and contractors on new code

requirements. One code official suggested the energy code include examples and worksheets to support their efforts, *"Education takes a lot of our time. What if there were some examples in the energy code that showed designers how to comply? The mechanical code has workbooks for makeup air and other things that lay it out for them, and designers fill in the numbers and square footage and it gives them a result. That'd be great if there was something like that in this commercial energy code."*

A few code officials discussed interacting with contractors and building designers who might not be aware that a new code has been released. According to code official contacts, lack of awareness can affect the level of detail provided to demonstrate compliance and to guide contractors who need to follow the plans. The level of detail in documentation emerged as an issue generally and was specifically highlighted as a challenge due to new code requirements requiring a greater level of detail. According to one code official, "*There are a lot of technical things in [the new energy code] designers must provide that they never used to before. So, it's really educating them first and then second getting them to update their plans to show many different new things they've never needed to before."*

Code officials highlighted **discrepancies between energy code requirements and other building codes** (e.g. mechanical, plumbing) as an on-going challenge because of the confusion it causes for contractors. "*The contractors are not aware of the energy code requirements - that information is not included in the trade specific information books.*" These issues are exacerbated by the release of a new energy code because it places a burden on code officials to be vigilant and educate designers and contractors.

2.4.2 Verifying Complex Systems

Code officials faced several challenges when it came to verifying complex mechanical systems for energy code compliance, including limited expertise, time constraints, and timing of mechanical design for design-build projects.

Several code officials noted that they do not investigate mechanical systems too closely due to lack of education. According to one official, *"we check for balanced ventilation but otherwise don't typically look into mechanical systems, they're too complex and we don't have enough training/education. We don't look into equipment efficiencies a whole lot, maybe we should, we just don't have enough experience or education on it to really get into that."*

Code officials also mentioned limited time for plan review and building inspections. Several contacts discussed needing to prioritize health and safety building codes over energy code. Two contacts said that they have a very limited amount of time on-site for building inspections and that thorough mechanical system inspections take more time than allotted. Finally, several code officials complained about the lack of oversight for performance path energy code compliance. Code officials are typically unable to verify performance path model results. *"When the design is prescriptive, it's very easy to check. But when they go to Chapter 11 Appendix G it's out of my hands because we don't have the right tool to review."* Several code official contacts suspected

the prescriptive path might result in higher performing buildings, suggesting that even when performance path is used, certain items should still be required prescriptively and not allowed to be substituted for trade-offs.

2.4.3 Cost vs. Benefit

Cost emerged as a significant challenge in energy code compliance. Code officials reported that contractors, designers, and building owners often view energy code requirements as an additional expense without immediate tangible benefits. One code official mentioned the need for a "*5-year payback analysis study"* to justify the expenses associated with new energy code requirements. Representative comments included:

- "*Cost is a big thing here. It is everywhere, but you get into some of the metropolitan areas and some of the projects they work on, cost isn't as big of a deal. Cost is always a big deal down here.*"
- "*[It's] too expensive. And I'll tell you that in a lot of cases, they're not wrong. The energy code today does not look at what it costs the individual building the building. It looks at what it costs over the lifetime of the building, and so you're asking the builder of the building to spend a boatload of money up front to save other generations down the line.*"

Code officials acknowledged the challenge in balancing the long-term energy savings and environmental benefits with immediate construction costs. Code officials find themselves in the difficult position of enforcing requirements that can increase project costs, especially for smaller projects or in areas where budgets are tighter. This cost concern often leads to resistance and can make energy code enforcement more challenging.

2.4.4 Commissioning

Half of the code officials interviewed indicated they were not familiar with commissioning requirements as it was either a newer code requirement or they had not worked on a project that triggered the commissioning requirement. Three code officials familiar with the commissioning process stated they are not involved as the commissioning report is delivered to the building owner. *"We ask if they are going to do a commissioning report for the project. If they say yes, we tell them those documents go to the owner when it's completed."*

Two code officials suspected compliance with commissioning requirements is poor although they were not certain. **Several code officials noted that they struggle to enforce and verify commissioning, and that they do not want to hold up issuing the certificate of occupancy.** Two code officials mentioned the requirement for commissioning to be performed for a full year, or through a full heating and cooling cycle—which would require occupancy and end their involvement.

2.5 Resources

2.5.1 Tools & Resources

Code officials rely on a variety of tools and resources in their work. Interviews revealed strengths in current practices and areas for improvement. The transition from print to digital processes has been a major shift, with many jurisdictions now using electronic plan review systems and online portals for permit applications and document submissions. Contacts frequently mentioned software like Bluebeam as a valuable tool for reviewing and marking up digital plans.

COM*check*™, a software tool that helps determine if a building meets energy code requirements, emerged as a widely used resource for compliance verification. Many officials rely on this software to verify compliance with prescriptive requirements. However, opinions on its effectiveness were mixed, with some contacts expressing concerns about the ease with which users could manipulate inputs to achieve compliance.

Mobile devices, such as tablets, are increasingly being used for on-site inspections. These allow officials to access plans and code information in the field, improving efficiency. However, some officials still prefer paper-based methods, highlighting a transition period in the industry.

Throughout the interviews officials mentioned the lack of up-to-date code books, particularly for the newly adopted energy code based on ASHRAE 90.1-2019. Officials expressed a desire for more practical, user-friendly tools to interpret energy code and assist with energy code enforcement. "*It would be nice to have something user friendly that we could use at a glance.*" Suggestions included better **checklists, fact sheets, and guides that distill complex code requirements into more easily applicable formats**. There was a particular emphasis on the need for tools to help verify compliance with the performance path, as many felt ill-equipped to assess these more complex compliance methods.

We also asked interviewees about technical support resources. Some officials mentioned reaching out to state-level experts, including individuals at MN DLI and CEE, or peers for assistance with difficult questions. However, others desire more readily available expert support, particularly for complex energy code issues. According to interview data, the ideal toolkit would include up-to-date reference materials, practical guides and checklists, reliable compliance verification software (especially for performance path projects), and accessible expert support.

2.5.2 Training & Education

Contacts consistently highlighted the importance of ongoing education to keep up with evolving code requirements, particularly given the recent adoption of ASHRAE 90.1-2019 as the basis for Minnesota's energy code. The primary sources of training included state-provided seminars and annual conferences hosted by AMBO and ICC Region 3. While many appreciated the flexibility of online options, they expressed preference for in-person, hands-on training formats. Code officials valued the opportunity for direct interaction with instructors and peers,

emphasizing the benefits of being able to ask questions, discuss real-world scenarios, and network with colleagues facing similar challenges.

Officials identified several gaps in the current training landscape. Many officials expressed a desire for more in-depth, practical training focused on energy code requirements and noted the need for better understanding of complex systems, particularly in areas like mechanical systems and performance path verification. Interviewees also discussed wanting to understand the 'why' behind code requirements, not just the 'what,' noting that this deeper understanding can be crucial to explaining and enforcing code requirements effectively.

Code officials also discussed the timing and frequency of training. Some officials thought training on new codes should be provided earlier in the adoption process, allowing them to be better prepared when new requirements come into effect. The rapid pace of code changes was noted as a challenge, with officials joking that they barely learn one set of requirements before having to adapt to new ones.

Several officials emphasized that training shouldn't be limited to code enforcers but should extend to industry professionals including contractors and designers. This broader educational approach was seen as a tool to improve overall compliance and reduce conflicts during the enforcement process.

Section 3 Designers

3.1 Summary

This section summarizes interviews with 15 design professionals in Minnesota. The interview data indicates mechanical designers prefer to be involved early in the overall design process to optimize energy performance and cost-effectiveness, particularly for new construction where performance-based compliance paths are more common. Designers described different processes for existing building renovations, which are less likely to pursue a performance path for code compliance due to physical and budget constraints.

Overall, the interview data indicates that commissioning is widely practiced, with designers playing an active role, but there are still challenges around timing, costs, and enforcement consistency that impact the effectiveness of the commissioning process.

Energy modeling emerged as a valuable tool for design optimization and code compliance, though firms have different approaches to accessing energy modelers. Designers also discussed the impact of value engineering on energy efficiency and challenges posed by evolving code requirements, particularly around specific technologies like ERVs and electric vestibule heaters.

Designers expressed a need for more accessible and frequent training on code updates with CEU credits. They also called for improved tools for code interpretation, including searchable online resources, enhanced compliance software tools, and real-world case studies demonstrating successful code implementation. Finally, more consistent statewide enforcement and better alignment between energy codes and other building codes also emerged as pain points.

3.2 Methodology

The team sought to better understand experiences of design professionals involved in mechanical system design or specification, or those reviewing plans prior to submittal to permitting/code review, through in-depth interviews.

Cadeo performed outreach to potential interview respondents by directly emailing 41 contacts from CEE, SB2030, and ZoomInfo. A CEE staff member with connections to the Minnesota ASHRAE chapter was able to access the ASHRAE membership list of over 800 members and assist with outreach. The ASHRAE outreach resulted in most of the responses of qualified individuals. All contacts were invited to use a brief screening survey to help the team confirm they were qualified for our research. The screening survey resulted in 17 qualified contacts opting into the research, 15 of whom completed the interview.

More information regarding the detailed methodology is included in Appendix B.

3.3 Respondents' Roles

The 15 interviewed designers reported holding a variety of roles and brought different backgrounds to their efforts in building design, HVAC engineering, and energy modeling. This diverse group offered insight into commercial energy code practices in Minnesota. While most respondents were mechanical designers, the sample included a mix of mechanical design consultants, design-build professionals, energy modelers, and sustainability specialists. Table 2 displays the mix of roles each respondent selected.

Table 2: Mix of Key Roles Per Designer Respondent

Key Roles	Respondent															Total
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	
MEP Consultant	x	x		x	x	x	x	x	x			x	x		x	11
Energy Modeler			x					x	x		x					4
Sustainability / Energy Code Specialist								x	x	x	x		x		x	6
Project Manager	x	x			x	x	x					x	x	x	x	9
Business Owner		x				x								x		3
Design-Build						x								x		2
Architect											x					1
Manufacturer Rep										x						1

The six respondents indicating they were resources of energy code or sustainable design in their firms also served as MEP consultants, energy modelers, and even as a manufacturer representative. Although not explicitly asked for their level of expertise or number of years in the profession, respondents tended to describe their professional history when discussing their roles and responsibilities. Designer contacts reported a wide range of experience, from entry-level designers to senior-level engineers and principals with 20+ years of experience. Five respondents provided historical perspectives on how energy codes have evolved. According to one designer, *"I've been in this space since 2008. I've watched the targets get more and more aggressive over time, and technology has gotten better."* Designers have witnessed the energy code and building industry evolve towards more aggressive efficiency targets over the past 10-20 years, requiring adaptation in design processes, technologies, and compliance approaches.

3.4 Design & Specification Process

3.4.1 Design Process

One third of designers specifically discussed their preferences for early involvement often in pre-design or early schematic design phases. Designers recognize that **earlier involvement leads to**

better energy performance and cost-effective solutions. This allows designers to provide input on expectations and design decisions that affect energy performance and align on budget constraints, rather than having to adapt designs to decisions made without their input. Representative comments include:

- *"I like to get in as early as possible. Recently I've been getting involved in pre-design. More commonly though I'm brought in somewhere around middle part of schematic design. Initial discussions are very important for aligning budgets [and project goals]."*
- *"[Ideal involvement occurs in] schematic through construction documents. In theory prior to final decision making, before construction, so that our energy model can influence change."*
- *"Right away. Pre-design. A lot of the times, an architect will reach out to me to ask me to consult with them if the owner has some type of sustainability goal."*

However, designers report it is more common to be brought in midway through schematic design or even design documentation, after the architects and owners have solidified the program. This can lead to a design process in which the mechanical/HVAC designers react to decisions made earlier. Two MEP consultants noted that mechanical/HVAC systems are sometimes seen as an afterthought by architects and owners, who are more focused on the aesthetics and layout initially. According to one of these contacts, *"We're not always brought in as early as I would like. Oftentimes the MEP systems are kind of an afterthought. Architects and owners are more concerned about how it's going to look."*

The timing of involvement also varies by project type and scale. Larger, more complex projects tend to bring in mechanical designers earlier compared to smaller, simpler projects. As one contact noted, *"The bigger the project the earlier we're brought in. For big developments the architect will bring us in early. Smaller retrofits or additions tend to be mostly flushed out."*

3.4.2 Code Compliance Path

We asked designers how energy code compliance strategies differ for new construction projects versus major renovations. When asked for a breakdown of energy code compliance path on projects over the past two years, responses varied widely, from mostly prescriptive to mostly performance-based approaches. Overall, respondents indicated new construction provides more flexibility and opportunity to optimize energy performance, while retrofits are typically constrained by the existing building features. One respondent, who works as a design engineer, energy modeler, and in-house sustainability and energy code specialist, summarized this difference: *"In new construction a lot of the time we do energy models, because we can find more cost-effective ways of achieving energy reduction and meeting energy code. For retrofit we typically will do prescriptive. It gets complicated with existing envelope to do a model."*

3.4.3 Renovation

Designers emphasized that since there is often little opportunity to modify or improve the building envelope on existing buildings, **renovations tend to focus more on mechanical system modifications to comply with code.** As one designer explained, *"With retrofits you may not even be able to touch the envelope and you put a lot of weight on the mechanical systems. Substantial remodels may [involve] replacing the windows but oftentimes there is not opportunity to improve envelope."*

The constraints present in existing buildings, such as mechanical room space, shaft runs, existing ductwork, heating fuel, and electrical load, push designers towards the prescriptive code path. The limitations of existing ductwork systems reduce options, as designers are often unable to significantly modify or upgrade the ductwork in retrofit situations. This can be aggravated for multifamily/low-income housing retrofits. As one designer explained, "*The space available is a big consideration. Most existing multifamily/low-income housing have in-unit mechanical systems not whole building systems, so they [might not] have the shaft space and mechanical space for renovating.*"

Existing equipment and infrastructure for certain fuel types can also be a **barrier to electrification**, making it challenging to switch from gas to electric systems in retrofits. One designer noted, "*On a renovation project it's hard to increase the electrical load. If the buildings got gas equipment, it's hard to go towards electrification. You can switch to some high efficiency equipment but it's hard to switch fully from gas to electric.*"

3.4.4 New Construction

New construction projects allow for a more holistic approach that incorporates at the envelope, building systems, and interactive effects. Designers report that it is easier to comply with energy codes in new construction since the entire team is more aware of the requirements from the start. Respondents estimated that most (60-80%) of their new construction projects were following a performance path for energy code compliance, which they report allows for more flexibility and encourages finding cost-effective solutions to achieve energy efficiency and code compliance targets. As one design engineer shared: *"When we're doing energy modeling [for new construction] we can look holistically at the building envelope, doors, insulation, everything, and the mechanical systems and how it all works together."*

Designers also noted a distinction between plan-spec and design-build projects. Contacts working primarily on design-build projects reported that their projects are much more likely to use prescriptive compliance.

- *"At most it's providing a* COM*check*™ *report for the units themselves. All our projects follow prescriptive."*
- *"95% are prescriptive*"

For performance-path projects, designer contacts described three main approaches to energy modeling:

1. Use dedicated in-house energy modeling teams. Four respondents said their companies have dedicated energy modeling teams who are not also design engineers.
2. Engage design engineers who are also responsible for modeling. Six respondents indicated that the design engineers within their firms are responsible for energy modeling, with two of those firms having dedicated energy modeling teams that include design engineers.
3. Outsource the modeling to external energy modeling specialists. Two respondents categorized themselves as the external energy modeling specialist, although none of the interviewed respondents at MEP design firms indicated the use of a third-party energy modeling specialist.

The external energy modeling specialists interviewed also indicated that while they provide energy code compliance modeling documentation, they are typically hired to meet additional green building and utility incentive program requirements. The breakdown of energy modeling access by respondent is shown in Table 3.

Table 3: How Respondents Described Their Access to Energy Modeling

Access Via	Respondent														
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
Energy Modeling Team	x		x	x			x		x			x	x		
Design Engineers	x	x						x				x		x	x
External Specialist			x								x				
Majority Prescriptive / No Modeling					x	x				x				x	x

Designers described notable variations in energy modeling approach between larger and smaller firms. The larger, more established firms tend to have dedicated in-house energy modeling teams or specialists (who may include design engineers) while smaller firms either outsource modeling entirely or have design engineers who also perform energy modeling. Several MEP designers described how the energy modeling process works at their firms:

- *"We have a team of people in our group, and we assign an energy modeler per project. Engineers who are doing the design are either also the energy modeler or work directly with energy modeler to inform the design…. we used to outsource but they provided the model results too late in the design process to be useful."*

- *"We have an internal team, a Building Science Leadership Team. They're experts at systems, sharing information, and doing energy modeling. In our office they do like 50% modeling and 50% design."*
- *"It falls on us as the engineers. We have 4 or 5 engineers who are capable of energy modeling."*
- *"Right now, it's just me at the MEP design firm where I work."*

We asked designers if they were familiar with the "simplified approach to building compliance path for HVAC systems" within ASHRAE 90.1, most (ten of 15) respondents indicated that they were not aware of it. Four respondents indicated awareness although only one recalled utilizing this compliance pathway on a project.

Designers were also asked about permit submittal responsibility. While they may be involved in putting together the permit documents, over half of the respondents said the actual permit application and submission is handled by the general contractor or mechanical subcontractor, not the design team. Three designers mentioned that as the project lead, the architect is often involved in leading the permit submittal process. Said one contact, *"We do the design and then there is a permit set that goes out that is submitted by the architect and GC for building permit. Mechanical, electrical, plumbing are permits under the building permit that are submitted by the subcontractors."* Both design-build respondents confirmed that as the general contractor, they are responsible for permit submittal.

3.4.5 Control Strategies

All the interviewed designers reported being involved to some extent with specifying or informing control strategies. Ten designers stated they were directly involved in specifying the control strategies and sequences for the HVAC, lighting, and other building systems. The remaining five respondents indicated a lower level of involvement in the control specifications but noted that they provide input and support to ensure the control systems align with the overall design intent and energy performance targets.

Designers who are directly involved in specifying control strategies typically begin by aligning strategies with the identified needs and usage of the building spaces. Nine respondents said this process starts with conversations with owners or building occupants to determine how the building will be used and operated. Several designers discussed the importance of considering maintenance capabilities when specifying controls. The ability of the building owner/operator to maintain a control system will

> *"We have a baseline for control sequences for all our different systems. We pull from that default and then modify based on energy code requirements and project needs. We talk to the owner and what the projects needs are: setpoints, humidity, talking with maintenance staff. We perform load calcs to ensure our equipment can handle the loads and space setpoints."*
>
> – Designer describing process of determining control strategy.

determine the complexity of the selected control system, sequencing, and schedule.

Another common strategy is to use baseline control sequence templates and modify them for the specific project needs. Designers had mixed opinions on the effectiveness of starting with a baseline control strategy template. Some felt it was an efficient way to start, others thought it allowed for outdated methods to continue to be used. Three designers specifically highlighted the use of baseline control specifications as a starting point for control strategies. As one described the process, *"We have a baseline for control sequences for all our different systems. We pull from that default and then modify based on energy code requirements and project needs."* Other respondents described this practice as problematic. According to one, *"The vast majority of the time, there's an engineer who put together the specs 30 years ago and they just copy/paste for every project. I think it's even worse for controls contractor and I'm not even sure they read the sequences, and they just control the way they always do it."*

Four respondents with energy modeling experience discussed using the modeling process to help identify optimal control strategies from both energy efficiency and operational perspectives:

- *"We [use the energy model to] look at where we can have different occupancy sensors and controls to cut down on energy use, as well as how the owner feels the system will work operationally for them."*
- *"The energy model software helps me identify the optimal control strategy, then we work with the internal commissioning [team] to help us vet out that idea to make sure it is real-world applicable."*

Design-build contractors rely on their relationships with controls contractors to specify sequences. One design-build contractor reported determining control strategies by "*working with the controls contractor that I hire and communicating the design intent. It's a collaborative process.*"

Building size and system complexity also affects how designers specify control systems. Larger buildings, or those with more complex systems, are likely to have some type of building management system. Smaller projects, or those with standalone systems, are likely to have individual, programmable thermostats. Representative comments include:

- *"If it's a central system, I always like to specify an open-source building management system. Otherwise, if they're doing more standalone systems, then it'd be just individual controls, typically a thermostat with programmability."*
- *"A smaller project with just a couple of rooftop units will have programmable thermostats. When we get into bigger office buildings, medical we'll get into building automation systems."*

3.4.6 Construction Integration

Designers take an active role in overseeing construction to ensure their design intent is properly executed and to troubleshoot any issues that arise. The level of designer involvement during construction varied, particularly by project location and contract requirements.

When asked about their involvement during construction, responses varied. A few designers noted they may not be as involved in the fieldwork if the project site is far away. In those instances, designers rely on the construction team to execute the design. Designers noted that contracts may require them to provide construction administration services or allow them to only get involved if requested.

Designers described several ways they may be involved during the construction process:

1. One designer highlighted the value of **pre-construction coordination** and how software tools are used to address anticipated issues: *"We use REVIT to help with clash detection pre-build. We try to highlight potential construction and inspection issues in pre-build meetings."*
2. Two designers described **reviewing shop drawings**, which are essentially step-by-step drawings detailing the construction process. Another designer shared that their MEP consulting firm is commonly responsible for producing shop drawings, *"We're involved in construction administration to the end of construction for at least 90% of our projects. We produce the shop drawings."*
3. Four designers indicated **responding to requests for information (RFIs)** from contractors during construction to ensure systems are being installed properly.
4. Nine designers reported being responsible for **reviewing equipment submittals** to ensure the correct systems and pieces of equipment are being purchased and installed.
5. Nine designers reported that they perform **site visits and inspections** at key milestones, such as halfway through and at the end of construction. This allows them to identify and provide feedback on any issues.

a. "Rough-in" site visits typically occur early in the construction process. Designers discussed the importance of being on site prior to drywall to catch potential issues during installation.

b. Final inspections occur towards the end of construction and often involve testing and balancing to verify systems are functioning as intended. Five designers discussed that the final site visit(s) typically involve creating a "punch list" which lists items that need to be resolved before the project can be considered finished. Designers emphasized the importance of this field oversight to catch and correct any issues

> *"On new construction we go out halfway through to see the internal systems before sheet rock goes up. Unless there's a huge mistake, usually the rough-in inspection is just a field report. Then we go out again at the final punch, ideally when all systems are functioning. We provide a punch list of all items remaining to give direction on what remains."*
>
> – Designer describing construction inspection

c. Three designers described focusing primarily on the design aspect of a project, using other internal team members for site visits and construction administration responsibilities.

3.4.7 Value Engineering

Value engineering (VE) is the process in plan-spec projects where the contractor reviews designers' specified systems, materials, and other building components to determine where construction costs could be reduced. Designers report VE is a common process, with nearly every project undergoing a VE exercise to evaluate MEP systems. Designers described the constant challenge of balancing energy code compliance and energy targets with owner budget constraints. Vigilant review of contractor submittals and use of energy modeling were key strategies employed by designers to ensure energy code compliance and intended functionality of building and its systems are maintained.

Designers emphasized the importance of thoroughly reviewing equipment submittals from the contractor to ensure the suggested equipment meets energy code and expected designed system efficiency. According to interviewed designers, VE processes do not significantly contribute to noncompliance, as it is relatively easy to push back if submitted equipment does not meet energy code minimums. However, several designers reported that VE leads to reduced energy efficiency overall. According to one designer, *"We designed a nice VAV* [variable air volume] *system for a daycare and it was just too expensive, so they went with constant volume rooftop units. They use a lot more energy, but we found ones that are code compliant."* This sentiment about VE leading equipment swaps and whole system changes was shared by both designers and design-build respondents. Representative comments include:

- *"The value engineering is really in each system type, which system meets your budget vs return on investment for utility cost. That determines if we go for standalone equipment vs geothermal wells for example."*
- *"I do VE all the time and I can do things way cheaper than the original design. Sometimes the consultants were clear with the owner about what type of systems they're designing, and they've allowed for it in a budget, and they are energy conscious, and they understand the premium for that initial cost. Most of the time though the owners don't understand the costs. When I receive a bid invite, I look at the design documents and find I can do it way cheaper than what is indicated, and I'll provide that as an alternate in my proposal."*
- *"If VE does impact MEP systems, it goes from VE to full re-design. Then we have an add service to re-design."*

Energy modeling also emerged as a helpful tool during the VE process, as it allows designers to test different options and identify the cost-effective ways to meet energy targets. Energy modeling can also show why certain systems or equipment are critical for meeting energy targets. As one designer/energy modeler contact shared, *"That's the big benefit of the energy model…I can say to the GC, hey this piece of equipment is a big reason why we are passing energy code in the model."*

Another designer suggested that mechanical costs can be reduced initially by increasing the envelope air tightness and therefore reducing the effect of the VE process on mechanical systems. *"The low hanging fruit is air infiltration. Code is 0.4 cfm/sf and we've done blower door tests with a magnitude of order lower at 0.04 cfm/sf. Reducing infiltration reduces the overall load and we can transfer costs from mechanical systems to infiltration. The new code addresses this but [air tightness] could be increased even more."*

3.5 Energy Code Compliance Challenges

We asked designers about challenges they faced in meeting increasingly stringent commercial energy code requirements in Minnesota. Contacts described several core challenges:

1. **Misalignment between energy code and other building requirements and codes.** Several respondents noted that misalignment between the energy code and mechanical/building code can lead to confusion on interpretation and prioritization. According to one contact, "Energy code and mechanical code are not always aligned, and this can cause variation in interpretation between the "Authority Having Jurisdiction" (AHJ) and design team. Contacts expressed a desire for better coordination and clarity between the various code bodies to resolve conflicts and provide more streamlined compliance pathways.
2. **Cost constraints, budget limitations.** Contacts noted that equipment costs are an ongoing obstacle to meeting and exceeding energy code, particularly as requirements increase. The

costs involved can lead to intense value engineering. However, in discussing costs, designers tended to conflate energy codes with green building programs, which have more stringent requirements.

3. **Educating clients on energy code requirements and implications**. Designers reported an ongoing challenge in helping building owners understand the implications of energy efficiency targets, like net zero, and the design decisions required.
4. **Climate extremes, especially designing for cold weather.** Designers noted the challenges of designing for Minnesota's hot, humid summers and very cold, dry winters, while also trying to meet stringent energy efficiency targets. As one designer noted, *"Thermal comfort is a big thing here in Minnesota. In the summer it's hot. It's humid. In the winter it's really, really cold and really, really dry. But if we adjust our setpoints to reduce energy usage people will be unhappy."*
5. **Electrification and transitioning away from natural gas.** This emerged as a challenge primarily because existing buildings tend to have gas systems and lack the needed electrical infrastructure. Contacts expressed concern about energy bill impacts as electricity is more expensive than natural gas. One designer reported, *"Electric is much more expensive than natural gas. Heat pumps don't work as well at low temperatures. Dual fuel can be a tough sell to owners because it is expensive and hard to justify having essentially two systems."*
6. **Lack of enforcement or inconsistent enforcement of energy code.** Designers described significant differences in energy code enforcement across jurisdictions, with some areas having very knowledgeable code officials and others providing minimal oversight. Designers expect better outcomes from more consistent statewide enforcement.

In addition to the somewhat structural challenges described above, designers mentioned several technical limitations associated with equipment or strategies deployed to meet energy code.

1. **Challenges with fan power limitations**. Five designers discussed fan power limitations as a key challenge in meeting energy code requirements. One designer described this being a challenge as they have *"really big air handlers moving a lot of high velocity air through very small ductwork often with long runs."*
2. **Complicated and specific requirements.** Designers expressed frustration with specific requirements, like the mandate for electric vestibule heaters, that lack simple solutions. Both design-build respondents highlighted issues around the energy code requirements for vestibule conditioning as a challenge. These contacts offered specific complaints:
   - *"Electric heaters in vestibule to temper the air. Code says that air cannot turn on unless it is colder than 60 degrees outside. There's no product or easy solution for that. So, you have to hire an electrician to install a heating stat outside and rig it to the power supply of the electric heater. It's added cost and it doesn't make any sense on why it's needed."*

- *"They don't want you to condition the vestibule, but as soon as you open the doors to the lobby, all the heat transfers to the main building and then you use the energy that could have been used to condition the vestibule for the lobby."*

3. **Lack of effective products**. Designers reported they struggled to find products like small, efficient ERVs for multifamily buildings, that could meet all the code requirements. They expressed concern about rapid code advancements that could outpace manufacturers' ability to develop products that meet their needs. Representative comments included:
   - *"The mandate for energy recovery ventilators (ERVs) [is a challenge], this is prescriptive now and I could see them becoming mandated where we cannot model around them."*
   - *"There was an existing apartment retrofit/remodel project that we were really limited by the existing building structure. We had to squeeze the permit in before the code change, especially with the new ERV requirement."*

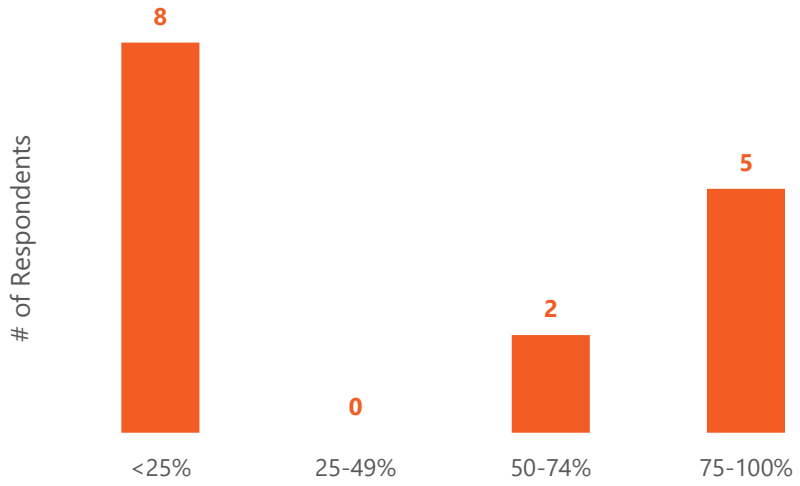
3.5.1 Commissioning

Designers view commissioning as an important step, but conversations indicated this is often an afterthought, with inconsistent enforcement across jurisdictions. Respondents provided insights into the prevalence of commissioning, the role they play in the commissioning process, and the challenges associated with commissioning.

Commissioning Prevalence. When asked how many of their projects in the past two years had been commissioned, responses varied from almost none to almost all projects. Figure 1 provides the distribution of designers by portion of projects they report are commissioned. The data indicate a bi-modal distribution, with about half indicating that very few projects are commissioned, and almost half indicating that most of their projects are commissioned. Even designers reporting that commissioning is relatively common acknowledged the quality of commissioning can be problematic. Representative comments include:

- *"About 95% [of projects are commissioned]. I work a lot in the public sector, so they require commissioning. How detailed that commissioning is, I don't know. Seems like it is often the bare minimum level."*
- *"I would say 75% are commissioned but probably not commissioned properly but it's tough to do so."*

Figure 1: Count of Designer Reported Commissioning Prevalence by Percent of Projects (n=15)



The project distribution visible in Figure 1 could reflect typical project types, as designers indicated that commissioning is more common on larger, complex projects, public/government projects, and those with specific sustainability or energy efficiency goals. Commissioning is more likely to be skipped on smaller, less complex projects where the systems are straightforward.

Designer Involvement. Designers are often involved in the commissioning process, providing design intent information, answering questions from commissioning agents, and helping resolve any issues identified. Nearly all designers said that commissioning requirements are included in the specifications and sometimes on the drawing set as well. Several designers shared that their firms have internal commissioning groups. Respondents assured interviewers that a separate engineer or commissioning team who was not involved in the design is responsible for the commissioning. Representative comments included:

- *"We do provide commissioning on both projects where we are a true third-party and where we are also the engineer of record, but [in those cases] a different engineer will perform the commissioning."*
- *"Commissioning does get done either internally by a group separate from the design team or by a third party."*

Timing Challenges. The timing of when commissioning agents are brought into the process can be an issue, with some reporting they are brought in too late in the design/construction timeline. As one noted, *"Timing is a big issue. Getting [commissioning agents involved] when they should get involved instead of at the last possible minute."* Timing challenges extended to challenges coordinating the schedules of all the various contractors and the commissioning agents for site visits. For projects constructed in phases, designers said commissioning could get delayed until the end, with the first phases operating for years without commissioning. One

designer described the need for more local commissioning professionals, stating that *"A lot of plan-spec jobs will hire an out-of-town commissioning agent and you're trying to catch them for 24-48 hours. If you could increase the local commissioning market it would speed up the process and improve the final quality."*

Owner/Budget Concerns. Designers noted that commissioning can be skipped when owners do not see the value. Some owners are resistant to paying for commissioning, seeing it as an unnecessary added cost rather than a valuable process. Representative comments include:

- *"Building owners expect it to be the engineer's responsibility and they don't want to pay the extra cost."*
- *"It is an unexpected cost for owners. It previously was not enforced by the AHJ and it's an extra ~$50,000 on a building and they're not expecting it."*

Enforcement and Consistency. Designers noted that commissioning may be skipped because it was not explicitly enforced by the jurisdiction, even if it was technically required. Designers described the need for more consistent enforcement and education of code officials on commissioning. Variability in how commissioning requirements are enforced by different jurisdictions creates confusion and inconsistency.

3.6 Energy Code Training & Resources

Interviews included several questions to understand existing training resources and to explore additional resources that could be helpful for design professionals.

3.6.1 Training Sources

Design professionals described their formal training on energy code as relatively sparse. Although nine of the 15 respondents hold the Professional Engineer (PE) license in Minnesota, which requires 24 hours of continuing education units every two years, 11 or the 15 respondents receive little to no formal energy code training, noting that there are no continuing education requirements specific to the energy code. Ten respondents indicated that their primary source of education on the energy code was studying and utilizing the code book itself, both online and hard copy. Designers reported that most energy code training is provided via internal company resources. Several designers mentioned when a new energy code is released, they or others in their company will research the code and host an internal presentation or informal training. Representative comments include:

- *"We have really good SMEs on our team and they…will update us on what has changed from the previous code cycles."*
- *"Mostly we do internal research and understanding. I've got AHSRAE 90.1 sitting on my desk. Our internal building science team will do a deep dive and put together an internal presentation on the updates."*

- *"One of my coworkers and I put together a presentation and [will go] to the architects and tell them about all the changes. So, I'm the one doing the training."*

Three respondents mentioned **manufacturer representatives and suppliers** as a source of information, including a respondent who was also an equipment supplier. These contacts described company efforts to host monthly training sessions and create a "training university." According to the equipment supplier respondent, *"We built a training room that seats about 100 people and we can broadcast our webinars. We store them so people can access them whenever they want for training purposes."* Another respondent reiterated overall reliance on the supply chain for information, stating, *"I tend to rely heavily on the big local supply-houses…these big sales companies that we buy our equipment from. They tend to be on the front end of equipment updates. They're good on doing their continuing education. They know where energy code is going and what equipment can be used. They keep us out of trouble."*

Designers also cited **code officials** as a resource for energy code education. Because designs are ultimately approved by the code official, designers may use code officials to understand how they interpret the code section in question. Representative comments include:

- *"Ultimately, it's up to the code official. Sometimes we call them during the design process and ask if our design aligns with what they're expecting to see."*
- *"If we're able to reach the AHJ and get their interpretation that is ideal."*

Designers also rely on training events and webinars put on by **industry associations**, such as ASHRAE or the American Institute of Architects (AIA). One designer mentioned attending the energy code conferences sponsored by the state. Assessments of overall quality were mixed and included:

- *"The AIA had great energy code updates and it was two CEU hours."*
- *"I did see [a webinar] floating around from AIA on energy code, but some of the people in our office watched it and thought it was poorly done… I do go to the AIA conference around here and I get a lot of CEUs that way."*
- *"I do listen to a lot of ASHRAE training pre-recorded webinars. You can go to the website and buy them. I did the high performing training by ASHRAE and I really liked it."*

3.6.2 Training Format

The interview guide asked respondents about favored training format, however designer responses were mixed. The data indicates a slight preference for in-person training because they generate more engagement and discussion, which makes it easier to stay focused. Others valued the convenience of virtual formats. Many designers saw the value of having a mix of training options available to them, including the flexibility of pre-recorded webinars and an ability to focus on specific topic areas. Comments in support of webinars included:

- "*Webinars are great…allows employees to stay in-office. They offer recordings so you can watch later.*"

- *"Our organization is a very dispersed workforce. Getting people in person is tough. Webinars are more accessible."*
- *"I tend to like pre-recorded webinars. Sometimes the live ones are too redundant, and it feels like a waste of time."*

Several designers highlighted that **case studies and real-world examples can make training and information more engaging and relevant**, allowing them to see the practical application and impacts. They viewed well-executed case studies as valuable resources for learning about energy code compliance.

- *"Anything to make it somewhat interesting, like a case study where you can see the effects. Have examples and use case scenarios of how code is applied…I like to see what other people's processes are. To be open and share without judgement and see what works where and in what situations."*
- *"When a building is built seamlessly, positive case studies are powerful. I would suggest using those examples to make a document that describes the process and what obstacles/roadblocks there might be and then follow up with a few case studies on projects that went well where everyone on the design worked well together…and the building is running well and efficiently. There's a lot of new people in the industry and that would be helpful for them."*

3.6.3 Additional Resources

We asked designers if there were additional tools, training or resources that would help them better comply with the energy code. Designers described the need for improved code interpretation and information tools, enhanced software tools, and more accessible and frequent training on code updates.

Requests for improved code commentary and explanations includes clear guidance on code interpretations and a **searchable online resource for energy code information with links to references and cases studies that could replace a physical code book.** Designers also reiterated the need for consistent state-wide enforcement expectations. This category includes a request for checklists and decision trees to help determine when to use prescriptive vs. performance path code approaches.

Improved software tools for compliance checking include improvements to COM*check*™ so that it provides better explanations for why a project is out of compliance, enhanced support, and an FAQ for using COM*check*™.

When asked about the format for additional training or tools, designers suggested short, focused training that provide CEU credits. They also requested that training courses be recorded and cataloged so they could be accessed on-demand.

Section 4 HVAC Contractors

4.1 Summary

A survey of 17 HVAC contractors in Minnesota revealed insights into their roles, challenges, and needs related to energy code compliance. Most respondents were involved in project bidding, functional testing, and equipment installation, with experience ranging from 1-5 to 10+ commercial building projects in the past two years. Contractors typically engage during bidding or equipment installation phases, with most of their work focused on renovations and retrofits rather than new construction.

Budget constraints and equipment availability emerged as the most frequent issues faced by HVAC contractors, followed by unclear code requirements. Contractors also expect concerns about increasing costs and system complexity as energy codes become more stringent. Contractors reported the quality of design documentation and control sequences as medium to low, indicating an opportunity for improvement in these areas. Commissioning practices varied widely by project, with public buildings more likely to undergo commissioning than retrofits or design-build projects.

Over half receive no regular, formal training on commercial energy code, though they report having access to necessary resources. There was a slight preference for in-person training methods, but pre-recorded webinars are a popular option. Contractors expressed a desire for additional training opportunities, particularly free sessions during slower winter months, as well as clearer code language and consolidated resources that combine trade-based and energy building codes.

These findings suggest several opportunities to improve energy code compliance among HVAC contractors in Minnesota. Enhancing the quality of design documentation and control sequences could address some immediate challenges. Developing more accessible and comprehensive training programs, especially those that can be completed during off-peak seasons, could help improve overall code understanding. Finally, creating clearer, more consolidated code resources could assist contractors in navigating the complexities of energy code compliance across different project types.

4.2 Methodology

HVAC contractors are a challenging population to reach by phone, so the team developed an email survey that contractors could respond to when it was convenient for them. The team relied on two sources to build a survey population frame, the MN DLI publicly available contact list of individuals with a mechanical contractor bond license, and ZoomInfo. The team sent three waves of invitations to identify additional eligible contacts, using a total of 1,454 email addresses.

The research team also prepared an initial screening survey to ensure that respondents were qualified for the study. This survey included questions about role and commercial building experience. Screening survey respondents with no commercial building experience and those that lacked any of the desired roles were excluded. A total of 17 qualified HVAC contractors completed the web survey.

More information regarding the detailed methodology is included in Appendix B.

4.3 Respondents Role

Contractors selected all responsibilities of their role. The most common response was engagement in project bidding. This was followed closely by functional testing of HVAC systems, programming or specifying HVAC controls, and installing HVAC equipment. Specifying or testing electrical systems was the least commonly selected responsibility, with only two contractors selecting this option. The full distribution of contractors' responsibilities is shown in Table 4.

Table 4: Roles Involved (n=17, Multiple Response Allowed)

Role	Count	Percent
Project bidding	15	88%
Functional testing of HVAC systems	12	71%
Programming or specifying HVAC controls	11	65%
Installing HVAC equipment in commercial or multifamily buildings	11	65%
Preparing compliance documentation for permit or inspection review	7	41%
Commissioning of mechanical systems	7	41%
Specifying commercial HVAC systems	6	35%
Interacting with code officials or addressing inspection review comments	6	35%
Specifying or testing electrical systems	2	12%

Contractors reported the number of commercial buildings, including multifamily, they had worked on in the past two years. About half of contractors (8 of 17) reported working on 1 to 5 commercial buildings over the past two years, while the other half (9 of 17) said they had worked on 10 or more buildings in the past two years. Contractors most commonly reported working on office buildings (15 contractors) followed by multifamily and retail buildings (9 contractors). Less common selections included industrial and school buildings (5 respondents each).

All but one contractor said they typically work for building owners, including owner-occupied buildings. About half (8 of 17) of contractors said they also work on public or institutional buildings. Only one respondent indicated working for a developer.

4.4 Design & Construction Process

Contractors reported they typically become engaged in the building process during bidding procurement (6 or 35%) and during equipment installation (5 or 29%). This can vary, depending on their role or relationship with the design team. One contractor said they are engaged during design development, another said they are brought in for controls programming, and two reported being initially engaged for functional testing of installed equipment.

These findings are consistent with contractor descriptions of their roles, which indicate they are involved in project bidding, installing HVAC equipment, programming HVAC controls, and functional testing (Table 4).

4.4.1 Control Strategies

The survey asked contractors if they were involved in specifying HVAC control strategies and/or programming system controls. Six (35%) contractors reported they are involved in specifying and ten (59%) said they are involved in programming HVAC system controls.

The ten contractors who reported being involved in programming controls were prompted to describe challenges they experience related to programming controls to meet energy code requirements. Two contractors described the complexity that arises because of the number and diversity of systems and control types available. They specified that proper labeling of systems and control sequencing is important. Two contractors shared that access to the energy code and misalignment between codes causes confusion. Said one, *"It would be nice to have one document that had all of the building codes stated and updated as new ones are created."* Another contractor said it can be difficult to program controls for systems with integrated ventilation and conditioning.

Reflecting the overall mix of renovation vs. new construction projects overall, contractors indicated most of their projects in the last two years were major renovations at 62%, with another 21% retrofit. Only 17% of their total projects were new construction.

We sought to understand the portion of new construction projects that followed a performance path for energy code compliance. Of the ten contractors who worked on some amount of new construction projects, three indicated they didn't know the energy code compliance path, three had no new construction performance path projects over the past two years, and four said that over half of their new construction projects followed performance path.

HVAC contractors rated the typical quality of the design documentation and the control they receive, as shown in Table 5. It is very rare for them to receive high quality documentation.

According to the HVAC contractor respondents, over half of the time the control sequence documentation is low or very low quality.

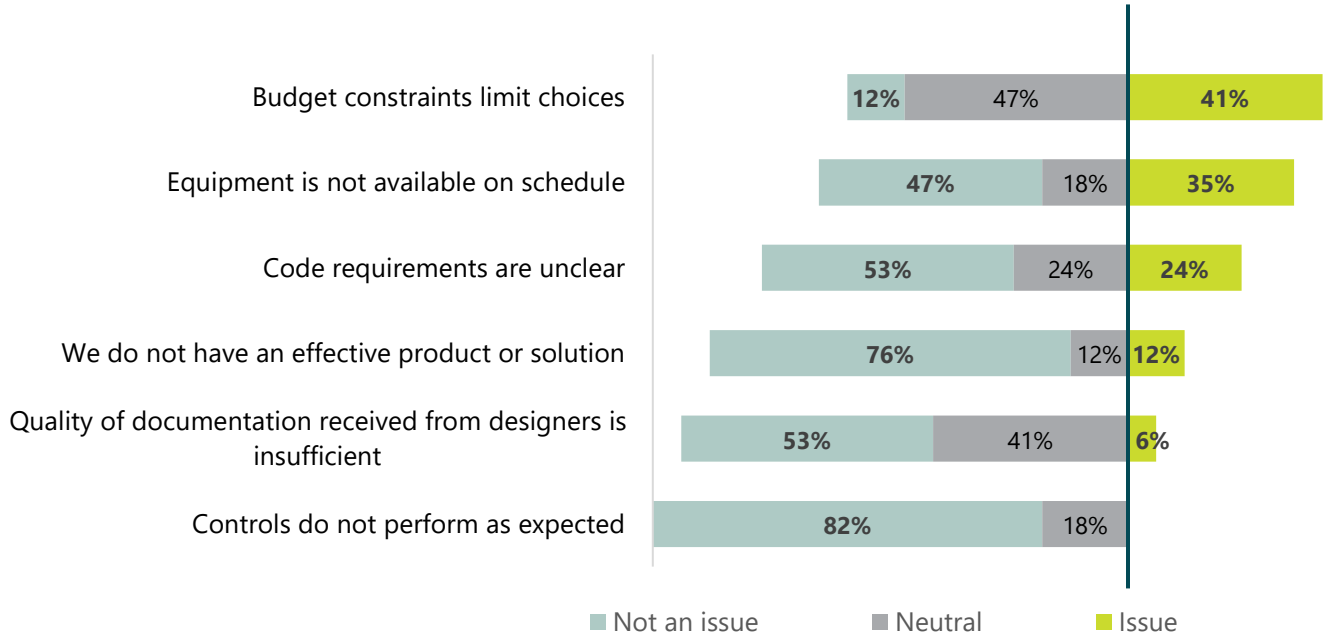
Table 5: Quality of Documentation

Quality Level	Design documentation	Control sequences
High: detailed and clear, requires little to no additional coordination with design engineer to understand design intent.	6%	--
Medium: includes details but may be some missing information that requires coordination or independent decision making.	59%	47%
Low: missing information, requires significant coordination or independent decision making.	36%	53%
Very low quality: little to no documentation is received, requires independent decision making.		

4.5 Energy Code Challenges

Contractors were asked to rate the frequency of a list of potential challenges they face on projects on a 1-to-5 scale where 1 means something is "rarely an issue" and 5 means something is an "issue on almost every project." Figure 2 displays the results in a three-point scale, where "1" and "2" are categorized as not an issue, "3" is neutral, and "4" and "5" are categorized as an issue. Budget constraints were the most reported issue followed by equipment not being available on schedule, and, to a lesser extent, unclear code requirements.

Figure 2: Contractor Rating of Challenges



Contractors overwhelmingly reported they did not receive inspection review comments related to energy code, with only three respondents (18%) receiving these comments.

Contractors were asked about challenges they expect as energy codes become increasingly stringent. Five of the 17 respondents mentioned cost as a main issue they expect to emerge. Six contractors expect increasingly complicated systems will be a challenge, with two of those respondents specifically referring to retrofit/existing building projects. One contractor anticipating complexity to be an issue highlighted the importance of education on code requirements to build understanding and ensure contractors can program control systems properly. One contractor expected clients will *"choose comfort over energy savings."*

4.5.1 Value Engineering

Nine of 17 contacts offered opinions on value engineering (VE). Contractor opinions varied widely on the VE process. Three contractors reported that VE negatively affects system performance and leads to overall poorer quality. Conversely, another four contractors see VE as a positive process, with one reporting that VE *"makes [sure] the equipment fits the circumstances of the structure and use."* One respondent reported that they do not believe the VE process affects energy code compliance. The remaining eight contractors did not offer opinions on value engineering.

Most contractors (11 out of 17) reported they are not involved in reviewing equipment substitutions made during VE or ensuring that the system is still energy code compliant. Three contractors reported checking the products themselves, either by verifying performance specifications, performing calculations, or otherwise proving the equipment works as designed.

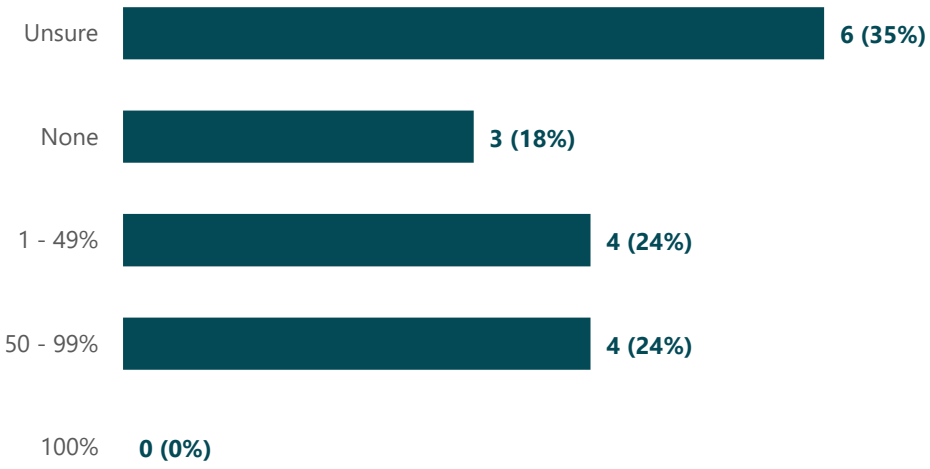
Two contractors said they verify performance with manufacturer or a trusted equipment supplier. Another contractor said that VE requires them to start their work over.

4.5.2 Commissioning

Just under half (7 of 17) of contractors report they are involved in commissioning while the remaining 10 are not. Four of the seven involved in commissioning reported being responsible for equipment startup and functional testing. Two reported assisting the commissioning agent or those involved, such as the manufacturer representative.

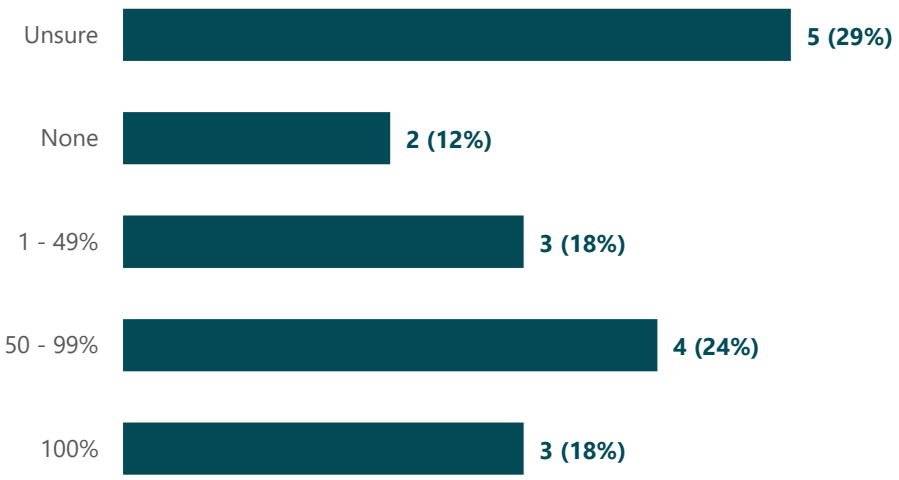
Contractors were frequently unsure of how commonly bid documents contain commissioning requirements, as shown in Figure 3.

Figure 3: Contractor Reported Portion of Bid Documents with Commissioning Requirements (n=17)



Contractor experience with the frequency of commissioning occurring on their projects varied, as shown in Figure 4. Five of 17 contractors reported they were unsure if commissioning happened on their projects and another two indicated commissioning did not happen.

Figure 4: Contractor Experience with Commissioning on Projects (n=17)



Contractors offered several reasons for why commissioning might be skipped. Two indicated that commissioning does not happen on retrofit projects, which represents the bulk of their work. Another said that commissioning happens primarily on publicly owned projects. One contractor noted that commissioning is rare on design-build projects.

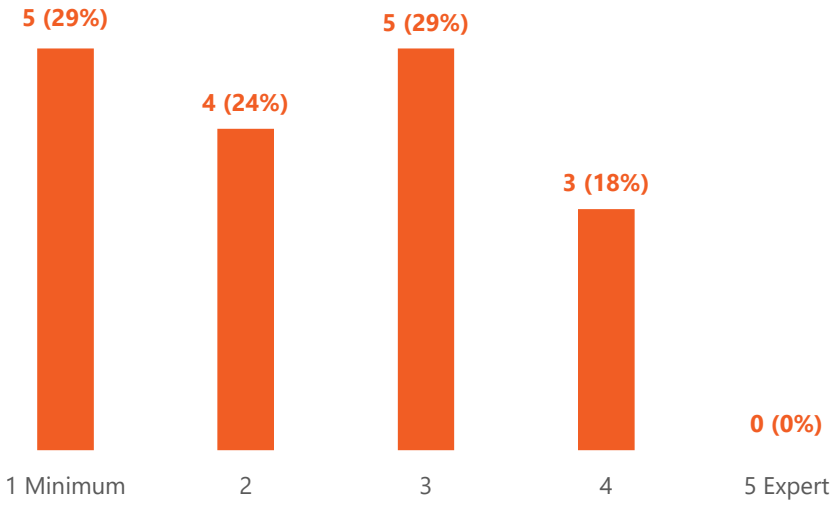
None of the surveyed contractors are responsible for commissioning or testing lighting systems.

4.6 Energy Code Familiarity & Training

4.6.1 Continuing Education & Training

Contractors rated their understanding of the current MN commercial energy code, with an even distribution from "1" to "4", as shown in Figure 5. None of the respondents rated themselves a "5" or expert.

Figure 5: Contractor Understanding of Energy Code (n = 17)



Contractors mostly reported they had access to the resources they needed to understand the commercial energy code, with only 35% reporting they lacked access to these resources. Common resources identified by respondents include using web browsers to search for information (not specific websites or resources), asking code officials for their interpretations, seeking information from manufacturers or equipment suppliers, and asking design engineers. One contractor noted using the energy code book itself as a source of information.

Over half (9, or 53%) of contractors said they receive no regular, formal training on commercial energy code. Among those that did receive training, six contractors (35%) reported receiving less than five hours and two (12%) reported up to 15 hours of training on energy code in a year. One respondent noted that utility companies will often host training.

Contractors offered a slight preference for in-person modes of training, including classroom experiences, on-the-job training, and field demonstrations. Pre-recorded webinars also emerged as a preferred method of training, mentioned by 41% of contractors; however, live webinars were only preferred by 29% of contractors. This indicates that contractors may be receptive to pre-recorded webinars and appreciate the convenience aspect but may not want to attend live webinars.

Most contractors reported they do not have credentials that require continuing education. Of the four contractors with continuing education requirements, one reported that their general contractor license has a 14-hour residential code requirement and 1 hour energy code requirement, although it is unclear if that requirement is for residential or commercial energy code. Another contractor reported having a Minnesota Electrical License that requires 16 hours of CEU per license period.

4.6.2 Additional Resources

Seven contractors confirmed the need for additional training and resources. One contact indicated it would be particularly helpful to offer free training opportunities in the winter months when work is slower. Two contractors mentioned an overall need for clearer code language. Contractors also saw the value of a resource that combines the various building codes and resolves discrepancies between them.

Section 5 Findings & Opportunities

This section presents the overall findings and potential opportunities for the Minnesota Advanced Code Collaborative as they plan intervention strategies to support the long-term goal of 80% site energy use reduction in commercial buildings. Because the data informing these conclusions are largely qualitative, the team should expect to adapt and incorporate new information as it emerges in the direct work with the codes "market."

In addition to presenting the findings and opportunities in text format, Cadeo created a preliminary logic model, collating findings and opportunities and suggesting recommended market strategies to overcome barriers and produce desired outcomes. This can be used as a guiding document for the program to steer strategic activities.

5.1 Findings & Opportunities

Energy code is often subordinated to other building codes and sometimes conflicts.

The energy code competes with other building codes and requirements for the resources of code officials and design professionals.

Code officials are time constrained and prioritize health and safety code compliance over the energy code. The electrical code compliance verification is typically handled by state inspectors or certified third-party inspectors.

Misalignment between the energy code and other building codes, such as mechanical and plumbing codes, causes confusion amongst all market actor groups.

Opportunity:

- Provide solutions for how to navigate conflicts between energy code and other building code. Solutions could include a centralized, searchable online research tool for code information and interpretation and standardized checklists and templates to streamline compliance review

Gaps in training and tools limit shared understanding of code requirements.

Market actors believe they are on their own when it comes to staying up to date on the energy code. This research confirmed a fragmented understanding of existing energy codes and uneven enforcement across the State. Code offices rarely have staff with specific energy code expertise, which can undermine consistency. Staying up to date on new energy code requirements is a challenge for all market actors. Code officials and designers in particular voiced frustration with not having access to the new energy code guidance when it was released in January 2024. Additional details on training and education by market actor role can be found in 5.2.

Opportunities:

- Develop a unified training platform with comprehensive, multi-format training options that meet the needs of all stakeholder groups. This platform should include in-person workshops, on-demand webinars, and hands-on technical sessions.
- Consider hosting training opportunities for contractors during slower months (winter for new construction, spring/fall for those involved in repair/replacement).

The Advanced Energy Codes Partnership would benefit from additional trusted messengers.

The number and diversity of entities involved in delivering code compliant new buildings and major renovations indicates the Partnership will need help carrying messages deep into firms and professional networks. Code adoption follows a typical adoption curve, with experts and early adopters aware and adjusting quickly while others must be pulled along through enforcement actions. To prepare the market, Minnesota should provide timely access to new code books and related tools prior to the energy code implementation date.

Opportunities:

- To effectively engage with these market actors over the long term, the Partnership should identify trusted messengers throughout the system and provide them with training, information, and resources to represent code best practices throughout the market.
- Leverage the relationship equipment suppliers have with designers and encourage them to host trainings and electronic libraries of resources.

Poor documentation quality creates challenges for enforcement and implementation.

Code officials and HVAC contractors report marginal quality in design documentation. The lack of details included in documentation (plan sets, energy code compliance documentation, and build specifications) requires on-going communication with designers to complete necessary documentation submissions. Contractors also struggled with the quality of design documentation and control sequences.

Opportunities:

- Develop and promote standardized templates for design documentation and control sequences to improve detail and consistency across projects.
- Encourage preconstruction meetings that engage design engineers early in the process, particularly for large, complex projects.

As performance path becomes more common, code officials are less able to verify code compliance and expected building performance.

Market actors indicate that energy modeling to support performance path compliance is becoming increasingly prevalent, particularly in new construction. This allows for a more holistic approach that incorporates envelope, building systems, and interactive effects and encourages finding cost-effective solutions to achieve energy efficiency and code compliance targets.

There are a variety of energy modeling packages and code officials are not trained to review model assumptions. Code officials report focusing on the end value from the COM*check*™ or energy model report and if the model indicates the building passes, they do not investigate further.

MEP design firms report having in-house energy modeling, which ensures the models meet the timeline requirements of the design team and streamlines analysis of equipment options. Design engineers either prepare the model or work directly with energy modelers to inform the design.

Opportunity: Market actors need specialized resources and training on the benefits and challenges of performance-based compliance path. Code officials would benefit from information on energy modeling best practices and straightforward verification methods.

- Performance path/energy models are increasingly deployed to navigate energy code complexity, and code officials will increasingly need to confirm model accuracy and verify that buildings are performing as designed.
    - Provide training and resources to code officials on how to review energy models
    - Work with designers to promote solutions that allow code officials to verify reasonableness of energy models
- Third party energy modeling consultants can be helpful but must meet the timeline required by the design team.
- Ensure training materials clarify the difference between envelope trade-offs and performance path.

Renovation/retrofit projects tend to follow prescriptive path

There is often little opportunity to modify or improve the building envelope on existing buildings; therefore, renovations tend to focus more on mechanical system modifications to comply with the energy code. The constraints associated with mechanical room space, shaft runs, existing ductwork, heating fuel, and electrical load push designers towards the prescriptive code path.

Design-build projects are more likely to use prescriptive approaches for energy code compliance as these projects tend to be more straightforward, lower cost, and face constraints on mechanical system modifications.

Opportunities:

- Investigate codes associated with renovation and retrofit projects to confirm prescriptive approaches are encouraging optimal energy savings.
- Identify utility programs or other subsidies to encourage investment in high-performance upgrades for existing buildings so these projects do not fall in a program gap.

Commissioning is inconsistently understood and implemented.

The odds that energy code related commissioning is happening as intended by code are low. Commissioning most commonly occurs on public projects, where the owners insist on it, and in large buildings with complex systems. Code official knowledge regarding commissioning is inconsistent, and their perspectives on enforcement likely affect project level commissioning.

For projects constructed in phases, designers said commissioning could get delayed until the end, with the first phases operating for years without commissioning.

Opportunities:

- Develop the workforce of commissioning professionals to improve access and quality.
- Provide education for code officials on commissioning requirements and their role.

As the Partnership works on additional code updates, addressing technical challenges with energy code implementation and areas of non-compliance could demonstrate a commitment to reducing pain points.

Market actors shared concern that rapid code advancements could outpace manufacturers' ability to develop products that meet their needs.

Code officials identified common areas of concern with technical energy code compliance including:

- Building envelope and insulation requirements, particularly air barriers and continuous insulation
- Mechanical system components, including economizers, horsepower limitations, and vestibule requirements

Designers and contractors expressed frustration with several mechanical challenges:

- Challenges with meeting fan power limitations
- Lack of affordable product availability for heat/energy recovery for dwelling units
- Vestibule air tempering control
- Difficult to program controls for systems with integrated ventilation and conditioning

Opportunities:

- Work with equipment suppliers to promote product or system upgrades that make it easier for market actors to meet advanced code requirements.
- Solicit ideas and solutions from market actors for areas that represent chronic challenges.

Baseline control strategy templates could perpetuate outdated methods

Designers often use baseline control sequence templates and modify them for the specific project needs. While this may be efficient, it can also lead to proliferation of outdated methods.

Designers emphasized the importance of aligning control strategies with owner/occupant expectations for building use and operation, particularly considering maintenance capabilities when specifying controls.

Opportunities:

- Provide updated tools and templates that encourage mechanical design consultants to update control strategies
- Encourage the use of energy modeling as a tool for identifying optimal control strategies for energy efficiency and operational benefits.

Value engineering (VE) does not lead to noncompliance but does reduce energy efficiency

Designers and contractors agree that VE processes do not significantly contribute to noncompliance, as there are collaborative efforts to ensure equipment and systems meet energy code minimums; however, both groups reported that VE leads to reduced energy efficiency overall.

Opportunities:

- Encourage the use of energy modeling as a tool for highlighting and quantifying tradeoffs in operational costs or long-term energy savings during VE.
- Mechanical costs can be reduced initially by increasing the envelope air tightness and therefore reducing the effect of the VE process on mechanical systems.

5.2 Logic Model

As part of this project, the team prepared a preliminary logic model displaying the interconnection of activities, outputs and expected outcomes associated with the Collaborative. In preparing the logic mode (displayed in Figure 6), the team acknowledged that there are three core aspects of the overall codes market:

1. ***Compliance***, which includes activities associated with supporting detailed and accurate compliance verification and providing access to effective tools and resources.
2. ***Advancement***, which includes activities associated with collecting and sharing data on emerging technologies, costs, and performance and participation in public codes processes.
3. ***Market "preparation,"*** which includes activities associated with outreach and market engagement and includes the utility and other above code program efforts that promote advanced building practices.

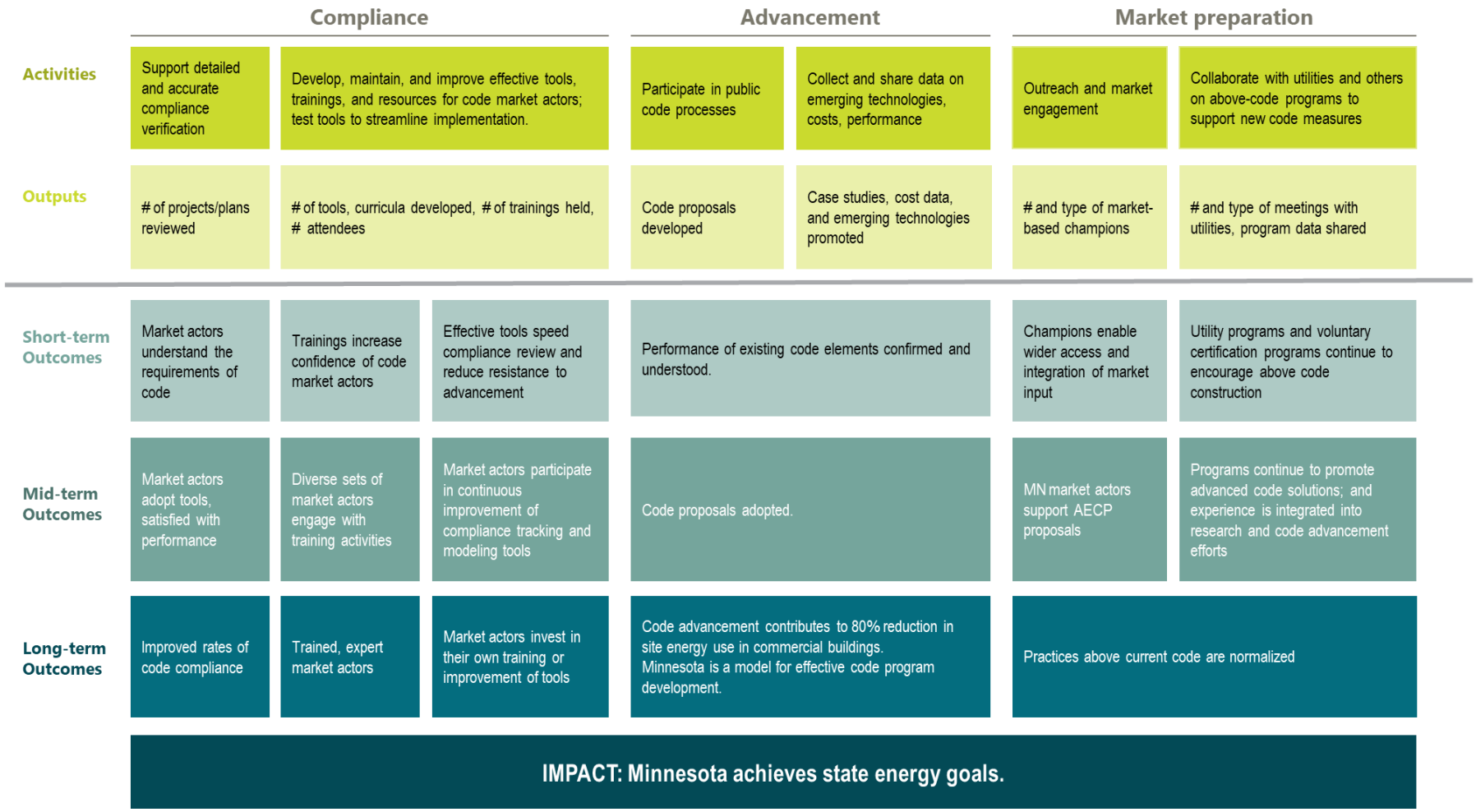
Together, these three activity domains support a braided overall strategy designed to lead to:

- Improved rates of code compliance
- Trained, expert, market actors
- Independent investment in training or effective tools for a given market need
- Code advancement that contributes to Minnesota achieving an 80% reduction in site energy use in commercial buildings
- Building practices above current code normalized

By achieving these long-term outcomes, Minnesota will be a model for effective code program development and achieve its state energy goals.

See Figure 6 to review the detailed diagram.

Figure 6: Logic Model



Appendix A Training and Education Findings by Role

Table A-1: Training and Education: Findings by Role

Current Training Approach		
Code Officials	Designers	Contractors
• State-provided seminars and annual conferences hosted by AMBO and ICC Region 3 • Self-education	• Internal company resources and trainings • Lunch & learns, trainings hosted by manufacturer representatives and suppliers • Training events and webinars hosted by industry associations, such as ASHRA and AIA • Contacting code officials to understand their interpretations • Self-education	• Limited training and education experiences, particularly related to the energy code
Credentials Required		
Code Officials	Designers	Contractors
• Certified Building Official (CBO)	• Professional Engineer (PE) license (NOT required or held by all respondents but is the primary credential held) requires 24hrs CEUs every 2 years • No energy code CEU requirements	• No consistent credentials • General contractor license has a 14-hour CEU residential code requirement and 1 hour energy code requirement
Preferred Training Modality		
Code Officials	Designers	Contractors
• **In-person** (classroom) • Direct interaction with instructors and peers, values the benefits of being able to ask questions, discuss real-world scenarios, and network with colleagues facing similar challenges • **Virtual** (live and pre-rerecorded) • Appreciate the flexibility of online options	• Preferred a mix of training options, including occasional in-person opportunities but favoring the flexibility of pre-recorded webinars	• **In-person** (classroom and in the field) • **Virtual** (pre-recorded) • Free training opportunities in the winter months when work is slower

Desired Topics		
Code Officials	Designers	Contractors
• Case studies/examples of applying the code • Details on complex systems (i.e. mechanical systems) • Better understanding of performance path The 'why' not just the 'what' behind code requirements • Training on new codes earlier in the process	• Short, focused trainings on specific topic areas, recorded and cataloged so they may be accessed on-demand • Case studies and real-world examples	• None mentioned
Additional Resources		
Code Officials	Designers	Contractors
• Training for industry professionals to relieve the burden on code officials • Resource that allows them to verify COM*check*™ results • Cheat sheet/checklists	• Improved code interpretation/code commentary and explanations • Searchable online resource for energy code information with links to references and case studies • Enhanced software tools for compliance checking • More accessible and frequent training on code updates • Consistent, state-wide enforcement expectations • Checklist and decision trees to help determine when to use prescriptive vs performance path	• A resource that combines the various building codes and resolves discrepancies between them

Appendix B Methodology & Outreach

In addition to the literature review described in Section 1, this project included primary data collection with three key populations in Minnesota: code officials responsible for commercial code enforcement, mechanical design professionals or design engineers responsible for specifying or recommending mechanical systems, and HVAC contractors responsible for selection, installation and/or controls programming for HVAC systems.

This section describes the steps the research team took to develop instruments and contact each group.

B.1 Code Officials

B.1.1 Instrument Development and Key Topics

The team developed an in-depth interview guide that focused on the following topics for Minnesota code officials:

- The experience and roles of respondents
- How jurisdictions are currently approaching energy code enforcement and the challenges they face, and how this might change as code becomes more complex
- The tools, support, and resources that could be used to assist code officials in enforcing energy code
- The education and training opportunities that could be provided to code officials to help improve their understanding of energy code and ability to enforce energy code.
- Assess code official perspectives on current energy code and potential code advancement

B.1.2 Population Frame Development

The team used a variety of sources to develop a comprehensive list of code officials working in Minnesota. Table A-2 provides a summary of the sources used to prepare the population frame.

MN Department of Labor and Industry (DLI)
The MN DLI provides an online contact list of 5,913 individual MN licensed professionals, 1,010 of whom are licensed Certified Building Officials (CBO), including 345 with a "limited" designation. The primary difference between a full and limited code official is the size and type of buildings that they can review. Building officials with a limited certification are restricted to residential and some small commercial buildings, although they may work on larger commercial buildings under supervision of a fully certified building official. The team considered excluding the limited population (CBO-L) but determined that these contacts could be valuable if they perform plan reviews or building inspections.

International Code Council (ICC)

The team accessed a contact list from the ICC website that contained 313 individual contacts, all individuals in the state of MN with a current ICC credential. By filtering for relevant ICC credentials, 170 individuals with energy code related ICC credentials were identified. This population holds credentials in areas such as plans examination and building inspection. The utility of the ICC list was limited because it did not include contact emails.

CEE + NORESCO

This list contained a limited set of high-value contacts, known to have worked with Center for Energy and Environment (CEE) in some capacity. This list also included a limited set of individuals found through ICC and subsequently identified by NORESCO as contacts who may have higher code literacy based on a high number of ICC credentials, particularly for more rural jurisdictions. There were 21 individuals in this curated contact list.

Table A-2: Code Official Population Sources

Source	Type of Contact	Count
MN DLI	Certified Building Official	665
	Certified Building Official - Limited	345
ICC	Energy code related credentials	170
CEE	Known contact + NORESCO screened	21
Total		**1,201**

To create a list of unique contacts, we combined the MN DLI, ICC, and CEE/NORESCO contact lists and removed duplicate contacts. This resulted in a final tally of **717 unique code official contacts.** CEE hypothesized that interview results may vary by urban versus rural jurisdictions. Cadeo flagged records of officials working within the Twin Cities Metro area (including the counties of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington). All cities within these seven counties are considered within the Twin Cities Metro area. Categorizing the code official population frame in this way results in a near 50/50 split in the population, as shown in Table A-3.

Table A-3: Code Official Contacts by Location

Twin Cities Metro Area	Count	Sampling Plan
Within	368	~5-10
Outside	349	~5-10

B.1.3 Outreach

The team leveraged an existing relationship with a contact at DLI who sent outreach emails to contacts with active CBO licensure. This DLI outreach yielded 19 responses to the screening survey, 14 of which scheduled and completed interviews.

B.2 Designers

B.2.1 Instrument Development and Key Topics

The team developed an instrument focused on exploring the specific role of designer contacts, their description of the overall design and construction process (including when they are brought in and their experience with energy modeling, performance path building design, commissioning, and control strategies), their experience with energy code compliance (including challenges and typical corrections), and strategies for staying up to date on commercial energy code changes.

We sought to reach design professionals involved in mechanical system design or specification, or those reviewing plans prior to submittal to permitting/code review.

B.2.2 Population Frame Development

The team needed to reach design professionals with recent experience performing any of the following tasks in commercial buildings:

- designing or specifying commercial HVAC systems or controls
- preparing energy models
- providing commissioning services

Because designers tend to work across county and state lines, the population and sampling approach was agnostic to location. Instead, the team focused on building a list from a variety of sources. The final population frame is described in Table A-4.

CEE Contacts

CEE provided records for seven designer contacts that had worked on plan reviews with CEE.

SB2030 Tracking Tool

CEE reached out to a partner in the Center for Sustainable Building Research (CSBR) at the University of Minnesota for designer contacts that have completed an SB2030 project. SB2030 or 'B3' is a set of energy efficiency guidelines that are required on State-funded projects in Minnesota. This resulted in an additional 19, high quality contacts.

ZoomInfo

ZoomInfo provides access to contact information for a variety of companies and business individuals. The team accessed this service using NAICs and SIC codes for HVAC engineering services and identified 15 additional contacts.

ASHRAE MN Chapter

The most comprehensive list came from a CEE staff member with connections to the Minnesota ASHRAE chapter, who was able to access this list to assist with outreach. The Minnesota ASHRAE chapter has approximately 800 members.[2]

[2] (ASHRAE Minnesota Chapter, 2024)

Table A-4: Population Sources: Design Professionals

Source	Quantity
CEE Contacts	7
SB2030 Tracking Tool	19
ZoomInfo Data	15
ASHRAE MN Chapter	~800
Total	**~850**

B.2.3 Outreach and Disposition

Cadeo began outreach by directly emailing known contacts, while the ASHRAE contact sent an invitation to all members of the Minnesota ASHRAE chapter. The ASHRAE outreach resulted in most of the responses of qualified individuals. All contacts were invited to use a brief screening survey to help the team confirm they were qualified for our research. The screening survey resulted in 17 qualified contacts opting in to the research, 15 of whom eventually completed the interview. Designers who completed the interview were provided with a $100-gift card.

B.3 HVAC Contractors

B.3.1 Instrument Development and Key Topics

HVAC contractors are a challenging population to reach by phone, so the team developed an email survey that contractors could respond to when it was convenient for them. This email survey contained a mix of open- and closed-ended questions and focused on the following topics:

- Respondent role, including how they engage in HVAC design and installation and the volume and type of projects they typically work on (with probes to understand experience with commissioning, controls sequencing, installation, and functional testing).
- How contractors are engaged during design and construction, including when they are typically brought in and if/how they specify control strategies.
- Typical commissioning approaches, including the portion of buildings they work on that are commissioned and scenarios in which this is skipped.
- Challenges and opportunities associated with installing or sequencing HVAC equipment to meet energy code compliance in Minnesota.
- Sources and strategies contractors use to stay up to date on code changes, compliance challenges, or code pathways, including any tools, resources, or trainings that would be helpful for them.

B.3.2 Population Frame Development

The team relied on two sources to build a survey population frame. (Table A-5**Error! Reference source not found.**)

MN DLI

The MN DLI publicly available list contained 4,838 individual contacts with a mechanical contractor bond license, 4,606 of which had email addresses associated with the license and 4,123 of those listed Minnesota as the primary state. The team removed 1,792 contacts with expired licenses and another 354 records indicating the firm focused on plumbing but not heating. Finally, we removed an additional 52 businesses associated with fireplaces, appliance repair, dairy operations, general handyman services, outdoor landscaping, and windows.

ZoomInfo

CEE was particularly interested in hearing from mechanical contractors who specialize in controls. DLI does not have this level of specificity on their site. By searching for mechanical contractors in Minnesota who specialize in controls, 28 individuals from 8 companies were identified as potential contacts. Outreach prioritized these 28 individuals as they are likely to have experience with HVAC controls in commercial buildings.

Table A-5: HVAC Contractor Population Frame Sources

Source	Quantity
Mechanical Contractor Bond	4,123
Expired	(1,792)
Plumbing	(354)
Misc	(52)
ZoomInfo	28
Total	**1,953**

B.3.3 Outreach and Disposition

The cleaned contact list resulted in 1,953 potentially qualified contacts. In June 2024 the team sent emailed survey invitations to a random sample of 350 DLI contacts and all the contacts identified via ZoomInfo. The team sent second and third waves of invitations to identify additional eligible contacts, using a total of 1,454 email addresses (Table A-6). Contractors who completed the survey were provided with a $100-gift card.

Table A-6: HVAC Contractor Survey Disposition

Disposition	Count	Category
Completed survey	**17**	**Complete**
Screened out, ineligible	24	Known ineligible
Invited, eligibility unknown (emails sent, unopened, & opened but in complete)	1,342	Eligibility unknown
List error: Email bounce back/unreached	71	Did not reach
Grand Total	**1,454**	
Response rate*	**1.24%**	

** Response rate is calculated by removing known ineligible contacts and list error contacts from the denominator.*

Appendix C Data Collection Instruments

C.1 Code Official Interview Guide

C.1.1 Minnesota Code Collaborative: Code Official In-depth Interview Guide

Table A-7: Overview of Data Collection Activity

Descriptor	This Instrument
Instrument Type	In-Depth Interview
Estimated Time to Complete	Target: 30 minutes
Population Description	MN code officials: plans examiners, building inspectors, and building officials
Sampling Strata Definitions	Urban/nonurban
Population Size	717 code officials
Completion Goal(s)	Minimum 10 interviews
Call List Source and Date	MN DLI License & Registration (compiled by NORESCO)
Contact Sought	Plans examiners, inspectors and code officials with experience reviewing commercial building plans and sites for code compliance in Minnesota
Fielding Firm	Cadeo
Incentive Plan	$100 per completed interview

Table A-8: Research Objectives and Associated Questions

Research Objective	Associated Questions
Document experience and roles of respondents	Q1Q1.▪ -96.-98.S2, Q1.▪ -96.-98.S3Q1.▪ -96.-98.S4Q1.▪ -96.-98.S5Q1Q1.▪ -96.-98.S2Q1.▪ -96.-

Research Objective	Associated Questions
	98.S3Q1.▪ -96.-98.S4Q1.▪ -96.-98.S5
Understand how AHJ's are currently approaching energy code enforcement and the challenges they face, and how they plan to approach enforcement as the code becomes more complex.	Q11Q11, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**, Q12, **Error! Reference source not found.**, Q21, Q22
Identify potential tools, support, and resources that could be used to assist code officials in enforcing energy code compliance	**Error! Reference source not found.**, **Error! Reference source not found.**, Q5, Q6, **Error! Reference source not found.**,
Identify education and training opportunities that could be provided to code officials to help improve their understanding of energy codes and ability to enforce energy code compliance	**Error! Reference source not found.**, Q7, Q8, **Error! Reference source not found.**, Q14,
Obtain an understanding of how code officials feel about current energy codes and energy code advancement	Q15, Q16 Q15 Q16

C.1.2 Background

The goal of the Code Official data collection is to understand the experience of code officials responsible for ensuring compliance. Interviews will focus on challenges and opportunities, professional development needs, access to technical resources and support systems, and communication preferences. A note for reviewers, this interview guide is not a script. Question

framing may be modified somewhat to appropriately reflect the role/expertise of specific interviewees.

C.2 Instrument

Introduction

Thank you for your time today! We are working with the Center for Energy and Environment to understand the barriers and opportunities for energy code compliance in Minnesota. The information you provide will be anonymized and analyzed to identify trends; your responses will not be attributed.

Do you have any questions for me before we get started?

To help notetaking accuracy, we'd like to record this conversation. These recordings are destroyed after we have verified our notes. Do we have your permission to record this conversation?

Screening & Experience [ASK ALL]

S1. Please start by describing your current role, including your primary responsibilities.

S2. Thinking of buildings you have worked with over the past two years, about what portion were commercial?

[If zero] Thank and terminate.

S3. [If not zero] What types of commercial buildings do you typically work on? (Probe to understand the portion of multifamily, warehouse, office, mixed use and similar)

S4. What portion of your time is dedicated to energy code enforcement?

[If zero] Thank and ask S5, then terminate.

S5. Are there staff in your office who specialize in energy code enforcement?

Overall Experience [ASK ALL]

Q1. Can you talk me through the typical process for reviewing [or inspecting] a project for energy code compliance?

Q2. What are the specific tasks in that process that are the most challenging?

Q3. Who is responsible for reviewing or inspecting electrical energy code measures? [Probe: lighting controls specifically, what role/entity/office]

Q4. In your experience, to what degree do most commercial buildings comply with commissioning requirements? [Probe: does this vary by system?]

Q5. Where do you see the most non-compliance?

Q6. If you could change one thing to make energy code verification faster and easier for you, what would it be?

Tools & Support [ASK DEPENDING ON ROLE]

Q7. [PLANS EXAMINER] What tools do you use to review plans for energy code compliance?

Q8. [BUILDING INSPECTOR] What tools do you use during site visits or inspections? [e.g. paper code books, accessing code on tablets?]

Q9. [BOTH] Does your department use an electronic permitting software, or accept hard copy plan sets, or both?

Q10. Do you have resources to ask questions/find answers about the energy code when you are doing plan checks [or inspections]?

Q11. [If not or in addition] How would you most like to access help - would a network or technical support line be beneficial?

Design Team/CX Interactions [ASK ALL]

Q12. Where do you see designers [and/or contractors] struggling the most with energy code compliance? [Interviewer note: these should be more in depth questions/responses. Probe for quality of design, energy code/modeling documentation]

Q13. In what stages of plan review or inspection, if any, are commissioning agents involved?

Training & Education [ASK ALL]

Q14. What certifications does your jurisdiction require for your role? Do you have any additional certifications?

Q15. How do you hear about new tools or approaches for plan review [or building inspection]?

Q16. Where do you typically receive training and how do you hear about training opportunities?

Q17. Thinking about trainings you've attended, or information sources you've found valuable. Can you describe your ideal training format? [In-person classes/workshops, webinars, on-line courses, check lists, forums with other code officials]

Q18. Thinking about energy code compliance, what would you like to learn more about?

Code Advancement [ASK ALL]

Thinking about future energy codes targeting new technologies and more advanced energy requirements:

Q19. What is the most common complaint you hear from designers or contractors when a new, more stringent energy code is adopted?

Q20. What do you think are the biggest challenges associated with adopting and enforcing more stringent energy codes?

Conclusion

Q21. Before I let you go, is there anything else you think we should know as we assemble information on improving energy code compliance in Minnesota?

Q22. As this group moves forward with the development of tools and other resources to help make energy code verification faster and easier, we'll need input from plans examiners and inspectors on drafts of those tools and resources. Could we reach out to you in the future for your input?

C.3 Designer Screening Survey

Screening survey for Designers

Hello,

Center for Energy and Environment (CEE) is recruiting code officials for their work on the Minnesota Advanced Energy Codes Partnership. The goal of this study is to better understand the experience of professionals working to meet commercial energy code in Minnesota. This research will inform training materials, resource development, and support other efforts. CEE is looking to speak with mechanical designers, design engineers, energy modelers and commissioning agents about their experience. A third-party research firm (Cadeo) will be managing this effort and ensure that responses are kept confidential and used for research purposes only.

We would love to hear from you and are offering a $100 honorarium for completed interviews. Please use this link to answer a few brief questions about your professional role and contact information. Cadeo may reach out to schedule time to speak with you.

Please see CEE.org for more information or reach out to jmaclennan@cadeogroup.com if you have any questions about this study.

S1. Are you involved in: **[Select all that apply]**

a. Designing or specifying commercial HVAC systems,
b. Programming or specifying HVAC controls,
c. Preparing energy models,
d. Providing commissioning services,
e. "Stamping" plans, or verifying that designs are consistent with commercial energy code in Minnesota,
f. Interacting with code officials or addressing plan review comments,
g. None of these. **Thank and terminate.**

Q23. About how many commercial and multifamily buildings have you worked on in the past 2-3 years?

- _____ **[IF ZERO, Thank and terminate.]**

Q24. What types of commercial buildings do you typically work on?

[**MULTIPLE RESPONSE**]

- Multifamily
- Office
- Industrial
- Retail
- School
- I don't work in commercial buildings **[Thank and terminate.]**
- Other _____

Great, you are exactly the type of professional we would love to talk to.

Add in fields to collect name/email/phone.

Cadeo staff will reach out to schedule with you soon!

C.4 Designer Interview Guide

C.4.1 Minnesota Code Collaborative: In-depth Interview Guide

Design Engineers

Table A-9: Overview of Data Collection Activity

Descriptor	This Instrument
Instrument Type	In-Depth Interview
Estimated Time to Complete	Target: 30 minutes
Population Description	Mechanical Designers: Professionals involved in mechanical system design and specification for commercial construction. (Specifically: design engineers, mechanical system designers)
Completion Goal(s)	5-10 interviews
Call List Source and Date	In development (Cadeo and CEE working jointly on this)
Contact Sought	Professionals involved in mechanical system design or specification, or who review these plans prior to submittal to permitting/code review. We will confirm if/how these folks might be involved in establishing control strategies or working with installation contractors.

Descriptor	This Instrument
Fielding Firm	Cadeo
Incentive Plan	$100 per completed interview (can be donated to American Red Cross)

The goal of the market actor data collection is to understand the experience of mechanical designers responsible for design decisions/specifications related to building energy systems or compliance with energy code and HVAC contractors responsible for HVAC controls. This interview guide is specifically designed for design engineers and mechanical designers responsible for compliant, effective designs in new buildings or major retrofits where code review will occur. Interviews will focus on:

- challenges and opportunities,
- professional development needs,
- access to technical resources and support systems, and
- communication and learning preferences.

Table A-10: Updated Research Topics

Research Topics	Questions
Respondent role: • How is respondent engaged in design and installation projects? • What is their role specific to ensuring energy code compliance? (system design, equipment selection, bid review, plan review + stamping, energy modeling, commissioning) • Volume and type of projects they typically work on.	S1, Q1, Q2, Q3
Design and construction: • When in the design process are they typically brought in? • How does energy code compliance strategy vary (by procurement model, customer type, building type, new building vs. TI/renovation?) • What about performance path buildings? • Are they involved in specifying control strategies? (If yes, how are control sequences determined?) • Are they involved in commissioning? When does this typically occur?	Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12

Research Topics	Questions
• About what portion of the buildings worked on over the past two years received commissioning? In what scenarios is commissioning skipped?	
Code Compliance Challenges & Opportunities: • What are the most common challenges in designing to meet energy code compliance in MN? (Do they work in other states? How does MN compare?) • What are the most common plan review comments they receive? • How are they involved during the construction phase and if familiar, what are common inspection corrections?	Q13, Q14, Q15, Q16, Q17, Q18
Energy Code Familiarity and Training: • How do they stay up to date on code changes? • Do they attend trainings on code updates or compliance issues? What type (sponsor, content) and how frequently do they attend? • What do they look for when choosing trainings to attend? • How are energy code pathways selected? Are they involved in this decision? • What types of tools, resources, or training would be most helpful to ensure installed equipment is compliant with energy code?	Q19, Q20, Q21, Q22, Q23, Q24

C.4.2 Instrument

Introduction/Screening

My name is _____ and I'm calling from Cadeo, an energy-focused research firm. We are working with the Center for Energy and Environment in Minnesota to understand how the energy code works for design professionals like yourself. We are particularly interested in understanding the perspective of professionals involved in designing mechanical systems, specifying these systems, or ensuring these systems are energy code compliant. I'd love to schedule time to talk with you, or proceed now, if that works for you.

To make sure my questions are appropriate for you, I have a few questions about your professional role.

S2. Are you involved in:

[Select all that apply]

- Designing or specifying commercial HVAC systems,
- Programming or specifying HVAC controls,
- Preparing energy models,
- Providing commissioning services,
- "Stamping" plans, or verifying that designs are consistent with commercial energy code in Minnesota,
- Interacting with code officials or addressing plan review comments,

-97. Not applicable/None. **Thank and terminate.**

Great, your experience is exactly what we need to understand. I'd like to continue. Please know the information you provide will be anonymized and analyzed to identify trends; your responses will not be attributed.

Do you have any questions for me before we get started?

To help notetaking accuracy, I'd like to record this conversation. These recordings are destroyed after we have verified our notes. Do we have your permission to record this conversation?

Experience [ASK ALL]

[ASK ALL]
We'd like to understand a little bit more about the types of projects you work on.

Q25. Thinking about your projects over the past 2-3 years, about how many commercial and multifamily buildings have you worked on?

Q26. What types of buildings do you typically work on?

Design and Specification Process: [ASK ALL]

Q2. At what point in the design process are you typically brought in? (Programming, schematic, design development, construction documents, bidding/procurement?)

Q3. How do energy code compliance strategies differ for new construction projects vs major renovation/retrofit?

Q4. Who is typically responsible for applying for permits?

Q5. About how many of the buildings you worked on in the past 2-3 years followed a performance path for energy code compliance? (Can accept portion answers as well if a count is too challenging.)

- **If more than zero:** Who is responsible for the energy modeling in these projects? (probe to understand who executed modeling)

Q6. Are you familiar with the "simplified approach to building compliance path for HVAC systems" within ASHRAE 90.1?

- **If yes:** Approximately how many designs have you worked on in the past 2-3 years that elected this pathway?

Q7. Are you involved in specifying control strategies? (If yes: How are control sequences or strategies determined?)

Q8. How are you involved with commissioning?

- **If experienced with commissioning:** Probe to understand timing, resources, challenges.

Q9. How are commissioning requirements conveyed in the documentation?

Q10. About what portion of the buildings you worked on over the past two years were commissioned?

- In what scenarios is commissioning skipped?

Code Compliance Challenges & Opportunities: [ASK ALL]

Q11. What are the biggest challenges in designing [or reviewing] mechanical systems to meet energy code in MN? (Probe to understand the quality of the documentation, clarity of code requirements, time or budget constraints, or lack of effective products/solutions.)

Q12. As energy code becomes more stringent, where do you see the biggest challenges?

Q13. What are the most common energy code related plan review correction comments you see?

Q14. We are curious to understand how value engineering affects code compliance. How do you ensure that equipment substitutions will still meet energy code?

Q15. How are you involved during construction? (Probe to understand if/how they confirm proper installation, or if they provide inspection corrections.)

Energy Code Familiarity and Training [ASK ALL]

We have a few questions just about how you stay abreast of code changes.

Q16. What sources do you turn to for information or training on commercial energy code when you have a question, or the code is updated? (Probe to understand if these are specific training events, web resources, or people, or a mix.)

Q17. About how many hours of training on commercial energy code do you receive per year?

a. **If not zero:** Who provides it? (For example, design organizations, manufacturers, building departments, the state, OTJ?)

Q18. What format of training do you receive most (For example, in-person, webinar, prerecorded, apps, or on-the-job training?)

Q19. Thinking about the training and education you've received, what has been most valuable to you?

Q20. Do you have credentials that require CEUs?

a. **If yes:** What are they and what are the requirements?

Q21. What types of additional tools, training or resources would help design professionals like you better comply with the energy code?

Closing: [ASK ALL]

Q22. Did we miss anything? Do you have any comments you'd like to make sure get included in our analysis?

Q23. Would you be willing to participate in additional paid research, for example focus groups or similar?

Q24. Thank you so much for your time today! We are providing a $100 honorarium for research participants; please confirm the email address you would like us to send that to.

C.5 HVAC Contractor Survey

C.5.1 Minnesota Code Collaborative: Survey

HVAC Contractors

Table A-11: Overview of Data Collection Activity

Descriptor	This Instrument
Instrument Type	Survey
Estimated Time to Complete	Target: 10-15 minutes
Population Description	HVAC Contractors: Professionals involved in the installation of mechanical systems, particularly those involved in controls sequencing and system functional testing.
Completion Goal(s)	5-10 interviews
Call List Source and Date	In development (Cadeo and CEE working jointly on this) DLI licensed mechanical contractors
Fielding Firm	Cadeo
Incentive Plan	$100 per completed interview (can be donated to American Red Cross)

The goal of the market actor data collection is to understand the experience of HVAC contractors, particularly those responsible for HVAC controls. This interview guide is specifically designed for HVAC contractors responsible for the installation of complex mechanical systems

and controls sequencing to ensure mechanical systems function as designed. Interviews will focus on:

- challenges and opportunities,
- professional development needs,
- access to technical resources and support systems, and
- communication and learning preferences.

Table A-12: Research Topics

Research Topics	Questions
Respondent role: • How is respondent engaged in design and installation projects? • What is their role specific to ensuring energy code compliance? (project bidding, equipment selection, equipment installation, controls sequencing, functional testing, commissioning) • Volume and type of projects they typically work on.	S1, Q1, Q2, Q3
Design and construction: • When in the design or construction process are they typically brought in? • Are they involved in specifying control strategies? (If yes, how are control sequences determined?) • Are they involved in commissioning? When does this typically occur? • About what portion of the buildings worked on over the past two years received commissioning? In what scenarios is commissioning skipped?	Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16
Code Compliance Challenges & Opportunities: • What are the most common challenges in installing or sequencing HVAC equipment to meet energy code compliance in MN? (Do they work in other states? How does MN compare?) • What are the most inspection comments they receive?	Q17, Q18, Q19, Q20, Q21

Research Topics	Questions
Energy Code Familiarity and Training: • How do they stay up to date on code changes? • Do they attend trainings on code updates or compliance issues? What type (sponsor, content) and how frequently do they attend? • What do they look for when choosing trainings to attend? • How are energy code pathways selected? Are they involved in this decision? • What types of tools, resources, or training would be most helpful to ensure installed equipment is compliant with energy code?	Q22, Q23, Q24, Q25, Q26, Q27, Q28, Q29

Initial Outreach Email

Hi [Name],

We are working with Center for Energy and Environment (CEE) to better understand contractor experiences with HVAC equipment installation and system control programming in Minnesota. We would greatly appreciate your participation in a survey to help shape programs to improve commercial energy code compliance and the experiences of building stakeholders in Minnesota.

This survey is voluntary and confidential and should take about 10-15 minutes to complete. To say thank you for your time, **we are offering a $100 e-gift card.**

Please click this link to access our survey. [insert link]

Please reach out to jmaclennan@cadeogroup.com with any questions. Thank you for participating in this research effort!

Follow-up Outreach Email

Hi [Name],

We contacted you earlier this week and would like to remind you to please take 10-15 minutes to complete a quick survey on contractor experience with mechanical systems and controls in Minnesota. We only need 20 more responses – will you help us reach our goal? As a reminder, we will send you a $100 gift card within 2 days of completing the survey as a thank you.

[Survey link]

Please reach out to jmaclennan@cadeogroup.com with any questions. Thank you for participating in this research effort!

C.5.2 Instrument

Introduction/Screening

S3. Are you involved in any of the following: **[Select all that apply]**

- Project bidding
- Specifying commercial HVAC systems
- Programming or specifying HVAC controls
- Preparing compliance documentation for permit or inspection review
- Installing HVAC equipment in commercial or multifamily buildings
- Functional testing of HVAC systems
- Interacting with code officials or addressing inspection review comments
- Commissioning of mechanical systems
- Specifying or testing electrical systems
- Not applicable/None. **[Thank and terminate]**

Q25. About how many commercial and multifamily buildings have you worked on in the past 2years?

- _____ **[IF ZERO, Thank and terminate.]**

Q26. What types of commercial buildings do you typically work on?

[**MULTIPLE RESPONSE**]

- Multifamily
- Office
- Industrial
- Retail
- School
- I don't work in commercial buildings **[Thank and terminate.]**
- Other _____

Experience [ASK ALL]

Q27. Who are your typical customers?

[**MULTIPLE RESPONSE**]

- Public or institutional clients
- Developers
- Owner-occupied buildings
- Other _____

Design and Construction Process: [ASK ALL]

Q27. At what point in the building process are you typically brought in?

- Design development
- Construction documents

- Bidding/procurement
- Equipment installation
- Controls programming
- Functional testing
- Other _____

Q28. Are you involved in specifying HVAC control strategies?

- Yes
- No

Q29. Are you involved in programming mechanical system controls?

- Yes
- No

Q30. [**IF YES**]**:** What challenges do you experience programming controls to meet energy code requirements?

- [text box for short answer response]

Q31. What percentage of HVAC installation or control programming projects you have worked on in the last 2 years were:

[**ADDS TO 100%**]

- New Construction
- Major Renovation ____
- Retrofit ___

Q32. [**IF NEW CONSTRUCTION IS MORE THAN 0%**] What portion of new construction buildings have you worked on in the past 2-3 years that followed a performance path for energy code compliance?

- 100%
- 50-99%
- 1-49%
- 0%
- Unsure

Q33. How would you rate the overall level of **quality of the mechanical system design documentation** you receive?

- High – very detailed and clear, requires little to no additional coordination with design engineer to understand design intent.
- Medium – includes details, but there may be some missing information that requires coordination or independent decision making.
- Low – missing information, requires significant coordination or independent decision making.
- Very low – little to no documentation is received, requires independent decision making.

- Please add any additional thoughts on the quality of design documentation.
  _____

Q34. How would you rate the level of **detail and clarity around control sequences** in design documentation you receive?

- High – very detailed and clear, requires little to no additional coordination with design engineer to understand design intent.
- Medium – includes details, but there may be some missing information that requires coordination or independent decision making.
- Low – missing information, requires significant coordination or independent decision making.
- Very low – little to no documentation is received, requires independent decision making.
- Please add any additional thoughts on the quality of design documentation_____

Q35. How frequently do bid documents specify commissioning requirements?

- 100%
- 50-99%
- 1-49%
- None
- Unsure

Q36. Are you involved with commissioning?

- Yes
- No

Q37. [**IF YES**]**:** Please describe your role or involvement with commissioning.

- [text box for short answer response]

Q38. About what portion of the buildings that you have worked on over the past two years were commissioned?

- 100%
- 50-99%
- Less than 50% 1-49%
- None
- Unsure

Q39. In what scenarios is commissioning skipped?

- [text box for short answer response]

Q17. Are you ever responsible for commissioning or testing lighting systems?

- Yes
- No

Code Compliance Challenges & Opportunities: [ASK ALL]

Q40. Below are some challenges that might emerge when installing or programming mechanical systems to meet energy code in MN. For each one, please rate how common each is in your experience. Please use a 1-to-5 scale, where 1 means this is rarely an issue and 5 means this is an issue in almost every project?

[**MULTIPLE RESPONSE**]

- Quality of documentation received from designers is insufficient
- Code requirements are unclear
- Equipment is not available on schedule
- Budget constraints limit choices
- We do not have an effective product or solution
- Controls do not perform as expected
- Please add any additional thoughts on challenges that might emerge when installing or programming mechanical systems to meet energy code in MN._____

Q41. As energy code becomes more stringent, where will the biggest challenges emerge?

- [text box for short answer response]

Q42. Do you receive inspection review comments related to energy code?

- Yes
- No

Q43. How would you describe the impact of value engineering (VE) or equipment substitutions on commercial energy code compliance?

- [text box for short answer response]

Q22. When equipment substitutions are made during value engineering (VE), how do you ensure the design is still energy code compliant?

- [text box for short answer response]

Energy Code Familiarity and Training [ASK ALL]

Q44. On a scale of 1-to-5, how would you rate your understanding of the current MN commercial energy code? [1 means minimal understanding and 5 means expert understanding].

- 1
- 2
- 3
- 4
- 5

Q45. Do you have access to resources you need to understand and ask questions about commercial energy code?

- Yes
- No

Q46. What common sources do you turn to for information on commercial energy code when you have a question?

[**MULTIPLE RESPONSE**]

- Web resources [specify] _____
- Code official
- Design engineer
- Manufacturer/manufacturer representative
- Other_____

Q47. About how many hours of training on commercial energy code do you receive per year?

- 0
- 1-5
- 6-15
- 16-30
- More than 30

Q48. [**IF NOT ZERO**]**:** Who has provided the commercial energy code training that you have attended? Please select all that apply.

[MULTIPLE RESPONSE]

- Design organizations
- Manufacturer/manufacturer representative
- Building departments
- The state
- Other (please specify) _____

Q49. Please rate your preferred methods for receiving training. [1 means not preferred and 5 means highly preferred].

- In-person/classroom setting
- Live webinar
- Pre-recorded webinar
- Phone apps
- On-the-job training
- Field demonstration
- Please add any additional preferred methods for receiving training. _____

Q50. Do you have credentials that require continuing education units CEUs?

- Yes
- No

b. [**IF YES**]: What are they and what are the requirements?

[text box for short answer response]

Q51. What types of additional tools, training or resources would help professionals like you better comply with the energy code?

- [text box for short answer response]

Closing: [**ASK ALL**]

Q52. Would you be willing to participate in additional research, like a focus group on…

- Yes
- No

Q53. Thank you so much for your time today! We are providing a $100 honorarium for research participants; please confirm the email address you would like us to send that to.

- Your name
- Email Address
- Phone