Efficiency First: Minnesota's Approach to Push the Limits of Efficiency and Narrow the Efficiency Gap in Achieving Net Zero Code Goals

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ABSTRACT

Like many states, Minnesota has adopted a goal to get to net zero for new construction. Additionally, the state has set a pathway to achieving that by putting efficiency first. This approach minimizes the "efficiency gap," or the amount of on-site energy needed from renewables to meet net zero goals. In 2023, the Minnesota legislature memorialized this effort by adopting one of the strongest efficiency goals for energy codes in the country. Specifically, Minnesota set a goal for the commercial energy code to achieve an 80% reduction in energy use from the 2004 ASHRAE 90.1 baseline by 2036. This will be near the technical limits of efficiency and will be a major test of how much efficiency-only codes can contribute towards closing the efficiency gap in a non-coastal state. Meeting this goal will require a retooling of how the code development process works in the state. To this end, state agencies and codes advocates have started an effort – the Minnesota Advanced Energy Codes Partnership – that received DOE funding. This Partnership will provide the technical support for statewide stretch codes that go beyond model codes to progressively get closer to meeting the 80% reduction goal through the four code cycles that will happen in Minnesota by 2036. This paper will discuss the technical approach and results to date, including measure packages and modeling done to begin developing the pathway.

Introduction

Minnesota has recently seen a rapid evolution of its policy to reduce emissions in the new construction sector. It has adopted one of the most stringent efficiency goals in the country for commercial energy codes, namely, to reach 80 percent of the way to net zero energy through efficiency alone by 2036. To accomplish this, Minnesota and partners have started working to develop a cold-climate, Minnesota-specific, Title 24-style program to meet this goal.

With four code cycles between now and the 2036 deadline, our plan is to build a robust partnership and deep engagement with critical stakeholders while adopting progressively more aggressive codes beyond the model codes to reach the final goal of net zero. We will use a data-driven and stakeholder-informed approach to optimize the pathway we take and best meet Minnesota's climate and conditions. This paper will provide overall context for the process, focusing on the technical aspects of the work and relevance to other states.

How Minnesota Developed its Aggressive Goals

The Minnesota Department of Labor and Industry (DLI) is the agency with statutory authority to adopt statewide codes. To adopt new codes, DLI organizes a Construction Codes Advisory Council (CCAC) for the entire building code, and Technical Advisory Groups (TAGs) to advise on each section of the code. The CCAC considers the TAG input and provides final recommendations to DLI. DLI has ultimate authority in adopting the code, which is then administered by over 400 Minnesota cities and counties.

Minnesota is not a “home rule” state, meaning that only the state, and not local jurisdictions, can adopt building codes. In recent years, there has been a desire among more progressive cities to have the option to adopt stretch energy codes that go beyond the state code. This resulted in a push at the legislature for changing state statute to allow individual cities to adopt a stretch code. This was strongly opposed by the building industry, but it did help to spur a discussion on improving the statewide energy code above the model code, especially for the commercial energy code, for which there has historically been less resistance to advancement.

An important outcome of these discussions was the formation of a stakeholder process, jointly sponsored by DLI and the Minnesota Department of Commerce (the agency that houses the State Energy Office) to look at options for the state to improve its energy code. This resulted in the recommendation to achieve net zero in the commercial energy code, led by efficiency improvements (Minnesota Department of Commerce 2020). In turn, this resulted in adoption of that goal for Minnesota’s Climate Action Plan, adopted in 2022. Finally, in 2023, the legislature memorialized the goal to achieve 80 percent of the net zero goal through energy efficiency in state statute (Minnesota Statutes 2023).

The end result of the stakeholder discussions, spurred initially by local governments that desired a stretch code applying to their jurisdictions, was a commitment to achieve what is effectively a stretch code for the entire state and not only jurisdictions that opt into a more stringent version of the code.

A Partnership Approach to Achieving a Path to Net Zero

In early 2023, Center for Energy and Environment, with support from DLI and others, organized an effort called the Minnesota Advanced Energy Codes Partnership (“the Partnership”) for the express purpose of forming a collaborative effort among key stakeholders that could help develop the pathway to net zero. This group also provides the technical and stakeholder support that will be required for such an effort. With the support of U.S. Department of Energy funding through their Resilient and Efficient Codes Implementation (RECI) program, the Partnership was launched in late 2023. The immediate project need was to develop a game plan for the current code cycle, which started in early 2024.

With the state recently moving to three-year code cycles, there are four full code cycles between now and 2036. Compared to the most recent model code (ASHRAE 90.1-2019) Minnesota will need on average to save an additional 13.5% per code cycle. The project team has set the goal higher during the first two code cycles, as it will get progressively harder to find more efficiency improvements. Figure 1 shows the trajectory for achieving the 80 percent goal.

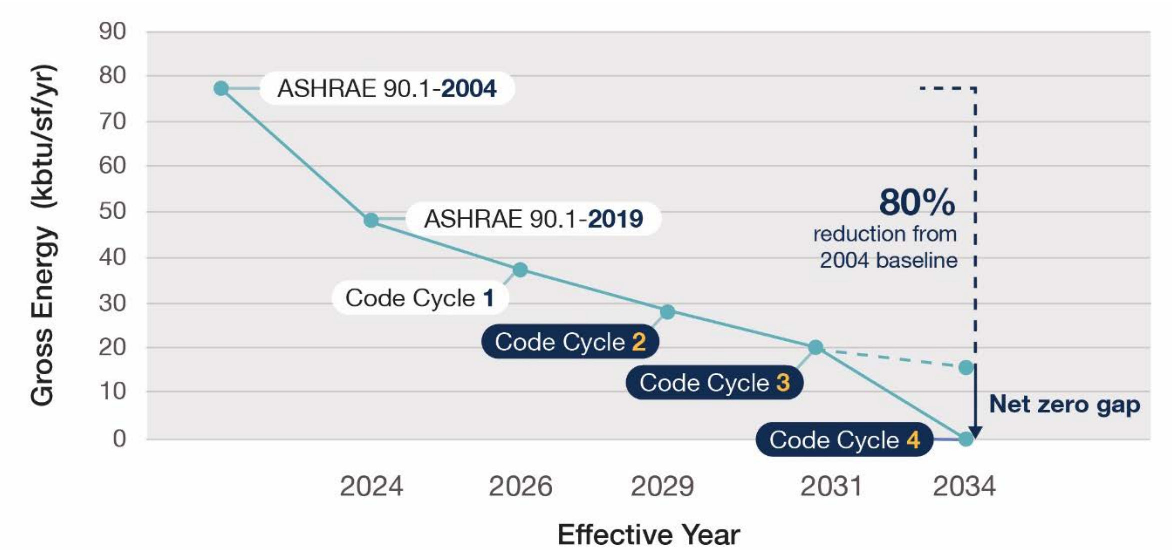


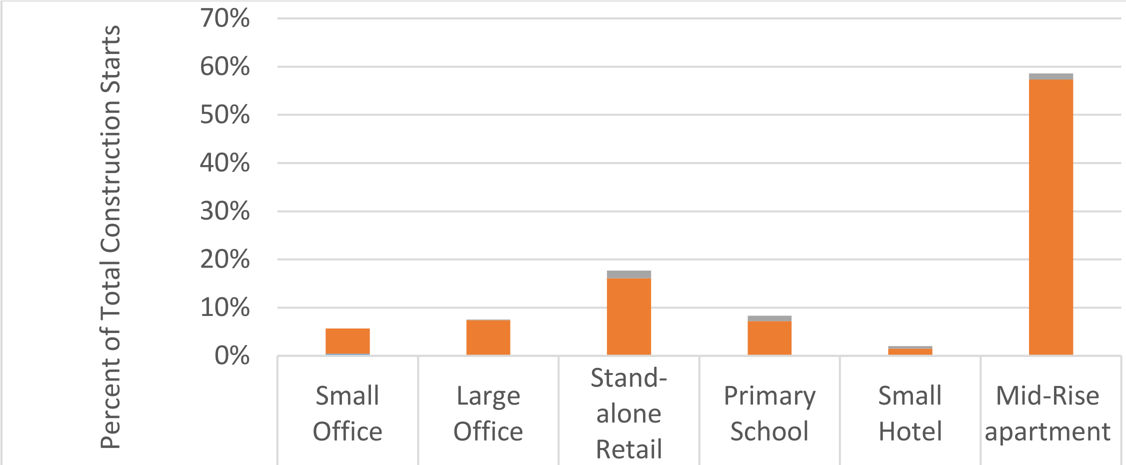
Figure 1: Minnesota's Adoption Path to Net Zero Energy over Four Code Cycles

Cycle One Energy Efficiency Plan

The project team has been working since October 2023 to develop an energy efficiency plan for the first cycle encompassed in the current legislation. A new ASHRAE 90.1 standard is published every three years, spurring the code cycle. For each of the four cycles between when the legislation was effective, 2024, and the achievement year, 2036, the project team is responsible for developing an energy efficiency plan with amendments to the model code that achieve incremental progress towards the goal.

A review of energy consumption by end use for the prevalent building types in Climate Zone 6A was conducted to better understand areas of opportunity. As shown in Figure 2 below, midrise multifamily buildings make up nearly 60 percent of building starts in Minnesota, followed by stand-alone retail (17.7%), primary schools (8.3%) and large office (7.5%). Given the predominance of multifamily buildings in the local market, finding amendments and measures that apply to multifamily buildings is paramount to reaching goals. The review also found plug loads to be the highest energy end use, followed by space heating and service water heating (PNNL 2021). Plug loads, space heating and service water heating comprise more than 80 percent of the total energy use in midrise apartment buildings.

Furthermore, ventilation is also known to be a large driver of both heating energy and electrical energy consumption in multifamily buildings, especially in Minnesota's cold climate. This makes heat recovery measures especially impactful in Minnesota. Considering plug loads are unregulated by building codes, the project team focused on prioritizing amendments that reduce space heating, service water heating and lighting energy end use for code cycle one.



	Small Office	Large Office	Stand-alone Retail	Primary School	Small Hotel	Mid-Rise apartment
CZ 7 (4.6%)	0.0%	0.1%	1.6%	1.1%	0.5%	1.3%
CZ 6A (94.7%)	5.3%	7.4%	16.1%	7.2%	1.5%	57.2%
CZ 5A (0.5%)	0.4%	0.0%	0.0%	0.0%	0.0%	0.1%

Figure 2: Minnesota Construction Starts by Building Type and Climate Zone (% of total sq ft) (PNNL 2023)

Current Amendments Under Consideration

Following this review, the project team prioritized seven amendments out of a total of twenty energy efficiency measures for the first code cycle.[1] Prioritization was based on energy impact, technical feasibility, cost-effectiveness, and market penetration for each amendment. Each amendment was also tagged to the prototypes to understand the energy savings impact. Additionally, stakeholder interviews were undertaken with subject matter experts to refine each code amendment for the first code cycle.

Windows. Fenestration is a significant opportunity for energy efficiency, as windows are often a large source of energy loss. For this reason, the project team is proposing a lower U factor for fixed and operable windows by expanding the current requirements in Climate Zone 7 to climate zone 6A and 6B for non-residential buildings. This would require a U-value of 0.29 for fixed and 0.36 for operatable non-residential windows. Considering these levels are currently achieved in other states with buildings in climate zone 6A and 6B, the proposed amendment anticipates minimal market disruption. For multifamily buildings, the team has proposed lower U factor for fixed and operable windows in alignment with the ENERGY STAR v6 specifications (U-value of 0.28 for climate zone 6A). Considering ENERGY STAR v6 has approximately 84 percent market penetration nationwide, this level is expected to be easily achieved by the market (ENERGY STAR 2019).

The commercial market includes storefront, curtainwall, and window wall window types. Market research indicates that both curtainwall and storefront windows are available with a U factor of 0.29 from a majority of manufacturers using a dual pane insulated glazing unit (IGU). Higher performance between 0.20 and 0.28 can also be achieved, at a higher cost, using a triple pane curtainwall products or a hybrid vacuum insulating glazing unit (VIG-IGU). The project

[1] A few additional amendments are still under consideration potentially raising to nine the number of planned amendments for code cycle one.

team will undertake further research to identify potential future code amendments as the technology scales and achieves higher market penetration.

Air Leakage. Reducing air leakage within a building is an effective strategy to reduce overall energy consumption through retaining warmed or cooled air. This proposed amendment would reduce the measured air leakage requirements (whole building air leakage test) for commercial buildings from 0.35 cfm/sf at 75 Pa to 0.30 cfm/sf at 75 Pa. The amendment will permit compartmentalization test for multifamily buildings where measured leakage of the dwelling unit shall not exceed 0.23 cfm/sf of testing unit enclosure area at 50 Pa.

Whole building air leakage testing conducted on existing Minnesota commercial and institutional buildings show that these buildings are often tighter than 0.25 cfm/sf at 75Pa test pressure. The requirement for a whole-building test could add cost, but this is not expected to be significant compared to the overall cost of the air sealing work itself, just to meet the current code. The allowance for sampling of dwelling units along with compartmentalization tests will also keep the incremental costs lower and ease compliance.

Daylighting. While lighting has become an area of reduced returns with the widespread use of LED lighting, there are still opportunities to further hone our technology to increase efficiency. This proposed amendment would require reduced electric lighting power in response to available daylight using continuous daylight dimming from 20 percent to 10 percent or less, and off. This proposed amendment will reduce the level of electrical lighting power used when daylighting is available to 10% power, rather than the current 20%, when combined input power is 75W or higher in primary and secondary daylit zones. This ensures that artificial lighting use is minimized when the natural environment is already providing that lighting.

This amendment is largely a factor of control. Generally speaking, the technology is already being used and no additional knowledge or change in practice is needed. Furthermore, the benefits are shown to outweigh any negligible cost that may be associated with this amendment (CASE Report, 2023).

Energy Recovery (in nontransient dwelling units). Increasing energy recovery is critical to energy efficiency because it captures and repurposes waste energy, reduces overall energy consumption and lowers operational costs. The efficiency of the heat exchanger depends on the sensible heat efficiency in winters and latent heating efficiency in summer. Given the heating-dominated climate in Minnesota, a higher Sensible Energy Recovery Ratio is more important for improving the efficiency of the heat exchanger. Therefore, this amendment increases requirements for Sensible Energy Recovery Ratio from 60 to 70 percent at 32°F at airflow greater than or equal to design flow for spaces served by an energy recovery ventilator (ERV) where active humidification is not provided. ERV's recover the heat and moisture from the exhaust air and use that to preheat incoming ventilation air, saving energy from otherwise wasted heat.

Energy Recovery (in spaces other than nontransient dwelling units. Similar to the above, this amendment seeks to increase energy efficiency by capturing heat that would otherwise leave the building. Specifically, this amendment proposes raising the Sensible Energy Recovery Ratio from 50 to 70 percent for spaces served by ERVs where active humidification is not provided at heating design conditions. It also raises the enthalpy recovery ratio from 50 to 60 percent at cooling design conditions.

Both of the amendments above are informed by the existing database of products which are available and technically and economically feasible. For residential scale equipment, the

Heating and Ventilation Institute (HVI) database was reviewed which carries products that meet the proposed efficiency levels. For commercial scale equipment, the AHRI database was reviewed to confirm the proposed efficiency levels. Since ERVs are already required by the 90.1-2022 standard, the amendment proposes only to raise the efficiency levels of the ERV to align with efficiency levels of the products which are widely available in the market.

Fan Power Limit. Limiting fan power can have a significant impact on the energy efficiency of an HVAC system. This amendment proposes updating the fan power limit in 90.1-2022 Standard for fan system motors exceeding 5hp (3.7 kW) to include smaller fans with electrical input power of 1kW or greater. The requirements would now cover more types of fans used in small, medium, and large HVAC systems and recognize the efficiency of using direct drive instead of v-belt transmissions. Updates to the fan power limits is based on updates in 2022 Title 24, Part 6, which has been in effect for three years, and addendum to the ASHRAE 90.1-2022 Standard which has been vetted by the 90.1 Mechanical Subcommittee. As mentioned before, this means that the requirement will be included in the next ASHRAE 90.1 model code and this amendment merely seeks to accelerate that adoption.

High Efficiency Warm Air Furnace. Increasing furnace efficiency reduces the amount of fuel required to heat the building. In Minnesota's cold climate, this is especially critical. Therefore, this amendment proposes to increase the efficiency of warm air furnaces (WAF) with maximum capacity < 225,000 btu/h from 80% AFUE to 93% AFUE or greater in multifamily buildings. Since the amendment proposes a greater efficiency than federal minimum levels required by DOE, it will be proposed as a trade-off approach to a package of measures which provide equivalent savings to the 93% WAF. The project team will undertake energy modeling analysis to identify a bundle of measures which will bring equivalent savings. Measures explored for this bundle might include a higher efficiency ERV system, reduced air leakage, and lower U factors for windows.

The amendment was intentionally drafted to allow use of products that are already readily available and widely used in the market. Gas furnaces are commonly installed in multifamily dwelling units. These units are typically all-in-one units with gas heating and electric cooling. The amendment will require all-in-one units such as Magicpaks to use a condensing gas furnace with efficiency equal or greater than 93 AFUE, a product offering which is already available in the market.

Modeling the Energy Savings from Proposed Amendments

To understand the efficiency impacts, the project team has been collaborating with Pacific Northwest National Laboratory (PNNL) since the initiation of the project in October 2023, to better understand modeling assumptions for energy savings analysis undertaken for the ASHRAE 90.1-2022 Standard adoption. As an outcome of this effort, the team decided to add parking garages to the multifamily building prototypes, which allowed capturing savings from parking garage lighting and ventilation control requirements in the ASHRAE 90.1-2022 Standard.

A total of 16 prototypes are being modeled to determine energy savings and cost-effectiveness for each of the amendments discussed above for code cycle one. While this work is still ongoing, preliminary results for the energy savings analysis indicate that 90.1-2022, combined with our amendments, will achieve a 19 percent efficiency improvement over 90.1-2019 (about 13% is from the new standard itself, and 6% from the amendments). The air leakage amendment has the highest energy savings, representing about half of the total savings from the package of amendments. Windows, energy recovery, and fan power limit are three of the other most significant contributors of energy savings.

Similar to the State Determination Analysis undertaken by PNNL, energy and economic impacts will be determined and reported for each building type and climate zone. Average results will be presented using weighting factors based on the floor area of new construction in state specific climate zones. For each amendment, the project team will also evaluate cost effectiveness, specifically to the state of Minnesota. The team intends to look at this through both the traditional incremental first cost approach and as a life cycle cost (LCC). This will allow a full picture of the cost impact of each amendment, as LCC accounts for factors including a multi-year study period, energy savings, incremental investment for energy efficiency measures, and other economic impacts. In some cases, the LCC can be negative for a given building type or climate zone based on the interaction of the amendments. However, the code will be considered cost-effective if the weighted statewide LCC is positive.

Future Code Cycles: Key Challenges

Currently, the team is focused on achieving goals for the first code cycle. However, we are also anticipating some major challenges in future code cycles that we will be working proactively to address. Some of the major challenges are covered in this section.

We are Approaching the Limits of Efficiency

The project team has not yet done a comprehensive feasibility analysis of reaching the 80 percent goal. Further, our goal is more than a decade away, and the pace of efficiency technology adoption is increasing rapidly. New technology developments that are currently emerging may advance rapidly over the next decade, resulting in a replenished well of efficiency for us to tap into.

However, the 80 percent goal is very aggressive and experts closely involved with model code development do not expect the model code, or even stretch codes based on the model code, to come close to that target in the next three to five code cycles. For example, the Chair of the ASHRAE 90.1 committee estimated that the ASHRAE-90.1-2031 model code would achieve 65 percent energy reduction over a 2004 ASHRAE 90.1 baseline, including a significant amount of on-site renewable generation. This was regarded as being close to the limits of cost-effective energy efficiency (Lord 2023).

Plug Loads Will Become Increasingly Important to Address

Plug loads have historically been ignored by energy codes, because they include equipment installed by the tenant after the certificate of occupancy is issued (and thus after code compliance inspections are completed). In addition, they are typically subject to pre-emption for equipment covered by Federal standards. However, they are increasingly a large portion of the remaining end use (Figure 3), as we achieve significant energy use reductions in other areas.

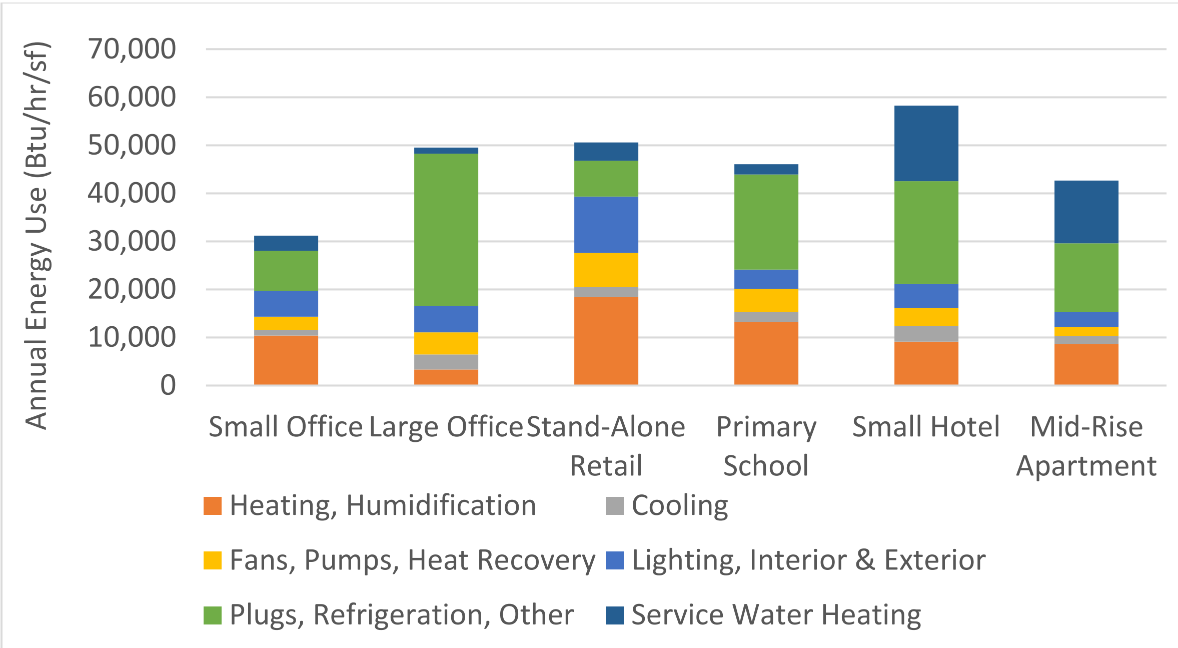


Figure 3: Annual energy by end use for Minnesota CZ 6A for major building types. *Source:* PNNL 2019

New Methods to Assess Cost-effectiveness Will be Required

Currently, cost-effectiveness is measured according to the economic payback for the building owner. However, as we move closer to net zero, this framework will become less relevant and more challenging to meet, especially as it does not adequately consider resiliency and climate impacts. A new approach will be needed to consider the benefits of greenhouse gas emissions reductions and the overall savings in repairs, reconstruction, and lost property replacement associated with more resilient buildings.

Compliance Support Strategies

In order for Minnesotans to garner the savings intended by the code advancements described above, commercial buildings must be designed and built per the energy code requirements. Verification through local permitting processes is the mechanism used to promote compliance. The permitting process specific to energy code requirements includes several challenges faced by designers, contractors, and code officials. Consistent with other states, lack of time to spend on energy code verification, complexity of code requirements, and lack of accountability create barriers to a fast and simple compliance process. As the energy code continues to advance to meet efficiency goals, complexity will likely increase, exacerbating existing barriers. For this reason, the Minnesota Advanced Energy Codes Partnership is also pursuing compliance support strategies. Figure 4 illustrates some of the key barriers associated with energy code compliance, and activities the Partnership is pursuing to address them.

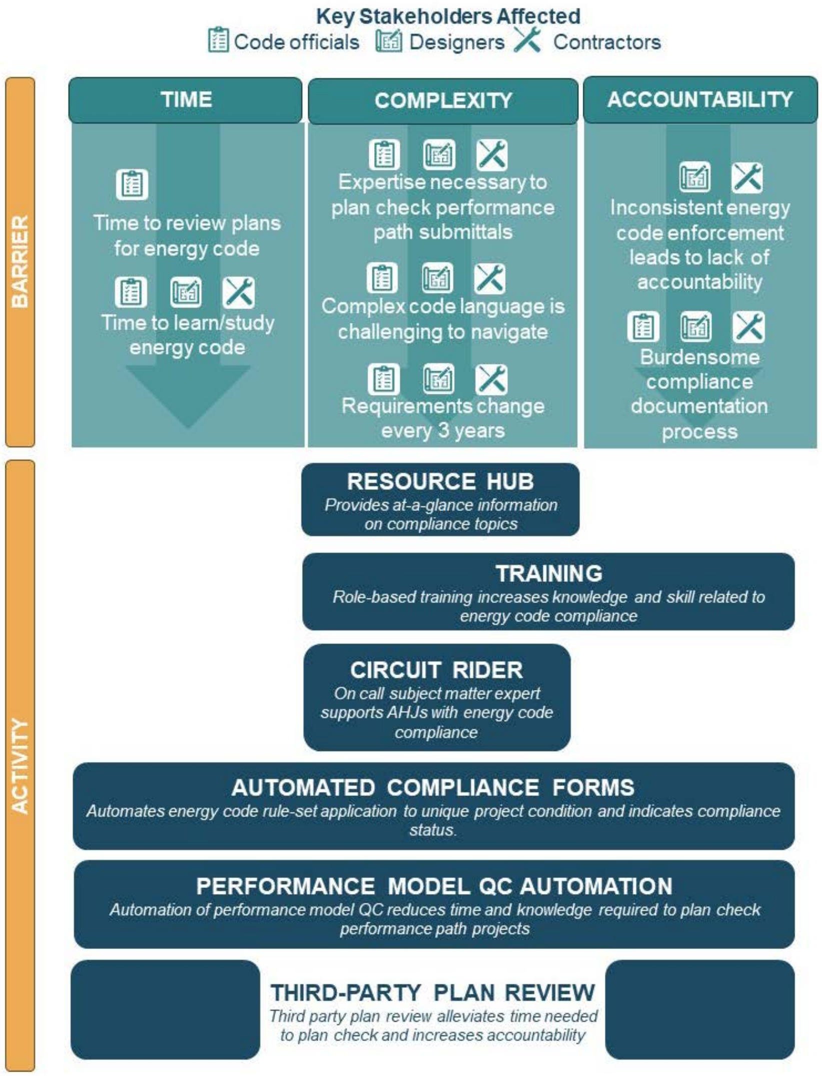


Figure 4: Key Barriers to compliance and activities pursued to address them.[2]

Based on recent compliance studies there appears to be significant opportunity for improved compliance. A Slipstream study found that average compliance rates in new commercial construction range between 70%-85% in Minnesota (Slipstream et al. 2020). Third-party plan reviews conducted by project team members indicate that compliance rates may be even lower in large commercial construction[3]. The project team has identified initial support strategies leveraging the team's experience administering code support efforts in other states.

[2] Note that "AHJ" in figure refers to "Authorities Having Jurisdiction," or the local governments that enforce the code. Also note that the "circuit rider" strategy identified in the chart is an effort funded by a consortium of utilities in Minnesota that also funds training activities, that the Partnership coordinates with.

[3] Out of 30 new commercial building applications reviewed through the community code support program (accounting for over 50,000 SF), 17% were non-compliant with over half of the evaluated measures, and 100% were non-compliant with at least one evaluated energy-code measure.

Support Hub, Training and Circuit Riders

The project team has begun to deploy a suite of resources to improve compliance and support the new construction market as codes advance. Code officials and designers need specialized energy code training to stay abreast of the rapidly changing energy code landscape. Our project team has begun the development and implementation of role-based energy code trainings that focus curricula on specific tasks that a user will execute related to energy code compliance. For example, a plans examiner training will guide learners through the use of an energy code plan review checklist to emulate tasks they will perform on the job. Practicing tasks during the training with an expert instructor there for guidance will help learners gain the knowledge and skill necessary to be successful outside the classroom.

Developing resources such as a plans examiner checklist represents our second compliance support strategy, which is the creation of an energy code resource hub. The resource hub is a website where code officials, designers, or other market actors looking to learn about the state energy code can find training opportunities and download support resources such as checklists and code requirement summaries.

It is critical to create trust with market actors that trainings and resources are technically correct and therefore offer a reliable location for code officials and design teams to find answers to their energy code questions. Our partnership with the State has been critical in the early stages of establishing trust with the market because they are widely viewed as the authority for energy code questions and trainings.

A utility-funded "circuit rider" program was launched in 2024, which is a compliance support strategy that has had success in other states. Through this program, energy code experts will visit code officials to provide hands-on support and training to improve energy code compliance. The circuit rider will build relationships with code officials and design teams working in the State and will distribute and promote resources available to them.

Create and Pilot Compliance Tools

As the code advances, it is expected that the number of commercial buildings that choose to comply with the code through a performance pathway will increase. This means that strategies that support performance path compliance will be increasingly important. The project team has partnered on another DOE funded project, led by Karpman Consulting, that will develop tools to automate quality control and reporting for projects that use energy modeling to demonstrate compliance with the energy code. The project will incorporate a standardized framework (ASHRAE Standard 229P) and enhanced data exchange capabilities into commonly used building energy modeling and compliance software tools, resulting in increased modeling accuracy, improved compliance, and stronger code enforcement. Minnesota will play a critical role in testing these tools, which should ultimately alleviate some of the burden on AHJs when it comes to reviewing performance path projects.

Another innovative strategy the team hopes to pursue is the development of digital compliance forms submitted at permit application to document compliant designs, and forms submitted at inspection to document as-built conditions. Mandatory and prescriptive requirements can be built into these forms as rulesets thereby automating the application of energy code requirements to specific project circumstances. Building in the rulesets enables the form to determine if the project data entered complies with code requirements, allowing designers to understand if their project designs comply prior to permit application, plans examiners to focus on comparing the forms to construction documents, and inspectors to spend their time verifying installations.

Third-Party Plan Review

A more unique compliance improvement approach that has been piloted and sustained in Minnesota is third-party plan review support for Authorities Having Jurisdiction (AHJs, the local governments that enforce the code). This began as a very small pilot, eventually expanded and funded by Minnesota state utilities, and now lives on through the Minnesota Advanced Energy Code Partnership. This approach to third-party energy code plan review provides no-cost support to specific Minnesota AHJs who have elected to participate. The AHJs share new commercial building permit applications with our review team, who then evaluate the projects for compliance with the Minnesota Commercial Energy Code and summarize their findings in a report. That report is then shared with the plans examiner or code official at the AHJ who may use the feedback in any way they see fit. Our program participants have found this approach to be very useful particularly in the case of building projects that elect to comply with the energy code through a performance pathway.

Projects complying with the code through a performance pathway must submit energy modeling along with supporting documentation that allows a reviewer to verify that the proposed and baseline building were modeled correctly and consistently when compared to the construction documents. However, most plans examiners have received no training on energy modeling and do not have experience reviewing energy models, making the verification of performance path projects particularly challenging. In addition, the review of a performance path project typically takes significantly more time than a prescriptive path review. For these reasons, the third-party plan review offering is a very effective support strategy. Another benefit of this strategy is the insight we gained into real projects and how they are complying, or not-complying with the energy code. These plan reviews can inform the Partnership’s training strategy by focusing on measures that are frequently missed in designs reviewed by the program. This relationship with AHJs also provides an opportunity for on-the-job training, with energy code correction comments made by expert reviewers seen and reviewed by the building project team members.

While this approach has proven to be a valuable support strategy, there are significant barriers associated with the current framework including review turn-around times and costs to scale the program. To date, this third-party plan review offering has been funded by either state, federal or utility funds, none of which can be guaranteed long-term. In addition, the support has been limited to three AHJs thus far, with plans to expand to six before the end of the DOE funding period. This offering would be very challenging to implement statewide and would require a significant and consistent funding stream to support the staff performing the reviews. For this reason, we believe this is not a long-term solution to supporting compliance. However, Figure 5 shows several alternative third-party plan review frameworks piloted in other parts of the country that address some of these concerns. Some frameworks pre-qualify contractors so that AHJs can contract directly with a third-party reviewer. Others require permit applicants to hire third-party energy code reviewers (Blair and Cheng 2023). The team plans to evaluate the feasibility of a modified approach to this offering in future years.

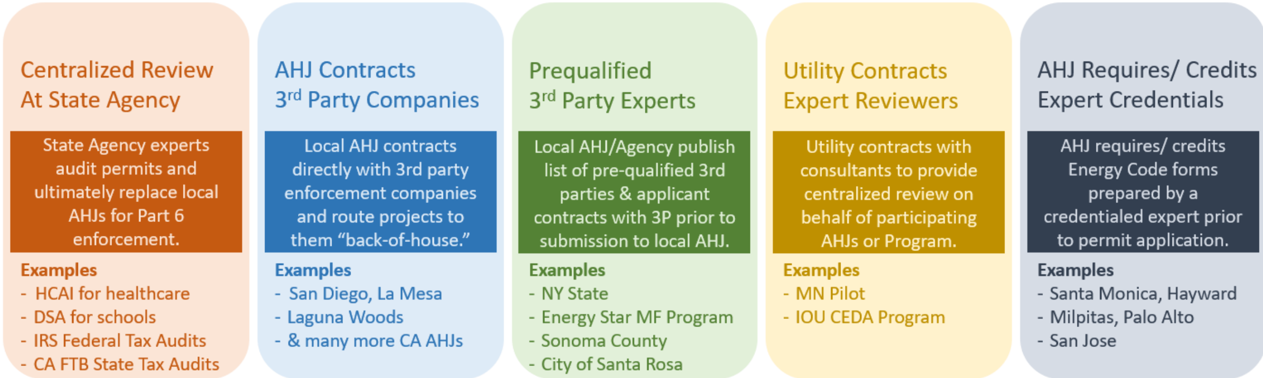


Figure 5: Possible 3rd party energy code enforcement frameworks (Blair and Cheng 2023)

Conclusions

There are several takeaways from the work done already that may be relevant beyond Minnesota.

- ***Significant savings from energy codes is still available.*** Combining the improvements in ASHRAE 90.1-2022 with our overall package of efficiency amendments results in a nearly 20 percent increase in efficiency compared to ASHRAE 90.1-2019, the basis of Minnesota's energy code that just went into effect earlier this year. Further, we have demonstrated that our package of amendments is reasonable and attainable, based on the market data we've collected so far. For the measure with the largest modeled energy savings impact – air leakage reduction – field research in Minnesota shows the market is already capable of easily achieving the requirements in the code.
- ***Minnesota's efforts will be an important test of the limits of efficiency in meeting net zero energy requirements.*** Many states are looking at net zero requirements. Reducing the efficiency gap to get to net zero will be an important step in helping meet the net zero requirements. Minnesota's goal to reach "the practical limits of efficiency" will be a test of how far and how fast a state can reach that limit, and what practical barriers might be the most challenging to overcome.
- ***Minnesota's experience as a non-coastal state with aggressive efficiency goals will be relevant to other states.*** All of the other states with aggressive statewide energy codes that go beyond the model codes are coastal states, which are often not considered relevant by states located in America's heartland, with large differences in politics and culture. Minnesota, firmly in the middle of the country, may be considered more relevant for other, non-coastal states. Even if those states do not pursue a strategy beyond adopting the model codes, Minnesota's experience may encourage them adopt model codes more quickly. This is because Minnesota will effectively be one or two code cycles ahead of the model codes, giving a head start in implementing measures that will trickle down to the model codes in several years. as most states in the country lag quite a bit behind in adopting the most recent model codes.
- ***Plug loads represent a major challenge for meeting goals***. As we rapidly increase the efficiency of other end uses, plug loads will become an increasingly dominant load since they are not regulated by energy codes for new construction. The energy code may need to adapt to address this load or parts of it, or other means may be needed to address plug

loads. Building Performance Standards, because they typically address the actual whole-building energy usage regardless of end use, may be a better policy tool for addressing plug loads.

- ***Innovation in compliance with energy codes is needed***. Measured compliance rates in Minnesota, as in most of the rest of the country, show significant opportunity for improvement. This gap between what the code says on paper and what it actually achieves will only increase as the code becomes more complex, compounding enforcement issues. Furthermore, it is expected that more and more projects will use the performance path to comply, for which local code officials are not equipped to check. Innovation in performance-path compliance is especially important for future iterations of the code.

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