Carrots or Sticks? Policy Options for Building Energy Standards

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ABSTRACT

California's building energy standards, known as Title 24, are among the most rigorous in the nation. Nevertheless, past evaluations have identified lost opportunities, given the current standards mechanism. The standards lag industry "best practices" by three to five years, many new buildings do not comply with the standards, and traditional enforcement methods do little to ensure efficient building performance (as opposed to paper compliance). Strict reliance on "sticks," i.e., more rigorous standards and stricter enforcement, is increasingly seen as inadequate to capture these lost opportunities.

To look for more creative ways to capture lost opportunities, Pacific Gas and Electric Company, in collaboration with the California Energy Commission, has initiated research to re-examine the standards process in California with an eye toward adding more "carrots" to the mix. Drawing from that research, this paper examines opportunities to leverage private market forces, local government initiatives, and publicly funded energy efficiency programs to promote more energy-efficient construction practices. Among the more promising innovations considered, the paper examines potential contributions to improved building performance from performance testing and diagnostics practices and the possibility of leveraging building industry concerns about insurance losses to promote better construction quality. Findings are based on a literature review of over 200 documents and in-depth interviews with over 50 industry experts, representing a variety of construction industry perspectives.

Introduction

Pacific Gas and Electric Company (PG&E) is currently managing a statewide research project was originally started under the auspices of the CBEE. The project focuses on two research objectives: (1) assess strategies for improving the construction industry's effectiveness in installing energy efficiency measures commonly used to achieve compliance with California's Title 24; and (2) assess how utilities can more effectively influence the standards development and implementation process by promoting consensus for incorporation of industry best practices in the standards. The California Energy Commission (CEC) has provided substantial technical advice and direction on all phases of the project. This paper discusses preliminary findings, conclusions, and recommendations associated with the first objective. The recommendations have not yet been reviewed or approved by the

statewide program managers team. The paper also focuses narrowly on the residential sector. A more complete report, addressing both objectives and covering both residential and nonresidential construction, is forthcoming from PG&E.

In addressing the first study objective, the research design seeks to test the plausibility of the following hypotheses:

- Significant gains in energy efficiency could be achieved in both the residential and nonresidential sectors by improving overall building construction quality and mitigating construction defects.
- Strict reliance on regulatory approaches, such as increasing the stringency of building energy standards and more vigorous enforcement (i.e., "sticks"), are inadequate to mitigate construction defect issues and capture the full energy efficiency benefits of improved building construction quality.
- A broader range of energy efficiency benefits can be captured by more closely aligning regulatory mechanisms and related public policies with existing market forces.

We should emphasize that our intent is not to definitively prove or disprove these hypotheses—doing so would require a massive undertaking. Rather, we focused on marshalling the available evidence, pro and con, to support more informed program planning and public policy formulation.

Our preliminary findings and conclusions are based on a literature review of over 200 documents and in-depth interviews with over 50 industry experts, representing a variety of construction industry perspectives. Literature sources included numerous papers published in industry conference proceedings, utility program market effects studies, and research reports from a range of public agencies throughout the U. S. Industry experts included utility program managers, building inspectors and other local government officials, builders and contractors, national laboratory research staff, and private sector experts in residential diagnostic testing, nonresidential building commissioning, construction finance, and construction insurance and litigation issues. Initial research has identified additional documents to review and approximately 30 additional candidates to interview. It will also serve as the basis for a series of focus groups to explore preliminary findings and recommendations, which will be documented in the full PG&E report.

In the remainder of this paper, we discuss the extent and nature of residential building performance issues we have identified. We then explore the prospects for addressing these issues via two strategies that appear to hold particular promise: diagnostic testing of construction projects and closer integration of energy efficiency and insurance liability concerns. We then close with a series of conclusions and recommendations drawn from the findings previously discussed. While this paper focuses narrowly on the residential sector, the conclusions are generally applicable to the nonresidential sector as well.

Extent and Nature of Building Performance Issues

We explored the extent and nature of building performance issues through both extensive literature review and interviews with industry experts with experience in the field.

We focused particular attention on deficiencies in building design and construction practices that had energy efficiency implications. We focused less attention on energy efficiency opportunities from improved construction materials and technologies.

In the residential sector, we found abundant evidence of building performance issues associated with HVAC system design and installation. Building envelopes are also prone to numerous construction defects, although the energy efficiency implications may not be substantial in California. HVAC and envelope issues are discussed in more detail below. Residential lighting systems offer numerous opportunities for improved energy efficiency through more stringent technology requirements but do not appear to be particularly prone to construction defects.

HVAC Issues

There are many factors that degrade HVAC system operating efficiency below nominal manufacturer-tested equipment performance. According to Neal (1998), four key factors affecting performance include incorrect refrigerant charge, inadequate system airflow, duct leakage, and system oversizing.

Incorrect refrigerant charge has been identified as a problem in over 70% of installations nationally (Neme, Proctor, and Nadel 1999). Correct refrigerant charge for installed systems requires improved HVAC contractor training and attention to detail in the final system tune-up process.

Inadequate airflow over the indoor coil, which is typically due to reliance on rule-of-thumb duct sizing procedures, results in undersized and overly restrictive duct systems. Industry experts identified the need for mechanical system design as part of the overall house plan as a primary solution to this problem. The lack of system design often constrains the HVAC contractor to sub-optimal solutions for routing the duct system through the existing framing. The consequences include undersized ducts to get through framing pinch points, reliance on building cavities in lieu of return air-supply ducts, and sharp bends in the ducts, which increase air turbulence and are vulnerable to leaks.

Duct leakage affects system performance in several ways. Return leakage causes unconditioned attic air to be pulled through the air handler unit, resulting in an increased cooling load on the evaporator coil. Supply-side leaks to unconditioned space reduce effective system capacity. A 4-ton cooling system with 11% supply leakage is effectively operating as a 3 1/2-ton system. Duct blaster tests have been developed to diagnose leaky ducts. For maximum utility, these tests should be conducted at the time ducts are installed while the contractor can still access the ducts to fix any leaks.

The practice of oversizing cooling equipment has been projected to be as high as 47% over Manual J prescribed sizing (Neme, Proctor, and Nadel 1999). [1] Oversizing increases cooling energy use and peak demand and requires the homeowner to pay for additional capacity that is not required. From the contractor perspective, oversizing of air conditioning systems has been the easiest way to minimize homeowner comfort complaints, which in

[1] Air Conditioning Contractors of America. 1986. *Residential Load Calculation—Manual J.* Air Conditioning Contractors of America

reality are due to a myriad of problems including shortcomings in duct design, excessive duct leakage, inadequate airflow, and improper refrigerant charge. A comprehensive strategy of mechanical system design, duct testing and inspections, and HVAC system tune-up can reduce the impetus to oversize cooling systems.

Envelope Issues

Much of California's climate is sufficiently mild that imperfections in the building envelope do not have catastrophic comfort or energy implications. Nevertheless, improperly constructed building envelopes appear to be common. A comprehensive builder training program completed during 1995-1998 found nearly a third of the houses tested had under-insulated ceilings (or other significant problems) and nearly half of the houses had walls with inadequate insulation, significant insulation compression, or other problems (Building Industry Institute and Consol 1998). The most viable solutions for improving the quality of insulation installation appears to be more regular training of installers and more routine inspections of insulation installation. Training efforts in California are hampered by widespread reliance on unskilled labor. Inspections are complicated by the short window of opportunity to inspect the insulation before it is covered over with wall sheathing.

While envelope issues may be less important than HVAC issues from an energy efficiency perspective (at least in California), it tops the list of risk management concerns. According to industry experts, residential building envelope problems associated with water infiltration are the most common sources of occupant discomfort and litigation. Water often infiltrates from below grade due to problems with the foundation. Water infiltration can also occur due to improper construction techniques in the building envelope. It is reportedly common to find double-glazed windows with bad seals in older homes. Poor roof and wall waterproofing, small roof overhangs, roof failures, and inadequate caulking and flashing all contribute to water infiltration. Moisture problems can also be traced to improperly operating HVAC systems that generate negative air pressure in the house, which can cause moisture to be drawn in and cause rot and deterioration of the insulation.

Diagnostic Testing as a Tool to Improve Residential Building Performance

Our review of performance issues in residential new construction have led us to conclude that significant gains in energy efficiency can indeed be achieved by improving overall building construction quality and mitigating construction defects. However, exclusive reliance on regulatory methods of mitigating these defects may be impractical or, at best, clumsy because mitigation requires changes in industry practices. For insulation installation and other envelope sealing steps, industry experts have advocated expanded training for the installers and a quality control mechanism capable of intervening before any problems are covered over and hidden. For HVAC systems, industry experts have advocated adoption of a

systems approach to design and construction, which includes a mechanical design of the HVAC and ducts as part of the initial blueprints; making sure designs are followed; and performance testing of the ducts and HVAC system. For convenience in the following discussion, we refer to a comprehensive system of design, inspection, and performance testing, covering both HVAC systems and envelope construction, as "diagnostic testing."

Potential Carrots

Despite the limitations of relying on regulatory sticks to impose diagnostic testing methods on the industry, a case can be made for policy interventions that promote diagnostic testing using carrots. The new construction industry has not adopted diagnostic testing practices on a wide scale to date. Without carrots that build on existing market incentives and overcome market barriers, future adoption may continue to be slow.

There appears to be broad consensus among industry experts on the reasons contributing to the current limited appeal of diagnostic testing practices:

- **Cost.** Builders start out at the subdivision planning stage by identifying the home features needed to sell to their target market and the sale price the market will bear for those features. Energy efficiency is not high on the list of home features builders perceive customers as wanting so builders can not increase sale prices to cover increased construction and testing costs for energy-efficient homes.
- **Lack of awareness of the extent of construction defects** on the part of builders. Diagnostic testing sells what the builder thinks he already gets.
- **Lack of awareness of the potential to avoid liability, callbacks, and litigation.** Particularly lacking is an understanding of diagnostic testing's impacts on indoor air quality, moisture control, health and safety. More research in these areas is needed.
- **Unwillingness of home buyers to pay for diagnostic testing.** They assume the home purchase price should already cover correct installation. Consumers expect the systems to work, so offering energy efficiency and functional systems as an upgrade has limited appeal.
- **Lack of knowledge, skill, and ability on the part of contractors.** For HVAC contractors, at least, this barrier may be mitigated by contractor certification, which is gaining momentum through Air Conditioning Contractors of America (ACCA).
- **Potential for project delays due to a lack of performance testing infrastructure.** Timeliness is critical but builders cannot be certain of existing raters' ability to inspect construction projects without interrupting the work flow.
- **Lack of awareness of who the service providers are.**
- **Lack of standardized methodology and testing procedures** that would make the process of diagnostics more efficient, cost effective and accessible.

While barriers to diagnostic testing certainly exist, the countervailing benefits are potentially significant. The potential benefits to builders from diagnostic testing include reductions in litigation exposure, improvement in customer satisfaction, and increased

product differentiation. Along with builders, contractors are expected to benefit from diagnostic testing by identifying any installation problems immediately, thus reducing the incidence of callbacks. From the buyer perspective, diagnostic testing improves home quality, particularly if it is done as part of a systems approach to construction. Without testing the mechanical systems, consumers do not know whether those systems work properly.

As we discuss in more detail in the following section, reduced litigation exposure is potentially a big benefit because, according to one interviewee, once a construction defect case goes to court, the litigants win 60% of the time. At that point, the builder may be liable for the repair costs of all discovered defects, not just the defect that triggered the compliant.

While many builders contend that home buyers will not pay extra for homes that have been diagnostically tested, the growing success of home labeling programs provides tangible evidence of the feasibility of marketing energy efficiency to the home buying public. Home buyers will probably never rank energy efficiency above criteria such as location, floor plan, or schools, but research suggests they will pay more for an energy-efficient home. Nevin, Bender, and Gazan (1999) have found that "home value increases by about $20 for every $1 reduction in annual utility bills." For energy efficiency marketing to work, home buyers need a trusted mechanism for identifying energy-efficient homes without minutely inspecting the homes themselves or becoming construction experts. Labeling provides that mechanism. The EPA/DOE Energy Star Homes Program requires diagnostic testing to ensure energy efficiency and then provides an easily recognized certification. The labeling program appears to be gaining momentum as a common platform for designing utility programs. Every major utility in California is instituting programs that promote ENERGY STAR buildings. Builders who have received an incentive to build a few model homes to ENERGY STAR standards are instead building entire subdivisions to the higher standards.

Perhaps the strongest evidence for the viability of diagnostic testing as a means of product differentiation and improved customer satisfaction is the number of builders who have adopted diagnostic testing measures independent of any utility incentives, simply to promote quality homes. ConSol has developed a user-funded private initiative that adopts a systems approach to construct high-quality, comfortable homes. The initiative incorporates detailed inspections and performance testing of the HVAC system. ConSol reports that diagnostic testing is a growing business, with approximately 6,000 homes in the construction pipeline through the initiative in Nevada and California. Over time, ConSol hopes to secure 20-30% of the new home construction market. ConSol also reports that on-site training in duct testing has been very popular with builders and their subcontractors. Contractors who thought that they were installing tight ducts could see where and how much leakage was occurring (Building Industry Institute and ConSol 1998).

Aside from the marketplace benefits, diagnostic testing measures have recently been incorporated into Title 24 in a way that confers additional project design flexibility. The most recent changes to Title 24, adopted in July of 1999, incorporate duct design and testing and building envelope sealing as optional compliance approaches. Incorporating these measures into the project earns the builder credits, which can be traded off against design features that otherwise would cause the project to exceed the design energy budget. The full impacts of those changes have yet to be seen. Many of the homes currently under construction are not

eligible for the credits because their building permits were pulled prior to the effective date of the standards revisions. As more builders gain experience and confidence with these new compliance credits, one may expect to see an increase in duct design testing and envelope sealing to take advantage of the compliance credits.

Policy Options for Expanding Diagnostic Testing

At present, builders don't see the value of diagnostic testing. They need education on how diagnostic testing contributes to improvements in their product in the form of reduced callbacks, improved comfort, and improved customer satisfaction. This implies the need for additional research to document increases in sale value, reductions in liability exposure, and increases in home turn-over. Builders also need training on how to market the benefits of higher quality homes. Builders also need assurances that the testing and inspection infrastructure is in place, that costs of additional testing and inspections will be reasonable, and that the process will not be disruptive to their construction schedule.

Experts we interviewed regard utility support as important, at least in the short term. Any phase-out of financial incentives over time should be gradual. Utility interventions are appropriate to overcome a number of market barriers by developing the testing and inspection infrastructure; offering education programs for builders, contractors, and home buyers; and conducting research to better measure the true costs and benefits of diagnostic testing.

Local government also has a role to play. Utilities and local governments are increasingly collaborating to offer time incentives. For example, PG&E is developing a pilot local government program that offers benefits to builders such as expedited plan checks, reduced permit fees, and possibly electronic paperwork filing. Several jurisdictions, including Irvine and Santa Barbara County, offer expedited plan checks in return for projects that exceed Title 24 standards by specified amounts. Piggybacking on utility calls for third-party initiatives from local governments, the Building Industry Institute is developing the Community Energy Efficiency Program, which offers improved plan check time and reduced local permit fees for projects that meet heightened construction quality standards. The program uses third-party diagnostic testing to confirm that the standards have been met. The program is currently enlisting partnerships with local governments.

Along with utility support, there seems to be wide agreement (though not universal) on three other ingredients for diagnostic testing success:

- Energy Star success is important. An easily recognized label is seen as valuable for making tight ducts and other construction quality improvements into marketable products.
- Well designed and tested ducts will eventually need to be a mandatory requirement in Title 24. Diagnostic testing will be necessary to demonstrate air-tightness.
- Energy standards must be simplified. Builders are not anti-efficiency but they are anti-hassle. If the hassle factor is perceived as high, then you lose buy-in from the builders.

The biggest area of disagreement is on the need for diagnostic testing to be performed by third-party inspectors. On the one hand, advocates argue that independent, third-party testing is essential to preserve the credibility of utility programs, Energy Star, and Title 24.

Without independent testing, any requirement would be toothless. On the other hand, critics have argued that third-party inspections interfere with the construction process and are thus extremely onerous. They also argue that independent inspections are unnecessary, that cheating on tight duct requirements would be minimal. Critics suggest as an alternative that resources be focused on contractor certification. After completing sanctioned training courses, contractors would self-certify their duct installations as meeting standards requirements, with the understanding that a fraction of their projects could be randomly selected for quality control audits.

Insurance as a Tool to Improve Building Performance

Perhaps one of the more tantalizing opportunities for harnessing market forces to improve energy efficiency is to link energy efficiency and insurance interests. The relationship is readily apparent: construction defects are an important contributing factor to building energy waste; they are also important sources of lawsuits, which, in turn, directly impact insurance rates for builders, developers, contractors, architects, and engineers. Conversations with industry experts indicate that reduced exposure to construction defect liability is a potential powerful motivator for builders and developers to adopt better construction practices. As previously noted, once a construction defect case goes to court, the litigants win 60% of the time. One interviewee reported that construction defect cases valued in the $100 millions have been lost in San Diego County. At least one consulting firm in the San Diego area generates 75% of its business from construction defect litigation and the remaining 25% from helping builders and general contractors minimize the risks of litigation.

According to LBNL, there are enormous insurance benefits to be reaped from better construction practices (Vine et al., 1998). Virtually every category of insurance, from property and liability to health and life, offers tangible benefits. In particular, lower claims in professional liability for builders is significant. In addition to reduced risk, improved construction practices are expected to reduce callbacks and litigation costs for both builders and contractors.

Before these benefits can be realized, however, we believe two significant barriers must be surmounted. First, advocates seeking to link insurance benefits and energy efficiency must document the extent and value of the benefits. The costs of improving construction practices and testing to verify the improvements are all well known. However, the quantitative benefits are not. One interviewee noted that the DOE Building America Program claims to have reduced callbacks for builders but offers no data to document the extent and value of the reduction. The lack of quantitative data means that builders and developers must be sold on the value of improved construction practices based on "hand-waving" arguments. Just as important, insurance carriers currently lack the actuarial data needed to justify lower insurance premiums for builders and developers who adopt improved construction practices. Advocates should not underestimate the magnitude of this challenge. To illustrate, a continually thorny issue in many construction defect cases is to attribute fault or responsibility for a particular defect to the various parties involved in the process (Sweet

1997). There is no reason to expect that attributing credit for avoided defects will be any easier.

The second barrier to be surmounted is to develop diagnostic testing mechanisms that address construction defects from both an energy efficiency perspective and a risk management perspective. As we have seen, the biggest construction issues from an energy efficiency perspective relate to the HVAC system design and installation and insulation installation. However, construction defect cases most often stem from moisture intrusion problems. One interviewee offered the example of a home, constructed as part of a utility residential new construction program, that suffered from poor drainage. The home was built on expansive clay soils, which were inadequately compacted before construction. Footing depths for the foundation were also inadequate. As the soil expanded and contracted with variations in moisture content, the foundation cracked, water infiltrated the house, and problems began. The house was damp inside, mold grew on the walls, and condensation collected on windows. Billed as a "Comfort Home" by the utility, the house was not comfortable, even though it was energy efficient.

The previous example echoes the cautionary note sounded by LBNL regarding the pitfall of equating energy efficiency too closely with quality construction. While it is usually true that the most energy-efficient construction practices are also the best for promoting health, safety, and comfort, the connection is not always automatic. We see this as evidence of a need for a broader perspective to building construction that recognizes energy efficiency as one of an array of important public policy objectives. At a minimum, diagnostic testing measures need to be developed that catch a full array of potential construction defects, not just those with energy efficiency implications. The challenge of course is that truly integrated initiatives exceed the legislative mandates for both the California Energy Commission and the Public Goods Charge programs, which are directed to focus on energy efficiency. As part of our recommendations, we offer additional thoughts on how such integration might be accomplished.

Keeping in mind both the opportunities and pitfalls of linking energy efficiency to insurance liability concerns, a number of policies and initiatives have been recommended to strengthen those links.

- Document the benefits of improved construction practices. Data should be actuarial quality and should document benefits from reduced litigation exposure and callbacks. Insurance companies may be willing to co-fund these types of studies.
- Promote mechanical system design in the residential sector. Many construction defects occur because contractors must design HVAC systems on-site, based on rules of thumb, and shoehorn the systems into the available space.
- Offer long-term warrantees on new buildings.
- Promote the use of home energy rating systems, diagnostic testing, and commissioning practices.
- Make sure that buildings are truly safe, secure, and comfortable, as well as energy efficient, and then market them as such.

Capturing the full benefit from improved construction practices should be a priority for energy efficiency advocates. As one expert noted, insurance credits would be recurring, not — just a one-time rebate, so they would contribute to more sustainable changes in industry practices.

Conclusions

Research conducted to date for this project has uncovered abundant evidence that building energy performance can, in general, still be greatly improved over existing energy standards. However, strict reliance on regulatory "sticks" to capture those benefits may be problematic, at least in the short term. Three reasons emerge as rationales for pursuing a more market-based "carrot" approach:

- Market acceptance of construction industry best practices are still far below the levels needed to support adoption of mandatory, across-the-board requirements for those practices.
- Fully capturing the energy efficiency opportunities available requires a system-level approach that examines the interaction of all system components and permeates the construction process from design to building occupancy and beyond. Such an integrated approach is difficult to legislate. Even if rules could be written that were not overwhelming in their complexity, they would be challenging to enforce.
- Fully capturing the energy efficiency opportunities available requires paying attention to an array of building issues, including occupant comfort, health, and safety. These issues are generally outside the regulatory authority of agencies responsible for administering energy codes and standards.

Our research has also found abundant evidence to support the feasibility of strategies to harness market forces in capturing the desired benefits. A building system approach can deliver an array of benefits, including energy efficiency. To be successful, the approach must incorporate energy efficiency awareness into the design process, make regular quality-control inspections throughout the construction process, and incorporate performance testing of the mechanical systems. If successful, this approach offers the potential to

- Improve construction quality
- Promote proper design and equipment sizing
- Reduce call backs
- Reduce litigation exposure
- Improve customer satisfaction
- Lengthen equipment life
- Improve comfort
- Improve indoor air quality
- Save resources and money

Recommendations

Within the new construction industry, there appears to be gathering momentum for the integrated design and construction approaches recommended here. This momentum is, in part, driven by the advocacy efforts of members of the energy efficiency community and, in part, by the natural market benefits they offer. Nevertheless, our research suggests several promising avenues for accelerating the momentum.

First, more research is needed into the true costs and benefits of a systems approach to design and construction, including performance testing and commissioning activities. While extensive research has already been initiated in this area, large gaps in our knowledge remain, particularly on the benefits side. These gaps must be filled with objective, quantitative data to make a compelling case to industry decision-makers for changes in construction practices. The data are also essential if the full benefits to those decision-makers is to be captured in the form of insurance premium reductions.

Second, a broader perspective to building construction is required that recognizes energy efficiency as one of an array of important public policy objectives. A truly inter-disciplinary approach to public policy making is needed that tears down or at least circumvents the administrative barriers erected between different regulatory agencies. We recommend convening a roundtable of regulatory officials that can act as an informal "ombudsman" to monitor and coordinate the regulatory activities of different agencies. Roundtable membership should include representation for a wide range of interests, including energy efficiency, occupational health and safety, indoor air quality, land use planning, water conservation, gas conservation, and waste management. A state tax credit for Green Buildings may be a particularly effective tool for providing market clout to such an approach.

Third, we recommend dramatically stepped up consumer education efforts to make construction quality a building feature with tangible market value. While we applaud efforts to date to establish Energy Star and related brands as a means of product differentiation, we believe these efforts, by themselves are too timid. They rely too heavily on the voluntary participation of builders and developers and they focus too narrowly on praising the exemplary builders. A far more effective model, in our opinion, would be the Consumer Union testing model. Homes and commercial buildings from all major developers should be thoroughly inspected. By soliciting the involvement of building owners shortly after they take occupancy, one can avoid the need to gain cooperation from the developer. Testing should be rigorous and thorough, use accepted testing methods, and should examine all aspects of building performance: resource efficiency (electric, water, gas, etc.), occupant comfort, health, safety. Results should be documented in a format easily accessible to a mass audience and widely published. Again, Consumer Reports should be the reporting model. While such an inspection and reporting program will inevitably challenged by parties who disagree with the findings (as the Consumers Union can attest), a well-documented, rigorous program based on sound building science will stand up to legal challenge and will generate the holy grail of energy efficiency market signals, consumer demand.

Finally, we recommend a set of regulatory initiatives, recognizing that regulatory sticks have their place, even if they are not the sole solution. We recommend requiring certification of HVAC and insulation contractors. Certification should be tied to successful completion of training courses. Each technician working on a construction project should be certified, not just the contracting business. By involving the state licensing board, certification can be linked to business licenses to give enforcement some teeth.

In addition, performance tests should be required for all HVAC systems. If the contractor certification mechanism is fully functional, the testing can be done by the installation contractor himself, without third-party oversight. Independent testing by a third party is needed only for a sample of projects (perhaps 10-15% of the contractor's total projects) for quality control purposes. Of course, failure of a quality control inspection should trigger additional inspections of the contractor's projects and should put his certification status at risk.

While our two regulatory recommendations may be seen as onerous within the construction trades, we believe their acceptance can be facilitated if packaged with regulatory benefits the construction industry values. The most sought-after regulatory relief the construction industry seeks, from our research, is simplification of Title 24. While computer algorithms have made initial compliance calculations routine, the complexity of the standards becomes a headache every time a change order is required on a project. Complex standards also make uniform enforcement a challenge. Properly managed, we believe, the standards can be simplified without unduly impacting their overall stringency or flexibility. If builders and contractors are afforded substantive input starting in the initial stages of revision, we believe a commitment to standards simplification can greatly enhance the regulatory component of a construction defect mitigation policy.

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