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Societal Implications of Performance-Based Earthquake Engineering

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ABSTRACT

This report considers various aspects of the societal implications of performance-based approaches to earthquake engineering. The societal benefits can generally be characterized as the "value added" of performance information in enhancing seismic design and risk management. The realization of these benefits rests on widespread adoption of performance-based approaches in engineering practice. At present, this is somewhat limited. Several future scenarios are considered that may result from changes in code provisions or from changes in societal perspectives about seismic safety. The challenge for regulatory officials is to establish meaningful seismic-safety standards given shifts in societal expectations about seismic performance. Broader changes in societal perspectives about seismic safety require not only greater societal awareness of earthquake risks and their consequences but also a transformation of the way that building owners, developers, financial entities, and the design community think about seismic safety. This transformation is akin to that achieved in the green-building movement in response to what is perceived as a societal need for healthful, more energy-efficient, and less costly to operate buildings. Seismic safety has yet to achieve a similar status of engendering a common concern. This may be in part because the societal benefits of performance-based seismic engineering are not well articulated or recognized.

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1 Introduction

Performance-based earthquake engineering provides methods for developing a better understanding of the seismic performance of buildings, bridges, and other infrastructure. These assessment methods can be employed to help decision makers better understand the seismic vulnerability of their facilities and the components that contribute to that vulnerability. These design methods can be employed to help make better decisions about the objectives for earthquake performance and design choices for meeting those objectives. These assessment and design methods are important for structures that are not adequately addressed by prescriptive codes, particularly those that have exotic designs or other features that make it difficult to apply the prescriptive provisions. More generally, a shift toward performance-based code provisions has a number of potential advantages for regulation of seismic safety for the construction or rehabilitation of buildings and other facilities.

Encapsulating the societal benefits of the performance-based approach is challenging. Although many examples can be provided of the use of the approach for seismic assessment and design, the benefits of the performance-based approach are hard to quantify. In some instances, facilities might not have been built or rehabilitated without performance-based approaches. This is particularly the case for the rehabilitation of buildings for which it is typically uneconomical to fully meet prescriptive code provisions. Key contributions of performance-based approaches are better information for decisions about seismic risk management and reduced uncertainty about prospective losses. From this perspective, many of the benefits of performance-based approaches relate to the value of improved information about seismic performance. This “value of information” perspective is considered as part of Chapter 2 of this report.

The broadest societal benefits of the performance-based approach are not just wiser decisions about seismic objectives and design, but the design and construction of safer facilities and of more resilient infrastructure. The realization of these benefits rests on widespread adoption of performance-based approaches in engineering practice. The design professions—

architects, engineers, and professionals responsible for the design of structural and nonstructural elements—need to be equipped to understand and take advantage of advances in performance-based approaches. This entails an understanding of the philosophy of performance-based approaches and developing new skill sets. Architects need to better appreciate the relationships between building configuration, structural features, and nonstructural components of facilities. Facility designers need to understand how modifications in the use of a structure affect its ability to withstand earthquake damage and maintain functionality. Earthquake engineers need to be well versed in the methodology of performance-based earthquake engineering as applied to seismic assessment and design for both new and existing buildings. Chapter 2 of this report also considers some future scenarios about adoption of performance-based approaches and their implications.

There is a difference between safety at any cost and safety gains that can be achieved for tolerable costs. Performance-based seismic assessment is appealing because it helps to expose the safety gains and associated costs. Decision makers can in principle decide what costs they are willing to pay—in terms of functional design choices and dollar outlays—to achieve different levels of seismic safety when measured in terms of potential dollar value of damages, downtime to facilities, or loss of life. Evaluating these tradeoffs takes on added complications when thinking about seismic codes and minimum performance-based seismic-safety standards. Societal expectations seem to be shifting about minimum performance goals from preventing loss of life—life safety—to increased emphasis on property protection. But, establishment of new regulatory objectives entails value judgments about "acceptable risks" that public officials are reluctant to make. Chapter 3 of this report considers the broader regulatory challenges with particular attention to setting seismic-safety standards.

Responding to these challenges requires new ways of doing business and different ways of thinking about seismic safety. An instructive example of this type of transformation for other aspects of building construction is the rapid growth of the "green building" movement. That effort encourages construction of energy-efficient and environmentally healthful buildings that are designed and constructed to have reduced operating costs. This movement has grown in response to what is perceived as a societal need for healthful, more energy-efficient, and less costly to operate buildings. While critics see the green building movement as simply efforts by some architects and contractors to gain market advantages, the movement is clearly striking a responsive chord among a range of diverse construction, environmental, and consumer interests.

Seismic safety has yet to achieve a similar status of engendering a common concern. This may be in part because the societal benefits of performance-based seismic engineering are not well articulated or recognized. Chapter 4 considers the adoption of green building requirements at the state level and the lessons from the green building movement for performance-based earthquake engineering.

The concluding chapter summarizes the discussion in this report and provides some observations about future challenges in “reaching out to society” in realizing the benefits of performance-based approaches for seismic safety.

2 Societal Benefits and Costs

A starting point for considering societal implications of the performance-based approach to earthquake engineering is to articulate the added value of the approach. Two major categories of benefits are considered in this chapter. One is prospective benefits from better decisions about risk management that are made possible by quantification of seismic performance. The second is the reduced uncertainties in understanding seismic performance that comes from improved methods of performance assessment. Consideration of each of these constitutes the first part of this chapter.

Apart from these considerations, many claims have been made about the prospective benefits and costs of performance-based approaches. Few of these have been systematically assessed. The second part of this chapter summarizes the various claims. This serves as a starting basis for identifying the potential benefits and costs of performance-based approaches.

The realization of the benefits of the performance-based approach rests on widespread adoption of these approaches in engineering and design practice. The final section of this chapter considers future scenarios about adoption of performance-based approaches and the implications for the realization of prospective benefits of performance-based approaches.

2.1 PROSPECTIVE BENEFITS: BETTER DECISIONS AND REDUCED UNCERTAINTIES

A key contribution of the Pacific Earthquake Engineering research has been development of a more scientific and rigorous approach to assessing seismic performance. The PEER methodology provides a basis for better quantification of information about seismic performance and for reduction in uncertainties as part of that quantification. Each of these provides an improvement in the quality of information for making decisions about seismic safety. The benefits of improved performance assessments are the "value added" of the information in enhancing seismic design and risk management. Table 2.1 summarizes the benefits of this improved information.

Table 2.1 Benefits of Performance-Based Assessments and Design

Dimension	Components	Potential Benefits
Quantification of Performance	• Understanding of risk objectives — predictions about casualties, downtime, and damages	• Better understanding of objectives and the tradeoffs they entail in attempting to avert prospective losses
	• Understanding of costs of achieving different objectives	• Improved basis for making informed decisions about risk management
	• Better understanding of components of vulnerability (e.g., structural versus nonstructural)	• Improved basis for design choices for reducing risks
	• Understanding of vulnerability of components of portfolios (e.g. multi campus buildings, highway system)	• Improved basis for prioritizing risk-management and recovery choices among different facilities or structures
	• Better understanding of existing code provisions (benchmarking of codes)	• Improved basis for greater precision in codes
	• Better understanding of the performance of non-prescriptive seismic designs	• Improved basis for evaluation of non-traditional structures and for rehabilitation of structures; basis for alternative code guidelines
Reduced Uncertainties	• Better estimation of components of risk (seismic hazards, fragilities, damages)	• Greater precision in predicting vulnerabilities
	• Better estimation of potential losses (damages, casualties, downtime)	• Improved basis for risk-management decisions including quantification of uncertainty.

The primary benefit of the quantification of performance is a better understanding of expected performance. This includes an improved understanding of risk objectives, costs of achieving different objectives, the components of different sources of risk as it relates to structural versus nonstructural contributions, and the vulnerability of different elements of a portfolio of buildings or infrastructure networks like highways. As shown in the right column, the key potential benefit of better understanding is a better basis for decisions about seismic design and risk-management choices. Chief among these is the ability to pose tradeoffs among different objectives—reduced loss of life, increased functionality, limited damage, different design alternatives, different risk-management choices, and the costs associated with these choices. An improved understanding of the vulnerability of different components of a portfolio of buildings, bridges, or other facilities could contribute to risk prioritization for managing different components (e.g., seismic upgrades) or for prioritizing recovery choices (e.g., bridge rehabilitation for a highway network).

Quantification of performance also provides a basis for rethinking existing code provisions and the implications of seismic designs that deviate from code prescriptions. As illustrated with research undertaken by (Liel, Haselton, and Deierlein 2006), performance assessments can be used to benchmark existing code provisions and to show the implications of changes in those provisions. That research addressed the changes in code provisions for risk of collapse for a four-story reinforced concrete building designed to the 1967 UBC provisions as compared to the same structure designed to the 2003 IBC provisions. This type of benchmarking quantifies vague goals such as “life safety” or “minimize risk of collapse” and provides the basis for establishing quantifiable regulatory standards. Similarly, quantitative performance assessments are necessary for understanding the performance of designs that do not adhere to prescriptive methods—so called “alternate designs”—as may occur for the seismic rehabilitation of some structures or for more exotic building designs. Experience over time with performance assessments of these structures can lead to guidelines about alternative code provisions.

The second part of Table 2.1 addresses the benefits associated with reduced uncertainties about seismic performance. As discussed in a recent National Research Council (2006) report, *Improved Seismic Monitoring, Improved Decision-Making, Assessing the Value of Reduced Uncertainty*, quantification of the risks associated with earthquakes is fraught with uncertainties. These include uncertainties about the extent of the earthquake hazard in a given location (hazard assessment), the likely ground motions associated with different events (hazard prediction), the response of structures to those ground motions (damage prediction), and the consequences of those damages (loss estimation). Performance-based assessments rely on quantification of each of these components. Improvements in assessment methodologies seek to improve predicted performance and to reduce the uncertainties associated with each component. The National

Research Council report, citing work by Keith Porter, argues that the greatest uncertainties are associated with hazard assessment and prediction (2006, p. 110).

The benefits of reduced uncertainties are by definition more precise estimates of expected seismic performance. But, not all aspects can be predicted with equal confidence and not all uncertainties can be reduced. A distinction can be made between epistemic uncertainty that expresses the limits of predictive models in depicting underlying processes, and aleatory uncertainty that stems from the inherent randomness associated with each component. Improved seismic performance assessment methods seek to produce more valid predictions about performance and to reduce epistemic uncertainty. The primary benefit of reduced uncertainty is greater confidence in predictions about performance. This, in turn, provides an improved basis for risk-management decisions and a basis for quantifying the degree of uncertainty associated with those decisions.

2.2 CATEGORIES OF BENEFITS AND COSTS

Much of the commentary about performance-based approaches to earthquake engineering in academic journals and trade publications consists of advocacy of the performance-based approach (see Prior and Szigeti 2003 for an overview). Critics, such as Hering (1997), argue that the performance-based approach is being promoted by the engineering community without consideration of the burdens that it imposes on the construction industry. The diverse commentary about the performance-based approach to earthquake engineering provides a variety of claims about potential benefits and costs of the approach.

Table 2.2 summarizes these by categorizing potential benefits and costs into broad groupings. The various claims that are made about each are noted for which the citations are necessarily selective. It is particularly striking that while there has been much commentary about the advantages of performance-based earthquake engineering, there has been no systematic assessment of potential benefits and costs.

Table 2.2 Claims about Benefits and Costs of Performance-Based Approaches

Consideration	Expectation [a]
Prospective Benefits	
• *Construction costs*	• *Lowered* due to greater ability to innovate in design and to optimize design choices (Alesch 1999, Everall 2003).
• *Innovation* potential	• *Increased* incentives for innovation in building approaches and materials (Sexton and Barrett 2005).
• *Enhancement of seismic safety*	• *Increased* due to better ability to predict performance and make better choices about risk management; assuming the choices are indeed made (Alesch 1999, Everall 2003).
• *Losses from seismic events*	• *Reduced* due to "better" choices about risk management; assuming the choices are made (Alesch 1999, Everall 2003).
Prospective Costs	
• *Cost* to:	
• *Building and facility owners*	• *Uncertain*—Greater potential costs of performance assessments and designs weighted against potential long run savings in losses (Alesch 1999).
• *Design community*	• *Increased short run* given educational needs for understanding methods of performance-based design and potential increased liability costs (Alesch 1999, Everall 2003, Loftness, Lam, and Hartkopf 2005).
• *Occupants of performance-based structures (tenants, renters)*	• *Uncertain*— may increase due to increased design costs and market value of safer buildings (Alesch 1999), but could be reduced due to lowered costs of construction and reduced insurance premiums.
• *Governments (regulatory authorities)*	• *Uncertain*— Increased costs of educating building regulators but potential for streamlined review processes for complex structures (Everall 2003); potential increased costs of developing alternative code provisions and standards.
• *Regulatory uncertainty*	• *Increased* - Potential for inconsistencies in interpretation of acceptable non-prescriptive designs and performance predictions; depends on processes for review of alternative designs (Everall 2003, Foliente 2000, May 2002).

Notes:

[a] Expectations provided by sources noted in parentheses about performance-based regulation when compared to prescriptive-based regulatory approaches.

A key argument about the performance-based approach is that it overcomes the limitations of prescriptive regulation that is viewed as overly rigid and for some circumstances too conservative in design requirements. This reasoning suggests that performance-based approaches will reduce costs of construction of facilities due to greater abilities to apply innovative design solutions and to produce innovations. Sexton and Barett (2005) caution, however, that innovation may be constrained because of the inability or lack of incentive of individual contractors to innovate. The broader benefits of enhanced seismic safety and reduced losses noted in the literature are consistent with the societal benefits noted in the prior section.

Consideration of costs depends on the perspective that is adopted: Whether one considers costs to building and facility owners, the design community, occupants of performance-based facilities, or governmental entities. As indicated in the bottom half of Table 2.2, many of these costs are uncertain. The general assumption is that there will be greater initial costs for many actors as they grapple with the implications of performance-based approaches. It is also presumed that design costs, construction costs, and review costs for governmental regulators will be lowered over time as these entities become more familiar with performance-based approaches. Other unknowns are the implications of changes in potential liability for design community and contractors if the expected performance of structures does not materialize in an earthquake event (see Alesch 1999).

An important consideration is the potential for regulatory uncertainty (see May and Koski 2004 for elaboration). Different interpretations of building officials of performance-based provisions or of performance assessments can frustrate use of the performance-based approach. This uncertainty, in turn, can undermine the potential benefits with respect to innovation and cost saving. As noted by Everall (2003) in discussing the experience with performance-based regulation of buildings in the United Kingdom, the reduction of this type of uncertainty rests on the adequacy and consistency of review processes.

2.3 TOWARD QUANTIFICATION OF BENEFITS AND COSTS

Quantification of the prospective benefits and costs of performance-based approaches to seismic assessment and design provides a basis for evaluating the "value added" of the approach. As well, quantification could lead to a better understanding of the situations for which the PBEE approach is most applicable. There are generally three approaches that could be employed for quantifying benefits and costs.

One approach is to consider value of information as it relates to the benefits of improved assessment and design. Similarly, the costs of obtaining that information could in principle be quantified. The primary means in the literature for assigning benefits to the value of information is the "willingness to pay" for information as has been developed in environmental economics (see Carson, Flores, and Meade 2001). The willingness of facility owners and other decision makers to pay for improved information about seismic performance clearly rests on their perceived benefits of that information. Any effort to collect "willingness to pay" assessments has a number of limitations. These include different wealth bases and risk horizons of those who are asked to make such estimates. In addition, some information like the delineation of seismic hazards approximates a public good that is freely, or nearly so, available. To the extent that the information is perceived as publicly available, clients would clearly feel less willingness to pay for it. Despite these limitations, the relevant research questions are: How willing are decision makers to pay for improved information about seismic performance? And, how willing are they to pay for improvements in that information (i.e., reduced uncertainties)? These questions have not been systematically addressed.

A second approach to quantifying costs and benefits is to attempt to establish values for each category as outlined in Table 2.2. This sounds more straightforward than it is in practice. There are substantial data needs and it is difficult to quantify broad benefits such as "enhanced seismic safety." The potential for double-counting different benefits needs be considered. And, problematic issues concerning the relevant time frame and the appropriate discounting of costs and benefits need to be addressed.

A third approach, adopted in the National Research Council (2006) study of improvements to seismic monitoring, is to assume that the benefits of improved information are those consequences that can be projected to follow from the availability of improved information—what the study authors label as "derivative benefits" from enhanced information (p. 63). Following this logic, the NRC report (2006, p. 130) makes assumptions about buildings at risk and rates of new construction to estimate the value of annual benefits of the performance-based approach that follow from better seismic information as $142 million. The largest categories of annual savings are improved seismic hazard maps ($49 million), refined analysis techniques ($34 million), and improved rehabilitation procedures ($34 million). The estimated savings increase as more buildings have seismic instrumentation. The study authors note the limits of these estimates but suggest they provide reasonable ballpark approximations.

The bottom line is that the benefits of performance-based approaches outweigh their costs when considered at aggregate levels such as the nation as a whole. The National Research Council study (2006) suggests that the aggregate potential benefits of improved seismic information far outweigh the costs of developing the information. The circumstances under which the benefits exceed the costs for individual structures are less clear. Building owners and facility managers are increasingly demonstrating their willingness to pay for performance-based design of new and rehabilitated structures. By definition, in such circumstances the perceived benefits exceed the costs. The potential benefits in terms of reduced loss of life, increased functionality, and reduced repair costs is illustrated by the use of the performance-based approach by the University of California, Berkeley, in guiding seismic upgrades of campus facilities (see Comerio, Tobriner, and Fehrenkamp 2006).

2.4 REALIZATION OF SOCIETAL BENEFITS

The realization of the benefits of performance-based earthquake engineering rests on widespread adoption of these approaches in engineering practice. The design professions—architects, engineers, and professionals responsible for the design of structural and nonstructural elements—need to be equipped to understand and take advantage of advances in performance-based approaches. Facility designers need to understand how modifications in the use of a structure affect its ability to withstand earthquake damage and maintain functionality. Earthquake engineers need to be well versed in the methodology of performance-based earthquake engineering as applied to seismic assessment and design for both new and existing buildings. At the same time, fundamental changes need to occur in how earthquake risks are weighed by building owners, the financial community, and regulatory officials. These are broader transformations of thinking about earthquake risks that require the design community to be at the leading edge of educating clients in how to think about choices and tradeoffs in seismic design.

There are a number of challenges in bringing about these changes (see May and Koski 2004 for elaboration). The design professions are understandably often reluctant to embrace new innovations (see May and Stark 1992). Under current liability provisions, the risks associated with problems in design and construction fall heavily on the design engineer and contractors. This serves as a deterrent to acceptance of new approaches, especially if they are not codified as accepted practice. Building owners and other decision makers are asked to think about different aspects of performance that they typically do not explicitly consider.

Ince and Meszaros (2004) suggest the transformation in thinking that is required for a performance-based world is akin to the transformation that has taken place in the doctor-patient relationship over recent decades:

> In the middle part of the 20th century, the practice of medicine was largely paternalistic. Patients asked few questions and ceded the dominant role for treatment to their physicians. It was presumed that "best" treatments existed, that these had been scientifically established, that doctors knew which were most current and valid, and that doctors (rather than patients) were in the best position to evaluate tradeoffs and make treatment choices…. A continuum of alternatives to paternalistic medical practices — from "informed consent" to "professional-as-agent" and "shared decision making" models — has evolved during the latter half of the 20th century. All involve greater information sharing, more patient responsibility, less presumption of physician omnipotence and recognition that diagnoses and treatment options are based on values and judgment, not just on facts or formulas. [(2004, p. 5); references deleted from the quote].

Ince and Meszaros appropriately suggest that the performance-based approach entails a transformation of engineering practice from "paternalism to shared decision making."

Given these considerations, different scenarios can be imagined about the way that performance-based approaches are embraced in the future. As discussed by May (2002), it often takes decades for engineering innovations to be widely accepted in engineering practice. Yet, the societal issues concern more than adoption of these innovations by engineering firms. At issue is the extent to which performance-oriented decision-making is integral to seismic-safety decisions about new and existing buildings, infrastructure, and other facilities. Table 2.3 suggests potential scenarios for the broader diffusion of performance-based approaches to seismic assessment and design.

Table 2.3 Potential Scenarios for Diffusion of Performance-Based Approaches

Scenario	Expectation
• *High-end engineering practice*	• Adoption by high-end engineering firms and their clients for highly-valued new and existing facilities; limited adoption beyond this (status quo).
• *Broader engineering practice*	• Adoption driven by changes in code provisions that embrace these concepts, but only as alternatives to prescriptive-based code provisions.
• *More fundamental code revisions*	• Adoption driven by more fundamental changes in code provisions that embrace these concepts as foundations for codes with simplified methods and design guidelines replacing prescriptive provisions where applicable.
• *Societal demands for seismic safety*	• Adoption driven by client demands for seismically resistant facilities and for functionality much as the "green building" movement entails embracing healthful buildings.

The status quo is perhaps best characterized as adoption by selected engineering firms in response to two sets of demands. The primary demand has come from recognition of the difficulty of applying new code provisions to the rehabilitation of existing facilities or structures. Simply put, applying new provisions is often prohibitively expensive and arguable in terms of desirability. The second source of demand has come from owners and operators of high-valued facilities—computer centers, hospitals, electric utilities—for which it is important to consider the functionality of the facilities in the aftermath of an earthquake. Although modern building code provisions have distinguished among different uses (occupancy classes) of buildings and specified more stringent requirements for higher-rated uses, this delineation does not adequately convey desired performance. The status quo scenario entails continued demands for performance-based approaches that fit these rehabilitation and new facility situations, but limited expansion of the demands beyond these situations.

A somewhat expanded scenario is the use of performance-based approaches more broadly in engineering practice assuming that there are changes in code provisions and regulatory practices that more fully embrace performance-based provisions. Performance-based concepts have been incorporated since 2001 as part of the International Building Code and since 2000 as part of the Life-Safety Code provisions promulgated by the National Fire Protection Association. As clearly stated in the International Building Code documentation, "the performance code is intended as a framework document that creates a method more closely reflecting society's expectations of building and facility performance…" (International Code Council 2001, p. 85). These code provisions are alternatives to prescriptive-based approaches. Because they provide little guidance about application of the performance-based approach, relatively few state and local building departments have adopted the performance-based provisions. As of mid-2006, the International Code Council lists one state (Pennsylvania) and 22 local jurisdictions as having adopted the ICC Performance Code for Buildings and Facilities.[1] This scenario entails continued evolution of these alternate code provisions and envisions incremental adoption of them over time by states and localities.

A further expanded scenario entails more fundamental code revisions that fully embrace performance-based assessment and design as code foundations rather than as alternatives. According to a recent review of international developments in performance-based approaches to building regulation by Meacham et al. (2005), a number of countries are moving in this direction.

[1] Information accessed on 5/16/06 from http://www.iccsafe.org/government/adoption.html

However, “there remain significant challenges in adequately identifying and defining performance, in understanding and addressing diverse societal expectations, and in establishing robust performance-based regulatory systems” (Meacham et al. 2005, p. 91). This scenario entails overcoming these obstacles so that performance-based methods and standards are the foundations for building and other codes. Those standards in turn would, as codes do today, drive practice.

A different, expanded scenario is driven less by codes and more by changes in societal perspectives about seismic safety. Under this scenario building owners, residential homeowners, facility managers, and others would in essence demand greater seismic performance. There would be a market advantage to constructing structures and facilities with greater seismic resistance and greater likelihood of functionality in the aftermath of major earthquakes. As noted above, some of this demand exists today but is largely limited to those who are responsible for high-valued facilities. This scenario entails a more fundamental transformation in perspectives about seismic safety including the development of “markets for safety” (see May, Burby, and Kunreuther 1998). The closest analog to this scenario is the societal embracement of “green buildings” as considered more fully in Chapter 4 of this report.

Three observations are evident from this brief sketch of possible scenarios. One is that wider embracement of performance-based approaches is far from automatic. The demand for these approaches has to be stimulated in order to achieve greater societal benefits. A second observation is that changes in code provisions are important aspects of this transformation. These will drive practice and in turn influence how structures are designed and built. The third observation is that the broadest societal benefits will occur only with more fundamental changes in thinking about and demands for seismic safety.

3 Regulatory Challenges: Setting Safety Standards

Performance-based seismic approaches are appealing because they help expose seismic-safety gains and associated costs. Decision makers can in principle decide what costs they are willing to pay in terms of design choices and dollar outlays to achieve different levels of seismic safety when measured in terms of the dollar value of damages, downtime to facilities, or loss of life. Evaluating these tradeoffs takes on added complications when thinking about seismic codes and minimum seismic-safety standards. This chapter addresses the complications of establishing seismic-safety standards in a performance-based world of seismic safety.

Societal expectations about minimum performance goals are shifting from a murky goal of preventing loss of life to an expanded emphasis on property protection. Increased attention to the economic consequences of earthquakes in the United States was apparent with the Loma Prieta and Northridge events. These entailed little loss of life but substantial economic loss and business interruption. At issue from a societal perspective is whether there is a collective desire to explicitly recognize these considerations as part of minimum seismic-safety standards. Writing shortly after the Loma Prieta event, Bruce Bolt summarized this quest as follows: "Because of indecision between minimizing loss of life and maximizing broader benefits, general agreement on acceptable earthquake risk remains confused" (1991, p. 169).

These issues typically do not typically attract public scrutiny. Instead, they most often play out in the back rooms of regulatory agencies in the give and take of approval of individual structures. At times, however, the stakes for seismic safety do attract attention and lead to more visible discussion of desired goals. One such instance is the debate that ensued during the government approval processes for a major San Francisco condominium and retail development, "Rincon Hill." While much of the approval process for this development addressed various issues concerning affordable housing, impact fees and so on, seismic considerations and the expected performance of the structures in an earthquake were prominent late in the approval process. The history of this is instructive in illustrating the difficulties of characterizing societal expectations and in translating these into meaningful regulatory standards.

Public officials are often reluctant to discuss the level of "acceptable risk" for seismic safety, as that implies a willingness to accept loss of life and/or substantial damage from earthquakes. Yet, an understanding of this is essential for establishing minimum acceptable standards for seismic safety and for decisions about whether a given structure is deemed acceptable or not with respect to seismic-safety criteria. The final section of this chapter considers the dilemmas of establishing acceptable risks in seismic policymaking.

3.1 ONE RINCON HILL: SHIFTING PERFORMANCE EXPECTATIONS

By 2003 developers and planners envisioned the Rincon Hill area in San Francisco as a redevelopment opportunity to contain some 5000 housing units and mixed retail in a dozen tall buildings of 8 to 40 stories. As with any large-scale undertaking that involved multiple developers and owners, the configuration of the vision underwent numerous changes over the ensuing years in order to accommodate neighborhood concerns, traffic considerations, affordable housing demands, business displacement, increased construction costs, and changing market considerations. Numerous players were involved including several developers who were working on plans for individual buildings.

Among the planned buildings was a development labeled One Rincon Hill consisting of two buildings—one 45 and one 55 stories—comprising 707 housing units (originally 712 units). The approval process seemed to be going well until, according to coverage in the *San Francisco Chronicle* (Goodyear 2005a), the city and county's Department of Building Inspection's chief engineer raised questions about whether the relevant seismic-safety standards were adequate to guard against injury and property damage. The *Chronicle* story quoted from an email of the engineer to the consulting engineering firm for the project that said: "We are establishing precedent in the way high-rise condominiums are being built in California and need to adhere to a standard of care that considers public safety first."

That action and the discussion surrounding it brought forth the issues of performance expectations and the associated seismic-safety standards. The core consideration for the building department official was what was meant by prevention of "major structural failures" in the City and County building code. As also reported in the *San Francisco Chronicle* coverage of the issue:

> The question is whether "major structural failures" should be interpreted as meaning buildings should simply be strong enough to resist collapse or whether they should be able to absorb damage that would otherwise render them uninhabitable. "The Department of Building Inspection believes that it is necessary to be 'prospective' rather than 'retrospective' in considering building performance, so that new buildings in San Francisco meet our expectations and do not surprise us with their failure to perform as expected," wrote Lawrence Kornfield, a chief building inspector, in a memo to department Director Amy Lee. (Goodyear 2005b)

As with past practice, a peer review of the design and analysis of the proposed structures had been undertaken prior to this controversy, and that panel recommended approval of the project. The response of the engineering consultants was that the building had passed peer review and that the city should not be making new rules on a project-by-project basis.

Nonetheless, the issues raised by the building department official caught the attention of some elected officials. One who took particular interest was the Chair of the San Francisco Board of Supervisors Land Use Committee. She was quoted in the *San Francisco Chronicle* as saying:

> I have become convinced that the central issue before us is not a specific project [One Rincon Hill] but rather our seismic safety standards for all new residential construction….Currently, the California Building Code requires seismic standards to safeguard against major structural failures and loss of life. But they do not speak to the functionality of the buildings after an earthquake—that is, whether or not residents will be able to return to their homes after an earthquake. I believe that we need building standards specific to San Francisco, specific to our needs. (Goodyear 2006)

The specific issue for approval of the One Rincon Hill project eventually faded as officials recognized that they could not make new policy around one project. Approval of the project was granted in March 2006. Nonetheless, this episode highlights the regulatory dilemmas in interpreting vague statutes and in attempting to respond to shifting societal concerns.

3.2 THE FALLACY OF ACCEPTABLE RISKS [2]

The challenge for San Francisco officials, as is the case for any regulatory authority, is to establish meaningful seismic-safety standards. These specify the minimum requirements for construction. The minimum standards at present are the vague language about life-safety goals as

[2] A more extensive discussion of the issues in this section is provided in May (2001).

embodied in the various formulas contained in seismic codes and guidelines. The end result is that no one really understands what the seismic-safety goals are beyond generalities of "collapse prevention," "loss of life," and "ensuring functioning of critical facilities." Risk analyst Hal Lewis noted over 15 years ago that the "almost universal obstacle to rational regulation is the failure of laws to specify an acceptable level of risk, and what we are willing to pay to get there" (Lewis 1990, p. 77).

The reason for this failure is simple: The term "acceptable risk" implies a politically unacceptable choice. Few elected officials are willing to stand up and say that any injuries or deaths in the event of an earthquake or other catastrophe are acceptable. Even military officials see loss of life not as acceptable, but as an inevitable consequence of military intervention. When forced to talk about risks, politicians tend to gravitate toward an untenable standard of zero risk. Moreover, elected officials are not comfortable in talking about expectations based on uncertain outcomes. Why talk about it if it is not certain to happen? Why confuse people with probabilistic statements?

The political reality is that acceptable risks are rarely explicitly defined. Politicians, who must deal with budget tradeoffs in deciding where to expend limited public resources, tend to begin by thinking about the costs of achieving safety. They consider, for example, how much it will cost to improve the seismic safety of a school to levels recommended by experts. Choices are framed largely with respect to the costs involved. Elected officials are more likely to start with a sense of unacceptable expenditures for seismic safety than desired levels of safety or acceptable risks.

As noted by Aaron Wildavsky (1988) in a provocative book, *Searching for Safety*, the quest for safety in the United States has been an iterative one between implicitly accepting risk and seeking safety. A given set of standards are put in place (e.g., response time for police or ambulance services, goals of protecting life safety for earthquakes) partly as compromise among competing interests but largely in reaction to unacceptable costs of additional improvements in safety. These standards hold until the consequences of a particular event show that they are intolerable. creating new demands and increased willingness to make additional investments in safety.

Some argue that an avenue for considering desired levels of safety is to think about willingness to tolerate different risks. However, comparison of risks, as a means of gaging acceptability, is fraught with problems. It can be useful to make comparisons of the probability of different events—an earthquake, getting struck by lightning, being involved in an automobile accident—in order to communicate what those probabilities entail. But, the acceptability of different risks entails comparing apples and oranges because of differences in the consequences of the events, the benefits associated with activities related to the risks, and the costs of addressing the risks. Simply put, individuals and society are much more willing to tolerate some risks than others. This is because of fundamental differences in perceptions of risks and benefits, and because of differing benefit-risk and cost-risk reduction tradeoffs.

3.3 REVISITING SEISMIC-SAFETY GOALS AND STANDARDS

The need for specification presents the fundamental Catch-22 of determining levels of acceptable risk. On the one hand, determining levels of acceptable risk is fundamentally a value judgment that presumably requires some form of collective decision-making. On the other hand, knowledge of relevant risk considerations, technical details, and costs and benefits are important for establishing meaningful standards. The first consideration argues for public processes for establishing safety goals. The second argues for deference to technical experts. Finding the appropriate middle ground is a serious challenge.

Three general observations can be made about collective decisions for seismic safety. One is that the nature of involvement by experts and citizens makes a difference in the definition of levels of desired safety. A variety of research has shown that experts often differ from lay people in their assessment of risks and the ranking of priorities for addressing those risks (see review by Fischhoff 1989). A second observation is that the legitimacy of the process for determining levels of desired safety is extremely important for public acceptance of the outcomes of that process. This is derived from the trust that citizens place in the agencies that are involved in establishing standards and the perceived fairness of the process (see discussions in Clarke and Short 1992, Dunlap et al. 1993, and Slovic 1993). A third observation is that the challenge is not only one of assembling collective views about safety but also of effectively communicating the tradeoffs in attempting to achieve different levels of safety. This latter point highlights the importance of having meaningful ways of expressing the stakes when choosing different levels of performance.

A recasting of acceptable risk into a discussion of desired *safety goals,* the costs involved of achieving these, and the tradeoffs that they impose could address some of the limitations from a societal perspective of the concept of acceptable risk. The emphasis here is on goals, not technical standards. An example of such an approach is the establishment by the Nuclear Regulatory Commission of a "safety goal policy statement" (see Nuclear Regulatory Commission 1997, and Okrent 1987; for a critique, see Fischoff 1983). The statement addresses risks to the public from nuclear power plant operation with two qualitative objectives and associated quantitative objectives.

The point is not the particulars of the objectives, but the fact that a deliberative, public process was used to establish safety objectives. Those objectives were subsequently translated into technical standards and a process for evaluating adherence to those standards using probabilistic risk analysis. The use of probabilistic risk analysis in informing choices about safety goals has become common in risk management for industrial facilities such as nuclear power and offshore oil and gas facilities. However, as Pate-Cornell (1994) notes in a review of quantitative safety goals, the establishment of such goals requires collective processes for deliberation about the goals.

Consistent with the points made here, Bostrom, Turaga, and Ponomariov (2006) argue that the establishment *a priori* of societal levels of acceptable risk as conceived in the "consequence-based engineering" approach developed by the Mid-America Earthquake Center for addressing community-level earthquake vulnerabilities is fraught with problems. These researchers emphasize the need for deliberative decision processes for bridging the gap between experts and citizens (also see National Research Council 1996). In particular, Bostrom and her colleagues suggest a role for "dynamic earthquake decision structuring" that involves "iterative analysis of a decision, in which the decision structure evolves over repeated analyses" (2006, p. 322). The iterative process provides an opportunity to inform stakeholders about the implications of the choice of different alternatives—seismic retrofit alternatives, seismic-safety standards, and other choices—so that stakeholders can identify and articulate their preferences. New alternatives and information may need to be developed as part of later iterations of this process in response to concerns raised by stakeholders. Although the details of this iterative process have not been worked out by Bostrom and her colleagues, key elements are the structuring of the presentation of information to provide realistic choices, exposure of tradeoffs among the choices, and reframing of choices in response to feedback.

In summary, societal considerations for seismic safety are not well served by a quest to define acceptable levels of seismic risk. Shifting the discussion to desired levels of safety is important for framing relevant decisions. However, this shift in thinking is not sufficient for evaluating tradeoffs among different safety goals and the costs of achieving them. Choices about seismic safety will be advanced with attention to framing collective deliberations that inspire confidence in the processes and the results. This suggests formation of deliberative, transparent processes that are not dominated by code-writing entities.

4 Reaching Out to Society: Lessons from Green Buildings

The increased societal concern about property protection reflects a growing awareness of the consequences of earthquakes. Little of this seems to have translated into a strong push among various stakeholders for greater levels of seismic safety. This requires not only greater societal awareness of earthquake risks and their consequences but also a transformation of the way that building owners, developers, financial entities, and the design community think about seismic safety. An instructive example of this transformation is how the “green building” effort has grown in response to what is perceived as a societal need for healthful, more energy-efficient, and less costly to operate buildings.

That effort encourages construction of energy-efficient and environmentally healthful buildings that are designed and constructed to have reduced operating costs. Commentators about the movement (e.g., Fleishman 2005) suggest that it has been fueled by increased concern over energy costs and the consequences of indoor pollution, along with recognition among the building industry that green buildings can have positive financial payoffs. The movement has become world wide with similar efforts to promote green buildings being undertaken in France, the Netherlands, Norway, Sweden, and the United Kingdom. While critics see the green-building movement as simply efforts by some architects and contractors to gain market advantages, the movement is clearly striking a responsive chord among a range of diverse construction, environmental, and consumer interests. These are considered in what follows.

One component of the green-building movement is the adoption of state requirements that green-building provisions apply to state buildings, schools, and other public facilities. As of early 2006, fifteen states required that state buildings or other public facilities be constructed to adhere to green-building standards. State policymaking for green buildings presents an enigma that is useful to examine given the important role that state governments play in adopting seismic-safety standards. On the one hand, the adoption of the state green-building requirements does not appear to be controversial. Legislative debates have taken place out of the limelight with enactment by overwhelming majorities. And, governors have signed executive orders about green buildings with little fanfare. On the other hand, as of early 2006 only 15 states had mandated state adoption of green-building requirements. The reasons for state adoption of green-building requirements are analyzed as part of this chapter.

Seismic safety has yet to achieve a similar status of engendering a common concern and, as such, the societal benefits of performance-based seismic engineering are not well articulated or recognized. Nonetheless, the green-building movement illustrates the importance of coalition-building among design professions, industry, and consumers to promote adoption of new philosophies of building design and construction. These lessons are considered in the final section of the chapter.

4.1 THE GREEN-BUILDING MOVEMENT

The green-building movement has evolved over the past decade from a hodge-podge of disparate interests to a broad-based industry coalition—the U.S. Green Building Council (USGBC)—comprised of some 6,000 building-related architectural, construction, engineering, finance, insurance, and supply organizations along with various governmental and non-profit organizations. Green buildings are "designed, constructed, and operated to boost environmental, economic, healthful, and productive performance over the conventional building" (U.S. Green Building Council 2003, p. 4). The USGBC organization promulgates voluntary standards, the Leadership in Energy and Environmental Design (LEED) standards, which are the basis for certification of buildings in accordance with a checklist of 69 attributes of green buildings. Based on the number of criteria met, a facility can be recognized as certified (26-32 points), silver (33-38 points), gold (39-51 points), or platinum (52 plus points).

According to Frangos (2005a) and the U.S. Green Building Council (2003), as of 2005 over 1800 buildings have been certified as complying with LEED standards. These include facilities by major automakers, Wal-Mart stores, bank branches of PNC Financial Services, and buildings at a number of universities. A new Seattle public library and a new Pittsburgh convention center were among the first public facilities to receive LEED ratings as silver and gold, respectively. One example of an iconic green building is the Bank of America Tower being constructed in midtown Manhattan New York City. This is the first commercial building to receive the LEED platinum status.

Unlike many environmental regulations, the green-building movement has not engendered large-scale opposition among business interests. The National Association of Homebuilders (NAHB) has typically led the charge against new regulations that are perceived as driving up the costs of home construction. In this instance, the NAHB has “sought to fill the need for cost-effective voluntary model Green Building guidelines to combat attempted mandates by regulators” with promulgation of model guidelines and formation of a Green Building Initiative to foster adoption of the guidelines (National Association of Homebuilders 2005). Although

Commercial construction has been the focus to date of most green-building activity, there is no organized opposition among commercial construction entities. Indeed, many commercial construction firms and the NAHB see business opportunities in endorsing green buildings.

Environmental groups have endorsed principles of green buildings as part of their advocacy of energy conservation measures but have actively promoted them only on a selective basis. For example, in 2003 the California Chapter of Greenpeace helped to organize a student 10-campus tour in support of green buildings on University of California campuses. Another example is the Environmental Defense Fund’s “Green Dream House” contest that gave away a house that utilized recycled products and conserved energy. The strongest endorsement of green buildings by environmental groups is the Natural Resource Defense Council’s advocacy of green construction for commercial and residential structures. The organization devotes a sizeable section of their website to examples of green buildings, certification procedures, and financial and other benefits of green buildings.

The limited resistance to green buildings is diffuse. There is skepticism about intangible benefits and concerns about certification costs and procedures (see Frangos 2005b). Critics question the LEED certification requirements for giving equal weight to relatively trivial tasks like installing bike racks and more extensive tasks like the use of solar energy. Another source of opposition is building suppliers, particularly wood suppliers that feel that their products are disadvantaged in gaining acceptance for green construction.

4.2 EXPANSION OF THE GREEN-BUILDING MOVEMENT [3]

A variety of factors have helped propel the expansion of the green-building movement from the nascent effort of a decade ago to extensive activities of today. These include adoption of widely accepted voluntary standards, federal leadership in calling attention to sustainable buildings, and coalition-building and educational activities of the U.S. Green Building Council.

4.2.1 Market Creation—The Role of Standards

A critical ingredient for the success of the green-building movement is the creation of a tier of voluntary standards for certification of green buildings that is widely accepted. As noted above, critics suggest that the standards are little more than a "checklist" of different actions that does not adequately reflect the contributions of the individual actions to sustainability improvements. In response to these criticisms, the standards have been modified over time.

According to the "White Paper on Sustainability" authored by the editors of *Building Design and Construction* (Reed Publications 2003), the brilliance of the LEED standards is threefold. First, the standard works well because it is simple to understand. Second, it appeals to the competitive nature of Americans: "it takes a complex, multifaceted problem—sustainable design and development—and turns it into a game, with clearly established rules and intricate strategies, where Building Teams can decide how far they want to go, right up to Platinum, and devise a strategy to meet the mark" (p. 8). Finally, LEED has another "secret ingredient" that makes the acceptance of the system so widespread: "a branded metric that establishes a means of comparison in the real estate market" (p. 8).

In essence, the standards and actions of the USGBC have helped to foster a market for green buildings. As with any healthy market, there is an increasing supply of buildings that are constructed to LEED standards and increasing demand for facilities that meet these standards. These demands have in turn spurred innovation by the building industry with respect to green-building technologies and materials. These include the development of super-efficient window systems and use of day-lighting, reflective roofing, efficient lighting systems, and new types of paint.

[3] Josh Sapotichne contributed in helping to author this discussion of the green-building movement.

It is important to note that the process of applying LEED standards does not guarantee optimal green-building results. According to a report by the Center for Sustainable Systems at the University of Michigan, "While LEED appears to be accomplishing the goals of an eco-labeling program that is [successful] as a marketing and policy tool, it is not as successful at being a comprehensive methodology for assessment of environmental impact" (cited in Reed Publications 2003, p. 9). In other words, a checklist and successful marketing strategy does not a comprehensive green-building methodology make.

4.2.2 Federal Leadership

National attention to issues concerning healthful and environmentally friendly buildings was spurred with President Clinton's announcement on Earth Day 1993 of an initiative for greening the White House. While not specifically linked to the green-building standards, the White House initiative highlighted the potential of green buildings. In 1998, President Clinton issued three "greening" executive orders—E.O. 13101, 12123, and 13148—calling upon federal agencies to reduce the environmental impact of their buildings and overall activities.

As the federal government's largest civilian property management organization, the General Services Administration was the first federal agency to join the USGBC in January 2001. The agency and has since formalized its commitment in following LEED standards for which all new GSA designs as of October 2004 had to meet LEED "certified" status. The GSA has also incorporated sustainable design language into key facility design and selection documents. A number of federal agencies—including the Department of Energy, Environmental Protection Agency, Forest Service, Interior Department, National Park Service, Department of State, and the U.S. Air Force, Coast Guard, and Navy—have subsequently joined the USGBC and have overseen projects that embrace sustainable building design.

4.2.3 Coalition-Building Activities

Markets do not just emerge; demand and supply often need to be stimulated. The U.S. Green Building Council played active roles in both aspects of market creation. The coalition is broad and fairly democratic in nature. One reviewer (Kats 2003) concluded that members feel as if they are listened to, since the LEED standards are continually evolving "through large professional, voluntary committees, and a staff" that is responsive to the diverse needs of its membership (p. 5).

As discussed in a review of the green-building movement in a special issue of *Building Design and Construction* (Reed Publications 2003), the process by which LEED standards were developed had flaws. The USGBC initially purposely excluded trade associations, which function on a consensus basis within their respective industries, from joining the organization, out of fear that trade groups would use their financial resources and lobbying capacity to take over the organization. Representatives of trade associations have subsequently been invited to join the USGBC.

The coalition has served multiple functions: raising awareness of green buildings, a forum for discussion of green-building standards, information-sharing, recognition of leaders in the movement, and education about green-building practices. Each of these enhances the market for green buildings by stimulating demand, enhancing supply, and encouraging innovation. As discussed in the review noted above: "The USGBC spends millions of dollars each year to support LEED in a number of ways, including: an extensive training program; the LEED Accredited Professional exam; a Resource guide; LEED templates; and extensive LEED website for registered projects, technical data, and scientific committees; and a growing staff of professionals dedicated to LEED" (Reed Publications 2003, p. 8).

4.3 STATES AND GREEN BUILDINGS [4]

As summarized in Table 4.1, as of early 2006 a number of states have recently required that state structures adhere to green-building standards. Some state requirements have been mandated by gubernatorial executive orders while others have been subject to legislative enactment. The provisions include state incentives for constructing green buildings, mandates for adherence to LEED provisions for new facilities, and requirements for LEED provisions for renovated buildings that meet specified size or value requirements. The relevant facilities differ among states for which all of the mandates include new state buildings.

State efforts concerning green buildings have received considerably less attention than the coverage of Clinton's greening of the White House and of the green-building movement

[4] A more extensive treatment of this material is contained in May and Koski (2007). As with this article, Chris Koski made noteworthy contributions to this report's discussion of state mandates for green buildings.

more generally. Media coverage has been relegated to reporting about the new requirements and stories about state buildings constructed as green buildings. Governors have signed executive orders with little fanfare. Legislatures have passed laws with limited discussion and overwhelming majorities (see Table 4.1). Consider the experiences of two states.

Table 4.1 State Mandates for Green Buildings

Year[a]	State	Provisions	Governor (Party)	
		Executive Order Adoption		
2001	New York	New state projects — incentives to be green	Pataki	R
2002	New Jersey	New school designs	McGreevey	D
2003	Maine	New or expanding state buildings	Baldacci	D
2004	California	New and renovated state facilities	Schwarzenegger	R
2005	Arizona	All state-funded buildings	Napolitano	D
2005	Michigan	New state-funded buildings and major renovations	Granholm	D
2005	Colorado	All state buildings	Owens	R
2005	Rhode Island	All new, expanded, or renovated public buildings	Carcieri	R
2006	New Mexico	All public buildings over 15,000 gross square feet	Richardson	D
		Legislative Adoption		
2001	Oregon [b]	Sustainable tax credit for green buildings	57-3; 26-3[c]	D
2005	Washington	New state-funded buildings and major renovations	78-19; 32-16	D
2005	Maryland	New, major state capital projects	134-1; 47-0[c]	R
2005	Nevada	All state-funded state buildings, tax incentives	38-0; 19-0	R
2005	Pennsylvania	Incentives for new school construction	193-5; 50-0	D
2005	Arkansas	Encouragement for green design in state facilities	91-0; 35-0	R

Source: U.S. Green Building Council (2006) for state adoption and content.
Notes:
[a] States are ordered within categories of adoption by year and month of adoption.
[b] Governor Glendening (D) issued a green building executive order in 2001 that was less extensive than the legislation adopted in 2001.
[c] State legislative roll call votes in State House and Senate respectively. Data collected from individual states.

In December 2004, Governor Schwarzenegger (R-California) signed an executive order requiring all new and renovated state-owned facilities meet LEED silver standards. This executive order is a part of the governor's sustainable development initiative that also includes executive orders calling for increased use of hybrid fuel technologies in state vehicles, an energy-reduction plan during times of supply-induced energy emergencies, and a reduction of greenhouse gases. Schwarzenegger's office issued a single press release for the executive order that folded green buildings into an announcement of plans for a new major electricity transmission line (California Governor's Office 2004). Perhaps because of the way the issue was announced, the requirement to meet LEED standards was largely unmentioned in the California press.

In April 2005, Washington became the first state in the nation to adopt legislation requiring state construction that meets LEED standards. The bi-partisan sponsored law requires LEED silver certification for state construction of buildings over 5,000 gross square feet including renovations where the cost exceeds 50 percent of the original building value. The bill encountered some opposition that focused on the unknown costs and benefits of the bill, and the burdens that new requirements would pose for state agencies. At the time of the bill signing and in subsequent months, the governor's office issued four press releases. Among them was an announcement that the Governor was awarded national recognition by *Public Works* magazine as among those "who have defined policy, brought their community or an issue into the spotlight, or set the standard within the industry" in citing the green-building legislation (Washington Governor's Office 2005a). Despite this publicity, the enactment of the requirement was largely ignored in Washington State media with some coverage of the bill signing and visits by the governor to state buildings that were being constructed to the new standards.

The arguments used by these two governors in touting green buildings had different emphases. Governor Schwarzenegger's rationale contained both in the executive order and the press release about it highlights the economic benefits of sustainable building practices. In addition to a projected cost savings of $100 million on energy costs, the press announcement cited the goal of "operating the most energy and resource efficient and healthful public buildings in the country" (California Governor's Office 2004). Washington Governor Christine Gregoire's comments about the green-building legislation highlighted the broader environmental benefits in noting "[w]ith this bill, Washington state is taking the lead to build schools and other state buildings that do a much better job of protecting Washington's air, land and water" (Washington Governor's Office 2005b).

The preceding discussion suggests that a number of factors need to be considered when analyzing adoption of state requirements for green buildings. One set of considerations is the pressure for action or inaction posed by relevant stakeholders. A second set of considerations is the role of the state energy bureaucracy. A third consideration is gubernatorial power over state agencies and legislative relations. A fourth set of considerations is energy demands. These factors are considered in what follows in analyzing first the adoption of state green-building requirements and second whether the requirements are adopted by legislative action or by executive order.

4.3.1 Data and Measures

Our consideration of state green-building requirements draws inspiration from the many studies that consider the political and economic determinates of state policy adoption (see Miller 2004 for an overview). The 50 states are the unit of analysis. We have attempted to match the year of various data to the year of the adoption decisions as closely as possible. As noted above, the adoption decisions range from 2001 to early 2006 for which the list of relevant states was obtained from the U.S. Green Building Council (2006). We use secondary data for 2001 and 2003 about energy demands, and for 2001 about construction sector size obtained from the *Statistical Abstract of the United States*. Data about the governor's party, status of divided government, and gubernatorial powers are for the year that the policy adoption took place with data for non-adopting states as of 2005. Data about bureaucratic structure are for 2005.

The expectation is that various groups' opposition to green buildings would lessen likelihood of adoption of state requirements and that support by groups would strengthen likelihood of adoption. Gaining an understanding of the pressure-group environment is difficult given the low salience of green-building issues at the state level. We employ a direct measure of interest-group advocacy and opposition drawn from a survey of state energy and building code officials conducted in 1995 by Burby and May (see May 1997). Respondents were asked about the existence of a set of organized interests and whether they advocated, opposed, or did not have a role in influencing the adoption or enforcement of energy and building codes.

We used these data to construct summated indices of the degree of advocacy and opposition for 12 groups that include (in order of involvement) state homebuilder organizations, chapters of national code organizations, professional architect organizations, organization of local building officials, energy-conservation groups, structural engineer organizations, local inspector organizations, construction industry organizations, utility industry groups, consumer advocacy groups, environmental groups, and insurance industry groups. Key supporters are state chapters of national code organizations and energy-conservation groups. The strongest opposition to stronger codes comes from state homebuilder organizations.

We also use the size of a state's construction sector as a proxy for the potential stakes in regulating green-building practices on a more widespread basis than state government alone. Because aspects of the construction industry benefit from green-building requirements by opening new markets for construction and with higher fees, construction interests may not be hostile to state green-building requirements. We measure construction influence as the percentage of gross state product that the construction industry comprises.

A relevant bureaucratic consideration is whether a state has an established agency with an energy-specific mission. While all states have designated energy officials as part of federal funding for state energy initiatives, the creation of independent energy offices is of particular interest. The assumption is that states with such organizations place higher priority on energy-related programs. These organizations also act as information conduits about sustainability programs like green-building requirements. Given these influences, we expect that states with separate energy organizations are more likely to enact green-building mandates. We use a dichotomous classification of whether the energy policy of a state is administered by an energy-specific agency obtained from a 2004 listing of state energy programs by the U.S. Department of Energy.

The relevant gubernatorial consideration is the degree of power that a governor has over state agencies. We employ Beyle's (2005) measure of gubernatorial appointment powers, which represents the extent to which a governor's ability to appoint executive level positions is independent of the state legislature. We employ measures from 2001 to 2005 based on year of state adoption; we use data for 2005 data for non-adopting states.

An obvious constraint for state policymaking is the match between the governor's party and those of different houses of the state legislature. As discussed by Bowling and Ferguson (2001, also see Ferguson 2003), the nature of divided government can profoundly affect opportunities for gubernatorial entrepreneurship. As evidenced by the listing of the governor's party and legislative majorities in Table 4.1, adoption of green-building requirements is not a highly partisan issue. But consistent with the broader patterns of divided government influences, we expect that governors with strong gubernatorial powers are more likely to turn to executive orders for policy enactment when they face legislatures with one or more chambers controlled by the opposite party.

We measure divided government in three different ways with particular attention to divisions among the legislative branch and the partisanship of governors. One measure is a dichotomous measure of divided government for which unified governments receive a score of zero and governments in which the governor and at least one chamber of the legislature differ by party receive a score of one.[5] A second measure is for divided governments with Democratic governors and at least one chamber of the legislature in Republican control as a score of one and all others scored zero. A third measure is for divided governments with Republican governors and at least one chamber of the legislature in Democratic control as a score of one and all others scored zero. Data for gubernatorial party and legislative control are from the National Conference of State Legislatures for 2001 to 2005 corresponding with year of green-building adoption; we use 2005 data for non-adopting states.

Consideration of commercial energy consumption and power cost are not central to our analysis but are important to consider in the context for state policymaking. We employ three indicators: commercial energy consumption per capita (2001 data—in trillions of BTU), the percent of total electric consumption that is consumed by commercial entities (2001 data), and the cost of commercial power (2003 data—in dollars per million BTU). The presumption is that greater demands, as measured by these three indicators, will increase likelihood of adoption of green-building requirements as one step in lessening energy consumption.

4.3.2 Modeling State Policy Adoption

Table 4.2 presents a set of logistic regression models explaining the likelihood of adoption of state requirements for green buildings. The models are based on explanations related to interest group influences, bureaucratic considerations, energy demands, and a combined model. The separate explanations are presented to show the relevance of each strand of explanation. Because of the inability to directly interpret logistic coefficients, the last column of Table 4.2 shows a more meaningful measure of the effects of each factor on likelihood of adoption. Each effect is the predicted change in the probability of adoption of a green-building requirement that is associated with a change in a given factor from the lowest quartile to the highest quartile of the

[5] We also considered whether it made a difference if divided government consisted of one house only (weak divided government) or both legislative chambers (strong divided government). The findings did not differ appreciably from those when using our simpler measure. The latter is preferred given the limited number of cases in our dataset, especially when considering analysis of legislative versus executive order adoption.

data while other factors are set at their mean value. Only statistically significant effects at the .1 level of significance or below are shown.

A few general patterns stand out from the findings in Table 4.2. First, the difficulty of predicting state adoption is indicated by the relative low percentages of the state adopters that are correctly classified except for the combined model. This is not surprising given that only 30 percent of the states have adopted requirements for green buildings. Second, the combined model is the most appropriate model to consider, since it has stronger conceptualization and greater predictive ability. We focus on these results in the discussion that follows. Third, each of the explanatory strands has factors that contribute to likelihood of adoption.

We consider various facets of interest-group advocacy and opposition for stronger energy codes. As shown by the effect analysis, interest-group advocacy and opposition as expected have opposing influences for which the strength of the latter is nearly three times the magnitude of the former. The positive effect for increased construction sector size shows that the construction sector is more likely to embrace rather than oppose green buildings. This factor also likely reflects a "wealth effect" in that states with larger construction sectors tend to be wealthier states that can better afford to bear the additional up-front costs of green buildings for state facilities.

Table 4.2 State Green-Building Policy Adoption

Explanatory Factors	Interest Groups	Bureaucratic Forces	Energy Demands	Combined Model	Effect Analysis [b]
	Logistic Regression Models for Different Explanations [a]				
Interest Considerations					
Interest group advocacy	.32** (.16)		--	.74** (.32)	.08
Interest group opposition	-.44 (.35)		--	-1.29** (.69)	-.23
Construction sector size (ln)	2.43 (2.18)			6.90** (3.73)	.07
Bureaucratic Considerations					
State energy agency	--	1.63** (.81)		2.25** (1.26)	.26[c]
Gubernatorial agency power	--	1.49*** (.02)		2.49** (1.23)	.16
Energy Demands					
Electricity consumption [d]		--	-8.68** (4.26)	-18.25** (8.94)	-.49
Percent consumptions that is commercial		--	.18*** (.07)	.37*** (.15)	.29
Commercial power cost (ln)		--	-3.98* (2.57)	-8.45** (4.56)	-.27
Constant	-5.24	-6.05	27.72	41.24	
Model Statistics					
Cox & Snell R^2	.10	.21	.21	.48	
Percent classified correctly	72	76	76	90	
Adopters classified correctly	20	40	40	80	
Chi-square Goodness of Fit	4.99	11.47***	11.76***	32.61***	
Sample Size	50	50	50	50	

Notes: * p < .10, ** p < .05, ***p < .01; Wald test (one tailed) for coefficients and Chi-square GOF for overall model fit. Standard errors in parentheses.

[a] Dependent variable is whether a given state adopted a Green Building requirement or not

[b] Each cell shows the change in the probability of obtaining a green building requirement associated with the explanatory factors. These probabilities are computed by evaluating the change in predicted probabilities for a given factor when moving from the value at the 25th percentile to that of the 75th percentile of all states while evaluating other variables at mean values.

[c] The relevant modeling of the effect for this variable is between no established state energy agency (value of 0) and an established agency (value of 1)

[d] Commercial power consumption per capita using ln values.

A key consideration in green-building adoption is whether a state's energy policies are administered by an independent agency that focuses solely on energy issues or an agency that deals with a number of different issues. The presence of an independent agency increases the likelihood of adoption by .26, everything else equal. We suggest that the presence of a focused energy agency serves multiple roles. One is an information conduit in bringing knowledge and expertise about green buildings to the executive's attention. Another is an advocate for greater attention to energy efficiency in state government. A third is a resource for addressing objections to green-building requirements. The creation of an independent energy agency may also show greater commitment on the part of states and their governors to address energy problems, making those states more predisposed to adoption of green-building requirements.

States for which governors have stronger appointment powers over state agencies are also more likely to adopt green-building requirements. As we show below, this reflects the willingness and ability of governors with stronger powers to enact executive orders for green buildings. Separate analyses show that the presence of divided government does not affect the likelihood of adoption of green-building requirements ($p = .33$ for divided government when added to the model). This likely reflects a combination of the nonpartisan nature of green buildings and the fact that executive orders can be employed to overcome legislative obstacles.

The findings concerning energy demands are more mixed compared to our expectations. As expected, states with larger percentages of energy being used by the commercial sector are more likely to adopt green-building requirements as indicated by the positive effect for that factor. However, the negative effects of increased commercial electricity consumption and of increased commercial power costs on likelihood of adoption are at first glance puzzling. We attribute these outcomes to the negative relationship between increased energy costs and consumption (Pearson $r = -.71$ $p = <.01$). Separate analyses show that states that adopt green-building requirements have higher commercial power costs, but those states and the commercial entities within them are also more likely to have taken steps to reduce energy costs.

Stated differently, green-building requirements are more likely to be adopted in states that have already taken steps to address high energy costs. This is evidenced by a number of states for which adoption of green-building requirements are part of broader sustainable energy initiatives and by the fact that a majority of states with green-building requirements are members of the Clean States Energy Alliance. As previously mentioned, Governor Schwarzenegger's green-building executive order was part of a larger sustainability initiative. Governors Richardson (New Mexico), Napolitano (Arizona), and Carcieri (Rhode Island) coupled these executive orders with comparable orders to increase fuel efficiency of their respective state's motor fleet. Governor Granholm's (Michigan) green-building order is but one plank of a four point energy executive order addressing energy efficiency in buildings, state motor fleet, state purchasing, and state capital outlay projects.

4.3.3 Form of Policy Adoption

One of the unique aspects of adoption of state green-building requirements is that a majority of the requirements have been adopted through gubernatorial executive orders. Consideration of the circumstances under which the requirements are adopted by legislation or by executive orders enhances the understanding of the role of different institutions in state environmental policy innovation. In examining this, we consider the contingent nature of gubernatorial decision-making. This incorporates the plea of Miller (2004) to open up the black box of state decision-making in policy adoption studies.

We expect that governors respond to their political environment strategically in making choices about executive orders in response to various considerations (also see Bowling, Ferguson, and Clemons 2006). One consideration is the interest-group environment. All else equal, governors will be gun-shy if there is opposition to the new requirements, and more likely to issue orders if there is support for them. Governors with stronger powers are more likely to use those powers. But, the choice about that discretion is likely to be affected by the presence of divided government. A simple expectation is that governors are more likely to issue executive orders if they face opposing party majorities in one or both houses of the legislature.

A more nuanced expectation is that their decision-making depends on the strength of their powers and their party affiliation. Stated differently, governors with strong powers are more likely to enact executive orders in the face of divided government. Additionally, the party of the governor is likely to make a difference in this calculus, since the issue presents different strategic opportunities to Republican and Democratic governors in the face of divided governments. Powerful Republican governors in this situation have a strategic advantage in issuing green-building mandates to claim credit with little fear of reprisal from Democratic legislatures that would normally be supportive of environmental legislation. Powerful Democratic governors encounter more risk of being overturned by Republican-dominated legislatures if they issue green-building mandates because of legislators' concerns about costs being imposed on government.

We are constrained by the limited number of cases of policy enactment for modeling adoption by legislative versus executive orders. This restricts the number of variables we can consider and the power of the statistical tests. Nonetheless, as shown in Table 4.3, some simple logistic models are relevant. Three models are presented that incorporate different aspects of interest-group, gubernatorial, and legislative considerations in predicting legislative (coded 0) versus executive order (coded 1) adoption of green-building requirements. Each has similar predictive power, which is largely a function of the high ratio of variables to observations. We consider the third model to be conceptually strongest. The last column of Table 3 shows the more meaningful measure of the effects of each factor on likelihood of executive order adoption for the third model. These are calculated in a similar manner to the effects described above.

All three models show that decisions to issue executive orders are responsive to the interest-group environment. As shown by the effect analysis, issuance of an executive order is much less likely if there is opposition to stronger energy-code provisions than the corresponding positive influence of support for stronger codes. The implication is that in the face of opposition, governors are more willing to let legislators deal with the issue. The positive effect for gubernatorial power shows that governors with strong powers are more likely to issue executive orders regardless of interest-group makeup or divided government.[6]

[6] As with other effect analyses, this statement applies when evaluating the other factors at their mean values. If the level of interest group opposition increases to the highest quartile of the data, the effect of gubernatorial power is reduced 43 percent.

Table 4.3 Legislative versus Executive Order Adoption

	Logistic Regression Models [a]			
Explanatory Factors	**Model 1**	**Model 2**	**Model 3**	**Effects [b]**
Interest Considerations				
Interest group advocacy	1.09* (.72)	1.09* (.71)	1.08* (.67)	.03
Interest group opposition	-3.02* (1.90)	-3.02* (1.88)	-2.97* (1.89)	-.43
Gubernatorial Considerations				
Democratic governor	-4.60* (3.53)	--	--	--
Gubernatorial agency power	6.64** (3.87)	6.59** (3.82)	6.09** (3.61)	.19
Legislative Considerations				
Divided government	.05 (1.21)	--	--	--
Divided government — Democratic governor	--	.26 (2.34)	--	--
Divided government — Republican governor	--	4.70* (3.51)	--	--
Divided Democrat X gubernatorial power [c]	--	--	.11 (.63)	n.s.
Divided Republican X gubernatorial power [d]	--	--	1.47* (1.05)	.68 [e]
Constant	-22.49	-27.02	-25.30	--
Model Statistics				
Cox & Snell R^2	.46	.46	.47	
Percent classified correctly	80	80	80	
EO adopters classified correctly	89	89	89	
Leg adopters classified correctly	67	67	67	
Chi-square GoF (p-value)	9.14 (.10)	9.15 (.10)	9.60 (.09)	
Sample Size	15	15	15	

Notes: * p < .10, ** p < .05, ***p < .01; Wald test (one tailed) for coefficients. Standard errors in parentheses.

[a] Dependent variable is whether a given state's Green Building requirement was enacted by legislation (value 0) or adopted by executive order (value 1).

[b] Cell entries show the change in the probability of Executive Order adoption of a green building requirement associated with the explanatory factors shown in Model 3. These probabilities are computed by evaluating the change in predicted probabilities for a given factor when moving from the value at the 25th percentile to that of the 75th percentile of data for all states while evaluating other variables at mean values.

[c] Divided government with Democratic governor and one or more houses Republican times gubernatorial power index.

[d] Divided government with Republican governor and one or more houses Democratic times gubernatorial power index.

[e] The effect is evaluated as the change in both the gubernatorial agency power and the change in the interaction term.

The remaining findings concern the role of gubernatorial power and divided government. Model 1 suggests that the party of the governor makes a difference but divided government does not. Models 2 and 3 unpack these considerations. In particular, the findings of model 2 show that Republican governors facing Democratic legislative opposition are more likely to enact executive orders, but the reverse does not hold for Democratic governors. The findings of model 3 further suggest that this influence depends on the extent of gubernatorial power. As shown by the effect for the interaction term of Republican divided government and power, those governors with strong powers and less receptive legislatures have an increased probability of .68 for enacting green-building mandates by executive orders than do other governors.

The notion of governors responding to political cues that correspond to their party affiliation and powers makes intuitive sense and is consistent with what Bowling, Ferguson, and Clemons (2006) label as strategic behavior in issuing executive orders. Our findings are also consistent with Bowling and Ferguson's (2001) findings about the impact of divided government and partisanship on the selection of issues by governors. They show that economic issues are more likely to be favored by Republican governors in the face of divided government, whereas they are less likely to endorse environmental issues.

The strategic behavior is further illustrated by our findings about how governors frame the green-building issue as illustrated by the difference between California's Schwarzenegger and Washington's Gregoire. In touting the economic benefits of green buildings Schwarzenegger could satisfy his constituency while also risking little fear that the generally pro-environmental Democratic legislature would object. In touting the environmental benefits of green buildings, Democratic Governor Gregoire risked little resistance from a Democratic legislature. As noted earlier, Schwarzenegger chose a low profile for the issue whereas Gregoire sought greater publicity.

This finding of a strong role for governors differs from most studies of state policy adoption that show limited gubernatorial influence (Gerber and Teske 2000, 860–61). This may be because prior studies do not adequately consider the issuance of gubernatorial executive orders. Our findings show that in the case of green buildings, governors respond to their political environments in exercising their administrative discretion through issuing such orders. They are less likely to issue them when faced with interest-group opposition and more likely to do so when they have strong powers; especially in states where Republican governors face legislative majorities of the opposite party. These actions are the consequence of strategic behaviors in deciding to endorse the issue and how to frame discussion about it.

Taken together, these findings demonstrate the relevance of state mandates that govern actions of public entities as noteworthy components of state environmental policymaking. This is a less studied aspect of state innovations in environmental policymaking that calls attention to the role of state bureaucracy and gubernatorial action in issuing executive orders.

4.4 GREEN BUILDINGS AND MARKETS FOR SEISMIC SAFETY

What lessons can be drawn from the green-building experience for performance-based earthquake engineering approaches? The broadest point is that the green-building movement has fostered a new ethic for developers, consumers, and building suppliers. This in turn has fostered a market for green buildings. Three sets of lessons stand out from the green-building experience. Similar lessons are provided by May, Burby, and Kunreuther (1998) in their discussion of lessons for seismic safety from developments in energy conservation, radon reduction, and termite control.

One set of lessons concerns the importance of understandable information about performance. Key elements are the development of rating systems and standards for taking action. The LEED standard for green buildings provided a means for evaluating "greenness" as well as a way of certifying adherence to various levels of the standard. Although the checklist approach has been critiqued, the key point is that it can be applied in a variety of settings and with relative ease. Another element is certification of builders who adhere to green-building standards providing a "good housekeeping" seal of approval. A final element is widespread educational efforts among consumers and the building community about green buildings accomplished through extensive media coverage, workshops, and professional trade publications.

A second set of lessons concerns the crafting of outreach programs and coalition-building efforts. These are targeted efforts aimed at various components of the building sectors involved in materials supply, design, and construction of buildings. The U.S. Green Building Council became both a forum and an advocacy organization for green buildings. It also took the lead in different outreach programs. Although the green-building movement may appear as a grass-roots springing of demand, the reality is quite different. The effort is a highly orchestrated one that involved strategic choices about coalition recruitment and activities. The design of effective outreach and educational programs for seismic safety requires multiple channels and partners involving highly targeted programs.

A third set of lessons involves governmental leadership and the leveraging of governmental resources. The Clinton administration's "greening of the White House" and issuance of executive orders mandating that federal agencies adhered to sustainable building practices provided important federal leadership. State-level mandates that public facilities be constructed to meet green-building standards added to that momentum. The federal and state actions helped legitimize the LEED standards while also fostering attention to the potential for green buildings.

Despite the important role of governmental leadership, the successes of the green-building movement and the programs discussed by May, Burby, and Kunreuther (1998) were not accomplished through governmental action alone. Each entailed harnessing the interests of non-governmental entities in order to bring about new markets. The clearest illustration of this is the critical role that energy utilities play in energy conservation. The general lesson is that the interests of non-governmental entities need to be mobilized in order to leverage governmental resources. Broad constituencies that advocate action are important catalysts for bringing this about, but they do not typically exist with respect to seismic safety.

5 Conclusions

This report has considered various aspects of the societal implications of performance-based approaches to earthquake engineering. These include consideration of the societal benefits of the approach as developed by PEER, scenarios for future adoption of performance-based assessment and design methods, the challenges for regulatory authorities, and the lessons for “reaching out to society” from experience from green buildings. This concluding chapter summarizes the key points of the earlier chapters and provides some broader observations.

5.1 SOCIETAL BENEFITS OF PBEE

The societal benefits of performance-based approaches to earthquake engineering have not been well articulated. The diverse commentary about the performance-based approach provides a variety of claims about potential benefits and costs of the approach that have been reviewed in this report. Simply put, the benefits are the “value added” of the performance information in enhancing seismic design and risk management. These include an improved understanding of risk objectives, costs of achieving different objectives, the components of different sources of risk as they relate to structural versus nonstructural contributions, and the vulnerability of different elements of a portfolio of buildings or infrastructure networks like highways. Quantification of performance also provides a basis for rethinking existing code provisions and the implications of seismic designs that deviate from code prescriptions. The benefits of reduced uncertainties are by definition more precise estimates of expected seismic performance.

Quantification of the prospective benefits and costs of performance-based approaches to seismic assessment and design provides a basis for evaluating the “value added” of the approach. Three different approaches for achieving this have been discussed in the report: (1) a “willingness to pay” approach to valuing the information; (2) valuation of specific categories of information and their costs; and (3) valuation of the consequences that can be projected to follow from the availability of improved information. None of these have been systematically undertaken. Partial assessments discussed in this report show that the benefits of performance-based approaches outweigh their costs when considered at aggregate levels such as the nation as a whole.

5.2 FUTURE SCENARIOS FOR PBEE ADOPTION

The realization of the benefits of performance-based earthquake engineering rests on widespread adoption of these approaches in engineering practice. The level of adoption of PBEE methods among engineering firms at present is fairly limited. Several scenarios beyond modest expansion of the status quo have been presented in this report: (1) the use of performance-based approaches more broadly in engineering practice based on changes in code provisions and regulatory practices that more fully embrace performance-based provisions; (2) broader adoption based on more fundamental code revisions that fully embrace performance-based assessment and design as code foundations rather than as alternatives; and (3) much wider expansion driven by changes in societal perspectives about seismic safety.

Regardless of the scenario that is considered, wider embracement of performance-based approaches is far from automatic. The demand for PBEE approaches has to be stimulated in order to achieve greater societal benefits. As is evident from the first two scenarios, changes in code provisions are important aspects of this transformation. These drive practice and in turn influence how structures are designed and built. The broadest societal benefits will occur only with more fundamental changes in thinking about and demands for seismic safety.

5.3 REGULATORY CHALLENGES

The challenge for regulatory officials is to establish meaningful seismic-safety standards. The minimum standards at present are the vague language about life-safety goals as embodied in the various formulas contained in seismic codes and guidelines. As illustrated here by the discussion of the One Rincon Hill development in San Francisco, what constitutes meaningful seismic-safety standards is increasingly being debated. These debates necessitate revisiting appropriate seismic-safety standards.

Specifying appropriate standards entails a fundamental Catch-22 in determining societal levels of acceptable risk. On the one hand, determining levels of acceptable risk is fundamentally a value judgment that presumably requires some form of collective decision-making. On the other hand, knowledge of relevant risk considerations, technical details, and costs and benefits are important for establishing meaningful standards. The first consideration argues for public processes for establishing safety goals. The second argues for deference to technical experts. Finding the appropriate middle ground is a serious challenge. As discussed in this report, the notion of "acceptable risk" is itself a problematic basis for establishing regulatory policy.

A recasting of acceptable risk into a discussion of desired *safety goals,* the costs involved of achieving these, and the tradeoffs that they impose could address some of the limitations from a societal perspective of the concept of acceptable risk. Simply put, societal considerations for seismic safety are not well served by a quest to define acceptable levels of seismic risk. Shifting the discussion to desired levels of safety is important for framing relevant decisions. However, this shift in thinking is not sufficient for evaluating tradeoffs among different safety goals and the costs of achieving them. Choices about seismic safety will be advanced with attention to framing collective deliberations that inspire confidence in the processes and the results. This requires formation of deliberative, transparent processes that are not dominated by code-writing entities.

5.4 REACHING OUT TO SOCIETY

The increased societal concern about property protection reflects a growing awareness of the consequences of earthquakes. Little of this seems to have translated into a strong push among various stakeholders for greater levels of seismic safety. This requires not only greater societal awareness of earthquake risks and their consequences but also a transformation of the way that building owners, developers, financial entities, and the design community think about seismic safety. An instructive example of this transformation that is considered in this report is how the "green-building" effort has grown in response to what is perceived as a societal need for healthful, more energy-efficient, and less costly to operate buildings.

A variety of factors have helped propel the expansion of the green-building movement from the nascent effort of a decade ago to extensive activities of today. These include adoption of widely accepted voluntary standards, federal leadership in calling attention to sustainable buildings, and coalition-building and educational activities of the U.S. Green Building Council. Several sets of lessons are drawn here from consideration of the green-building movement. One set of lessons concerns the importance of understandable information about performance. Key elements are the development of rating systems and standards for taking action. A second set of lessons concerns the crafting of outreach programs and coalition-building efforts. These are targeted efforts aimed at various components of the building sectors involved in materials supply, design, and construction of buildings. A third set of lessons involves governmental leadership and the leveraging of governmental resources. Despite the important role of governmental leadership, the success of the green-building movement was not accomplished through governmental action alone. Much was accomplished by harnessing the interests of non-governmental entities in order to bring about a market for green buildings.

The most salient lesson from the green-building movement for performance-based earthquake engineering is how the effort has grown in response to what is perceived as a societal need for healthful, more energy-efficient, and less costly to operate buildings. Seismic safety has yet to achieve a similar status of engendering a common concern. This may be in part because the societal benefits of performance-based seismic engineering are not well articulated or recognized. In this regard it is important to remember that the broadest societal benefits of the performance-based approach are not just wiser decisions about seismic objectives and design, but the design and construction of safer facilities and of more resilient infrastructure.

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