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Building Energy-Efficiency: Best Practice Policies and Policy Packages

Extended Summary

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Chapter 1 – Introduction

1.1. Importance of Building Energy Use to Reducing Global CO_2 Emissions

Climate change poses a serious threat to mankind over the coming decades. It will likely remain a critical issue through the lifetimes of our children and our children's children. The primary cause of climate change is the increase in greenhouse gas (GHG) emissions, the most significant of which (in terms of impact) is carbon dioxide (CO_2). Energy use and the accompanying CO_2 emissions have grown uninterrupted in the past decades (Figure 1-1). Buildings have been the end-use sector with the largest absolute growth in CO_2 emissions during this period. Figure 1-2 shows the emissions from the building sector for the United States, the European Union, China, India, and the rest of the world. The relatively low energy use in the building sector in India—combined with its large and growing population—foreshadows very substantial future increases in energy and CO_2 emissions from that sector in India (IEA, 2011a).

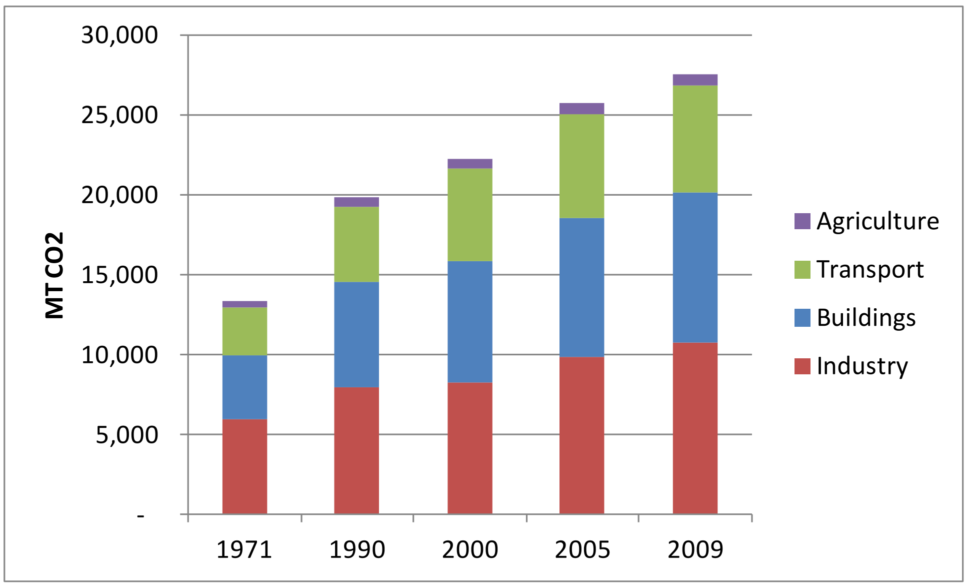

Figure 1-1. Global CO_2 Emissions per Sector (Mt CO_2)

Source: Sectoral emissions were calculated based on IEA data (IEA, 2011b) and following the methodology detailed in (de la Rue du can & Price, 2008).

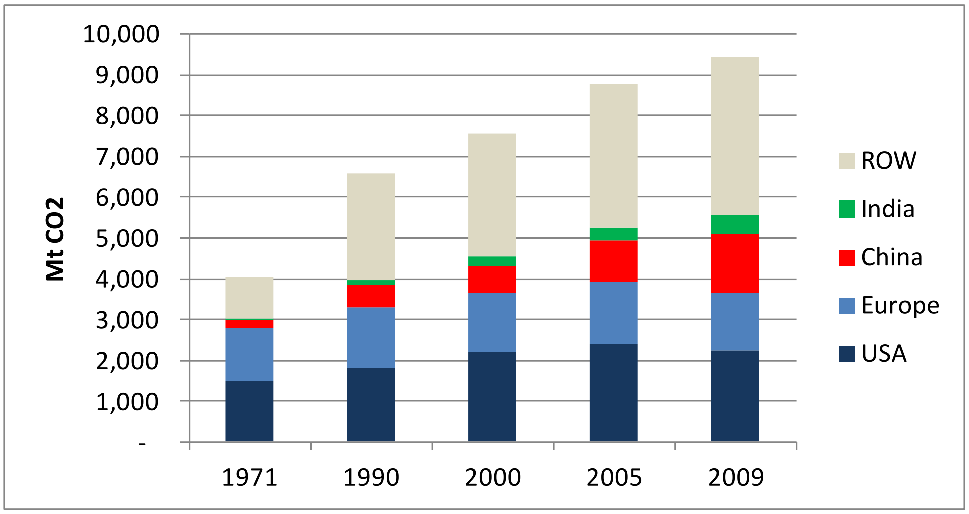

Figure 1-2. Building-sector CO_2 Emissions for the United States, the EU 27, China, India, and the rest of the world

Source: Regional emissions were calculated based on IEA data (IEA, 2011a) following the methodology explained in (de la Rue du can & Price, 2008).

In the four regions of the United States, the European Union, China, and India, as well as in the rest of the world, trends in CO_2 emissions growth from the building sector vary significantly.[1] Emissions have increased rapidly in Asia, notably in India and China, with average annual growth rates (AAGRs) of 6.6% and 5.5%, respectively over the past 38 years. The growth of emissions was slightly greater in the past decade than in the previous three decades.

In Europe[2] and the United States, on the other hand, CO_2 emissions from energy use in buildings over the period 1971-2009 increased at an AAGR of 0.4% and 1.1%, respectively. In the past decade, there had been virtually no growth of emissions in the United States (AAGR of 0.1%) and very little in Europe (AAGR of 0.3%).

These trends are shown in Figure 1-3. Further disaggregation of the data (not presented here) of Figure 1-3 shows that the growth rate of commercial building energy use was greater than residential sector building energy use in all regions (except in China where the two are approximately equal) during the recent past (2000-2009).

[1] Data are not available to separate out heating, ventilation, and air conditioning (HVAC) energy use for the four regions. CO_2 emissions from HVAC energy use have grown at a slower rate in Europe and the United States than non-HVAC energy use, but the trends otherwise follow those in Figure 1-3.

[2] The data we have are for Europe as a whole. Using data from the European Union would not change the observations in the text.

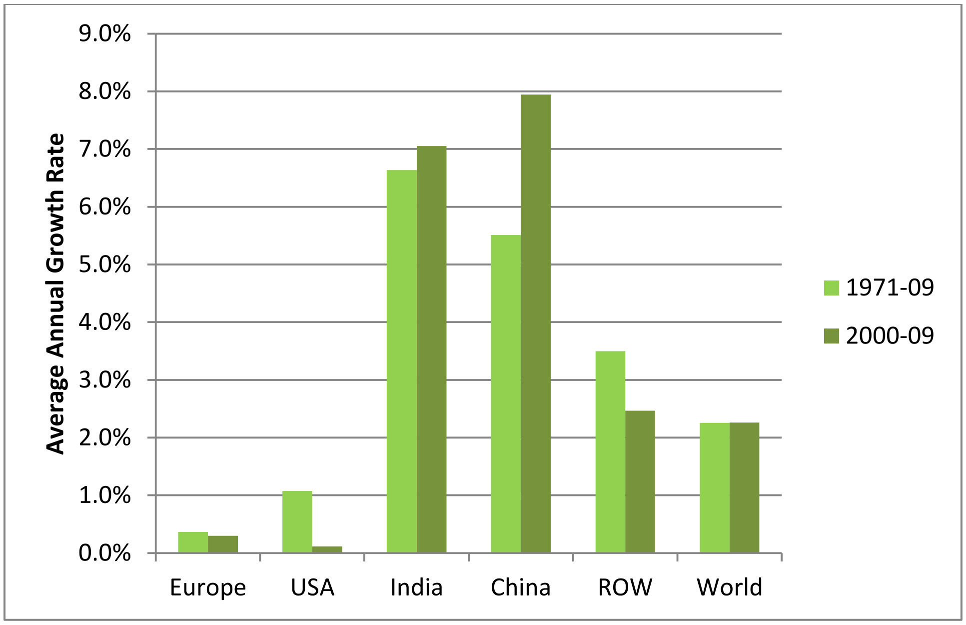

Figure 1-3. Average Annual Growth Rate of CO_2 Emissions from Energy Use in Buildings

Reducing energy use in buildings is the most significant among many opportunities to reduce GHG emissions. A piece of little-publicized analysis from the Intergovernmental Panel on Climate Change (IPCC) contains a remarkable finding that has proven this point. Figure 1-4 shows that, in the absence of carbon taxes or fees greater than \$20/tonne CO_2, the potential CO_2 emissions reduction from building energy use is projected to approximately equal the reductions from all other energy-related sources (energy supply, transport, and industry) combined!

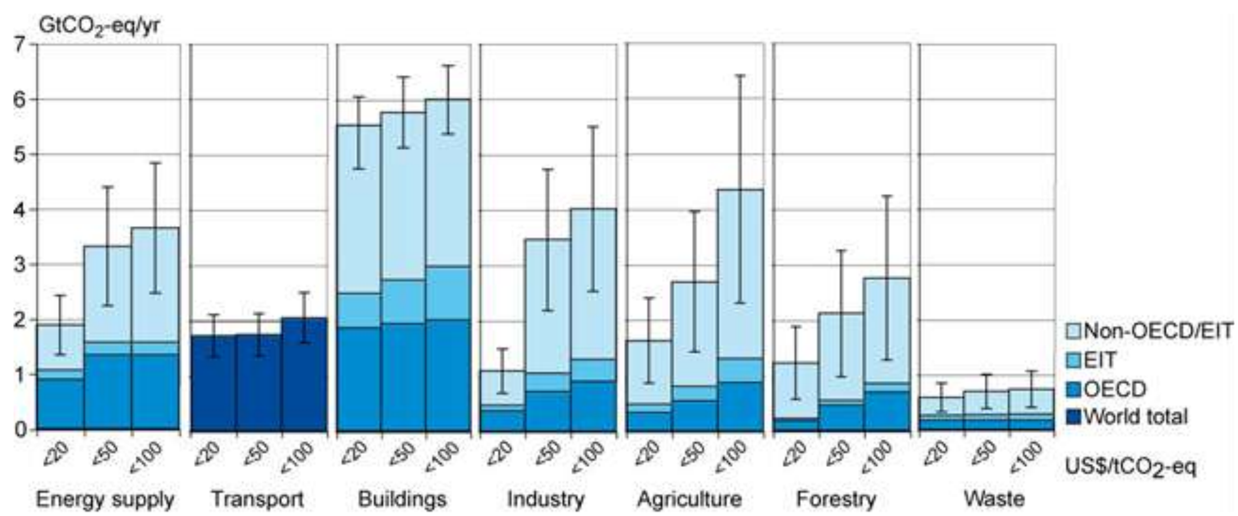

Figure 1-4. Estimated Potential Reductions in Annual CO_2 Emissions by Sector in 2030

Source: (IPCC, 2007)

Note: Estimates do not include non-technical options, such as lifestyle changes.

1.2. Objectives and Scope

The primary objective of this research has been to explore retrospectively the performance of building energy standards, labels, and incentives in reducing space conditioning energy use in buildings and the associated CO_2 emissions in major regions of the world.

We seek to achieve this objective by first reviewing experiences in the design, implementation, and enforcement of the three policies and policy packages[3] in the four regions: the United States, the European Union, China, and India. These regions will produce over the coming decades on the order of 80% of CO_2 emissions from building energy use in excess of emissions today.

The two developed regions (the United States and the European Union) differ importantly in the characteristics of their building stock and in the policies and institutions that underlie their efforts to reduce energy use in buildings. The two developing countries (China and India) differ from each other in the energy use of space conditioning in current and future buildings, as well as their policies, numbers of trained building professionals, and institutions that influence building energy use.

This review examines policies at the national and the regional (e.g., the European Union) level and assesses selected case studies of policies implemented at the sub-regional level in the United States, the European Union, and China[4]. *The combination of experiences in larger-scale (national/regional) policy implementation and smaller-scale (sub-regional) case studies forms the basis for identifying policies and policy packages that exemplify "best practices*."[5]

Although this report does not directly address the future, the information presented provides the context for defining opportunities and barriers to reducing building-related CO_2 emissions. The IPCC notes in its mitigation assessment that for the GHG emission reductions sufficient to limit global temperature rise to ~2°C, a deep, dramatic emissions cut is required. This translates into a need to reduce energy use dramatically. Two factors make buildings pivotal in efforts to achieve such deep cuts: emissions from energy use in buildings are growing faster than in other sectors, and the building sector has the most potential, compared with industry and possibly transportation, to use policies and technologies to cost-effectively reduce energy growth.

1.3. Definition of the Term "Best Practice"

Perhaps it is not a surprise that researchers and analysts do not see eye to eye when it comes to the definition of the term "best practice." Typically, "best practice" is associated with the use of

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[3] By "policy packages" we mean the combination of two or more of the three policies considered in this report with each other (or in principle with other programs and policies), implemented concurrently in the same place.

[4] No case studies are presented for India as that nation is in early stages of implementation of energy efficiency policies. All case studies deal with experiences that have taken place over a five, ten or more year period so that there is information available about their performance.

[5] The next section of this chapter describes how the term "best practice" is used in this report.

technologies; in this report, this term is used to describe implementation of policies and policy packages to reduce energy use in buildings.

The "first-tier"[6] criteria we use to screen potential "best practice" policies are:

- Large energy savings per building;
- High cost effectiveness;
- Effective administration and minimal administrative costs per building;
- High compliance rates; and
- Ability to scale to states, countries, or collections of countries (for case study policies).

Other details that are essential to understand the policies and how they are implemented include descriptive information such as the purpose and means of carrying out a program, whether it is voluntary or mandatory, the skill set of professionals in the building trades (including policy enforcement agencies), the types of buildings to which the program is applied,[7] features of the building market, and other qualitative factors.

Some of the "second-tier" criteria that one can identify for best practice policies, but for which data are generally not available, are:

- **Policy Design:**
    - Availability of tools;
    - Appropriate use of tools and their results;
    - Degree to which the policy drives advances in technology.
- **Implementation:**
    - Flexibility;
    - Feasibility;
    - Availability and clarity of information for consumers and building professionals;
    - Number and knowledge of implementation and enforcement officials;
    - Frequency of policy updates.
- **Enforcement:**
    - Quality of enforcement program;
    - Existence and magnitude of penalties for non-compliance.
- **Assessment and evaluation:**
    - Existence;
    - Frequency;
    - Quality.

Although additional criteria could be used, we do not use them for this report. This is because, for the majority of selected policies that have been applied in different countries and the regions (i.e., the European Union), it is not possible to find data on all of the "first-order" criteria. In contrast, because

6 By "first-tier" criteria, we mean those that in our judgment result in the largest energy and net cost savings.

[7] New or existing buildings, residential or commercial, single family or mixed use.

the focuses of the sub-regional case studies and technology examples are much more circumscribed than regional policies, in many cases we have information about “second-order” criteria.

Chapters 2–5 present our review of building energy-efficiency policies in the United States, the European Union, China, and India. Chapter 6 examines best practice case studies in the United States, the European Union, and China. Chapter 7 compares the stages of implementation and effectiveness of policies among regions. Chapter 8 concludes the report with findings and recommendations.

Chapter 2 – Best Policy Practices in the United States: Indicators and Issues

This chapter summarizes indicators as well as issues related to best practices in U.S. building energy codes, labels, and incentives.

2.1. Building Energy Codes

The subsections below describe indicators of best practices and issues related to U.S. building energy codes.

2.1.1. Best Practice Indicators

Transparency: The IECC and ASHRAE code development processes are open and transparent, allowing diverse stakeholders an opportunity to participate. This open process increases acceptance of the final product, which can be incredibly important to state-level adoption efforts.

Regular and frequent code revision cycles: The regular and frequent U.S. code revision cycles improve the stringency of codes and keep codes up to date with advances in technology and construction practices. The result is that building energy efficiency and energy savings continue to increase, and codes become tools for market transformation.

Flexibility in code design and compliance pathways: While far from universal in the United States, there are states and cities that allow for technology advances and provide tools and alternative compliance paths for meeting the standards. Two well-known examples are California at the state level and Austin, Texas with its zero-energy-capable-buildings code.

Local "stretch" codes: U.S. provisions for local governments to adopt codes that exceed the statewide requirements give flexibility to progressive municipalities, those with more resources, and those facing specific energy-related constraints who wish to enact more stringent minimum codes. More stringent codes at the local level result in energy efficiency beyond the minimum levels specified in state codes, which helps to increase the overall efficiency of the building stock.

Utility involvement: The U.S. practice of providing utilities with incentives to incorporate building code support into their program portfolios (i.e., allowing utilities to claim savings from code support activities) leverages utility relationships with builders, designers, and contractors; builds on utility expertise in education, training and outreach; and reduces the burden on local building departments.

Support from industry, non-governmental organizations, and governments: In some states, electric and gas utilities are empowered and allowed increased profits to provide technical assistance for customers in meeting standards and/or incentives for exceeding the standards. Some states and cities engage non-profit organizations with technical expertise to assist in design of standards. Local governments often provide support beyond code compliance. These are best practices; they are not, as yet, widespread.

Code compliance software: The use of code compliance software (such as REScheck or COMcheck) simplifies the task of establishing or evaluating designs to assure code compliance. These codes work with the national level (voluntary) codes and with some state-level codes.

Complementary policies: In some states, building codes are coupled with building energy labeling and disclosure policies as well as incentives for exceeding the code.

2.1.2. Issues

Code revision lead times: Current lead times for the IECC and ASHRAE code development processes and subsequent U.S. Department of Energy (U.S. DOE) review and certification curtail the aggressiveness of code revisions. By the time revised codes are implemented, technologies and construction practices have evolved, and the underlying cost and cost-effectiveness assumptions are often outdated. In addition, there is often a lag between U.S. DOE's adoption of a new code and states following suit. Establishing mechanisms to trigger automatic state review and adoption of the latest model codes as soon as U.S. DOE adopts them would ensure their timely rollout, which would increase energy savings. This has been the case in the U.S. state of Maryland where a trigger provision led the state to adopt the 2012 IECC before U.S. DOE had issued its final determination on the revised code. Such mechanisms might also reduce politically motivated delays in code review, which sometimes occur despite extensive stakeholder engagement in code development.

Funding and use of third parties: Allocating sufficient funding for code compliance and enforcement initiatives is critical to effective building energy codes. Funding should enhance or, at a minimum, maintain existing budgets for building department training, inspection, and outreach to the building community. One way to reduce the burden on local building departments is to expand code compliance models to include the use of third parties for plan review and inspections. Under a third-party compliance model, most costs are paid by the builder and passed through to homebuyers. The role of third parties will be of increased importance with the increased performance testing requirements in the 2012 IECC.

2.2. Building Energy Labels

The subsections below describe indicators of best practice and issues related to U.S. building energy labels.

2.2.1. Best Practice Indicators

Robust rating system: U.S. experience with the Home Energy Rating System (HERS) and more recently with LEED demonstrates the importance of rater training and certification and adequate tools for modeling and/or calculating a building's rating. These features increase the credibility of ratings and facilitate their use in mandatory programs and labeling policies.

Stakeholder involvement: The U.S. practice of engaging stakeholders in updates to rating and labeling improves the usefulness of these programs, increases buy-in and support for labels, and enhances marketing.

Consumer/user research: U.S. building energy and rating labels that have been based on consumer research incorporate designs and features that have made them effective in practice and facilitated implementation.

Public education and awareness: Campaigns to educate the public and prepare key market players have been critical to the success of new building labels and implementation of building rating policies in the United States. Education and awareness builds demand for voluntary labels and engages the market. Training for building owners and vendors has had a marked impact on early compliance with mandatory rating and labeling.

Program coordination among federal and state governments and utilities: Working with existing programs has leveraged the impact of U.S. labeling programs by taking advantage of existing program infrastructure and utilities' relationships with homeowners, building owners and managers, and other relevant stakeholders (e.g., contractors and real estate agents).

Detailed recommendations for building improvements along with ratings: The time when a building is rated or assessed for a label is a prime opportunity to engage owners in potential energy-efficiency upgrades. Providing recommendations as part of the rating package helps U.S. building owners understand their opportunities and options.

2.2.2. Issues

Need for broad mandatory labels and enforcement: To date, much of the activity on building energy labeling in the United States has focused on development of rating and labeling systems for adoption on a voluntary basis by builders and building owners, use in ratepayer-funded and other efficiency programs, or incorporation into lending programs. The recent emergence of mandatory building labeling requirements in a number of states and municipalities will increase the reach and impact of these rating and labeling schemes. Broader adoption of mandatory labeling requirements at the local, state, and federal levels is needed, coupled with strong enforcement.

2.3. Financing and Incentive Programs

Driving investments: Energy-efficiency resource standards, energy savings targets, and other policies can drive investment in energy efficiency. Targets, particularly when coupled with performance incentives or other measures that reward entities that exceed their goals, have been demonstrated to increase spending and to expand the breadth and depth of program offerings in the United States.

Stakeholder engagement: Engaging a broad range of stakeholders in policy and program development and implementation in the United States has helped create better-designed incentives and with increased participation rates.

The subsections below describe indicators of best practice and issues related to U.S. building energy incentives.

2.3.1. Best Practice Indicators

Incentives that match the market: Incentives can be matched to the market by adjusting their timing, amounts, and delivery mechanisms. Where program administrators have the flexibility to monitor the market and make midstream adjustments to their programs, programs are more effective in yielding energy savings and driving market transformation.

Education and outreach: The U.S. experience demonstrates the importance of funding program budgets and plans that are adequate to cover education and outreach to market participants, ensuring that participants understand incentive and program rules. The U.S. commercial buildings tax incentive was much more successful in driving lighting upgrades than other types of retrofits. The lighting industry's public outreach efforts played an important role.

Targeted programs: U.S. commercial-sector programs targeted to specific market segments maximize participation and savings as demonstrated by ratepayer-funded programs and ENERGY STAR efforts targeted toward the commercial real estate, office, retail, hospitality, food service, and health care sectors.

Evaluation: Tracking and evaluation mechanisms are built into the majority of U.S. programs. Those that also have the flexibility to make midstream corrections and improvements in response to needs revealed through program evaluation have been the most effective.

Policies to address barriers: In the most successful programs, program designers research potential barriers and objections to new energy-efficiency program approaches and work with stakeholders to address or pursue policy mechanisms to remove barriers before introducing programs.

Savings mechanisms: U.S. programs—particularly emerging on-bill financing initiatives—often include mechanisms to ensure that savings exceed payments (e.g., robust audit procedures). Effective project financing provides positive cash flow for the home or building owner while reducing the risk of default for the lender.

Mechanisms to facilitate repayment: Emerging U.S. programs have demonstrated early success by incorporating mechanisms for facilitating customer repayment of costs for energy-efficiency measures. Based on this experience, policy guidance and legislation that encourage the use of available financing (e.g., requiring that utilities offer on-bill financing with a revolving loan fund or loan-loss reserve from federal or ratepayer funds) is a best practice.

Investor risk: The chances of attracting private-sector capital are increased when the government establishes loan-loss reserves or covers on-bill programs in existing loan-loss reserves, an approach used in a number of programs in the United States. Loan-loss reserves differ from loan guarantees by only assuming a portion of the risk—enough to make programs more attractive to investors.

Financing linked to the building, not the owner: Initial experience with the Property-Assessed Clean Energy (PACE) program and similar financing options in the United States indicates that financing mechanisms that associate repayment with the building rather than with the current owner are promising ways to reduce the perceived risk that dissuades many owners from pursuing retrofit projects. These mechanisms also encourage installation of energy-efficiency measures at properties that the owner does not plan to retain for a long period.

2.3.2. Issues

Lead times and engaging other stakeholders: Experience to date demonstrates the importance of creating market certainty by allowing sufficient lead time for the market to prepare for a new program, and by establishing a program duration that makes it worthwhile for all parties to invest in marketing the incentive. As states and utilities with limited experience begin to offer incentive programs—which is happening in many previously lagging areas of the country—it is crucial that they heed the lessons learned over the past two decades, including the need to increase program impact by engaging other stakeholders in selling the program and its benefits to their customers and clients.

Support for comprehensive retrofits: Comprehensive retrofit projects maximize energy savings as well as other non-energy benefits by offering building owners an opportunity to consider interactive effects among building systems or system components, system design issues, and the role of operations and maintenance practices. Incentive and other programs that focus on specific individual building components, such as lighting, improve energy efficiency, but programs that encourage comprehensive retrofits produce the greatest overall savings and are most cost effective in the long run. Utility cost-effectiveness tests should be amended and updated to remove barriers to comprehensive retrofit programs. Among other issues, it is important to recognize that customers are often pursuing (and paying for) non-energy benefits as part of a retrofit. Cost-effectiveness tests should be applied so that participant costs associated with non-energy benefits do not distort the cost effectiveness of the program energy savings.

2.4. Conclusions

The United States has established a robust infrastructure of policies, programs, and tools energy-efficient buildings. Recent code revision cycles have produced increasing levels of energy savings with some leading jurisdictions working toward very low and net-zero energy capable new construction. The number of states adopting or updating building codes has increased significantly in recent years, and new efforts are under way to better evaluate code compliance and improve understanding of compliance deficiencies. Energy rating and labeling programs are generating a high level of interest and are viewed as trusted sources of information, increasingly influencing purchase and retrofit decisions. In the commercial sector, building rating and labeling has become a core component of many ratepayer-funded efficiency programs and is part of emerging mandatory energy-use-disclosure programs. In the residential market, ratings and endorsement labels are a growing presence, particularly for new homes. New rating programs targeting existing homes are being introduced to spur greater investment in energy-efficiency retrofits. State-level energy-efficiency policies and energy-savings targets are driving ever greater investment of ratepayer funds in efficiency and encouraging innovation in program design. Beyond ratepayer-funding, federal, state, and local policies are increasing public investment and encouraging greater private financing of efficient new construction and retrofit projects.

Despite excellent success in establishing a strong U.S. policy and program infrastructure, challenges remain. Among the areas where U.S. policy and programs could be improved are: timing of code updates and new programs, funding and other support for compliance, and developing programs to encourage comprehensive or "deep" retrofits to maximize savings.

In sum, the significant and laudable advances in code development and adoption in the U.S. sometimes fail to deliver their savings potential because of significant deficiencies in code compliance and enforcement; moreover, U.S. rating and labeling programs, while trusted and in many ways effective, must be updated and better utilized to identify and promote advanced performance and the most efficient buildings and homes—both new and existing. In a mature building market like the United States, existing buildings represent the greatest opportunity for energy savings but also present the greatest challenges technically, economically, and in terms of program delivery and implementation. To meet increasingly aggressive energy and carbon-reduction goals, the United States must build on and expand its program and policy infrastructure and incorporate best practices to accelerate the rate of building retrofit and deepen the level of energy savings in each retrofit project.

Chapter 3 – Best Policy Practices in the European Union: Indicators and Issues

This chapter summarizes indicators as well as issues related to best practices in the European Union's building energy codes, building energy labels, and building energy incentives.

3.1. Building Energy Codes

The subsections below describe indicators of best practice and issues related to EU building energy incentives.

3.1.1. Best Practice Indicators

For many years, building codes have been a central driver of energy efficiency in new buildings. As a result of the EU Energy Performance of Buildings Directive (EPBD), and particularly with the requirement to achieve nearly zero energy buildings (nZEB) starting in 2020 (2018 in the public sector), the importance of building codes has been further enhanced. EPBD has moved EU member states toward integrated building energy performance-based codes as opposed to prescriptive, element-based requirements. The EU experience highlights the following best practices:

Regular and transparent code revision cycles: A few EU member states (Denmark, Germany, and others) have regularly set tougher building energy performance standards, with two to five years between updates, and with revisions announced well in advance to prepare the industry for the next round of regulation. Research, development, and demonstration projects that far exceed the prevailing minimum standards have also been useful in providing leading indicators of potential future targets for energy performance.

Voluntary standards: Voluntary standards provide a means to go beyond the minimum national requirements and demonstrate the practical experience of constructing or renovating buildings to higher energy performance levels. In Europe, the Passive House and MINERGIE standards demonstrate good practice. As the number of buildings meeting such voluntary standards has grown, so policy makers increasingly see them as defining the next iteration of mandatory performance codes. However more effort is needed to define low-energy buildings and nZEBs in term of energy performance, to share experience among all member states, and to possibly harmonize definitions.

Learning by sharing: A unique feature of the EU region is that it deals with 27 member states that have different cultures, languages, backgrounds, and experience. Nevertheless, the European Union has been successful in establishing a platform for communication among professionals and practitioners, which has helped them share experience and has proven to be an effective way to converge on some harmonized definitions, methodologies, and standards. The access to a network of experienced actors on specific topics has brought invaluable resources to the process. Communication networks have been most successful when organized for specific actors. Here are two successful EU examples:

- Concerted Action (CA) is a European network restricted to policy makers in charge of preparing technical, legal, and administrative building energy-efficiency policy. This network has created a gateway for country representatives to learn from others on different aspects of energy performance of buildings policy implementation.

- An example at a national level is the French Effinergie, where experts and constructors come together and work on developing standards for low-energy buildings. Participants use the network to share knowledge about construction of such buildings.

3.1.2. Issues

Compliance with building codes: The strategy for control and enforcement varies a lot among EU countries, and data are lacking on compliance rates by country. Compliance is a very important subject but also a sensitive issue in Europe. Moreover, definitions of non-compliance and therefore compliance rates vary significantly among country studies. The definition of compliance can range from simply submitting the right documents to checking the energy performance calculation method to comparing measured energy performance values to calculated values.

Comparing building code stringency: Despite some harmonization in the use of whole-building performance standards, there is still wide variation in the way member states have set these standards, and there is no robust, simple, and fair method available to compare the different national requirements. Early in 2012, the European Commission (EC) published a methodology and guidance for calculating cost-optimal levels of minimum energy performance requirements for buildings. These documents will help each country to compare current code energy performance levels with cost-optimal levels. This will also allow evaluation of progress toward cost optimal policies within each member state.

Low-energy building cooling and lighting standards: Voluntary low-energy building standards, such as Passive House, have so far been adopted mainly in colder regions of Europe. There is a need to develop suitable standards for warmer regions in the south and to increase deployment of low-energy buildings. Passive House has been successful in demonstrating how it is possible to significantly reduce the need for space heating, but the standard does not include cooling or lighting. A low-energy standard for cooling and lighting needs to be developed, and buildings using this performance standard need to be constructed as examples that can be replicated.

Gaining more experience with nZEBs: With the requirement for all new EU buildings to be nZEB within a decade, there remains a major learning curve for practitioners across Europe regarding the technical specifications, construction practices, and costs of such buildings, both residential as well as non-residential.

3.2. Building Energy Labels

The subsections below describe indicators of best practice and issues related to EU building energy labels.

3.2.1. Best Practice Indicators

The Energy Performance Certificate (EPC) was introduced in all EU member states as a requirement within the EPBD. Examples of EPC and other labeling best practices in Europe include:

Labeling including recommendations: In 2002 the European Union required all member countries to design national systems for energy certificates and labels for buildings in the next four years (by 2006). Subject to criteria that were established, each country could design the certificates and labels for their own circumstances. The use of certificates was mandatory. By 2008 labeling and certification programs were widespread throughout the EU. Evaluations have been carried out since 2010 using a common methodology across EU member countries.

The EU program for certifying and labeling energy use in buildings is unique among large regions for being both widespread and mandatory. It may turn out to be the most effective policy approach for encouraging retrofit of buildings in general and at point of sale.

Building an information pyramid: The use of a centralized database that registers information on building labels issued is an important tool to understand the energy performance of the building stock and how it changes over time. Such a database can be used to develop benchmark tools and other supportive materials. The information in the database provides an important feedback loop for building assessors to continually improve the quality of EPCs and to ensure that the recommendations that accompany EPCs are relevant and up to date.

3.2.2. Issues

A few areas for more research have been identified to help improve the impact of labeling programs in the European Union:

Methodology: More research is needed to understand factors leading to differences between measured and calculated estimates of a building's energy performance. Such research requires an approach that depends on a variety of techniques—from the behavioral sciences, engineering, and statistics at a minimum.

Evaluation: Because each EU country has adopted its own label design, evaluation of the rate of public acceptance of labels among EU countries could help us understand how different designs affect consumer behavior. Research is also needed to identify how best recommendations can be presented to positively affect a building owner's decision to invest in improving a building.

Control and enforcement: Research is needed to identify countries that have successfully used EPCs in control and enforcement procedures.

3.3. Financing and Incentive Programs

The subsections below describe indicators of best practice and issues related to EU building energy incentives.

3.3.1. Best Practice Indicators

Mobilizing private investors from banks: Policy makers need to leverage private funding to invest in energy saving measures. The German KfW development bank is a very successful example of a public – private partnership that encourages banks to promote investment in the energy performance of German buildings. Policy makers need to develop mechanisms and a conducive environment for such investments to be recognized as a financial asset class for banks as well as building owners (households and commercial owners).

Targeting deep renovation: German programs not only increase renovation rates but target deep renovation. The financial incentives are set proportionally to the depth of the retrofit (i.e., the resulting energy savings). The German example is further studied in the case studies in Chapter 6.

A palette of incentive programs: Across the European Union, a large array of incentive programs has been implemented. Some of the high-impact programs, such as tax incentives, energy-efficiency obligations (EEOs) and loan schemes, are the result of several years of evolution and refinement to meet changing market conditions while absorbing experience from other territories. Member states need to increase the size and participation rates of successful programs in order to increase savings. Challenges remain for policy makers in designing incentive instruments that motivate consumers to use less energy in buildings and for the construction industry to produce, offer, and use more energy-efficient technologies.

3.3.2. Issues

Comparing incentive programs: The critical question about which incentive scheme results in the most savings at the least cost remains unanswered. This is true for several reasons. The most important is the large variety of methodologies used to calculate energy and CO_2 savings in different countries or even among different schemes within countries. A variety of metrics are used, including primary energy versus final energy and lifetime savings versus first-year savings. Even when lifetime savings are considered, countries use different lifetime and discount rate assumptions. These would need to be harmonized for a thorough and accurate comparison. In addition, not all countries systematically evaluate their programs.

3.4. Conclusions

The European Union is actively engaged in realizing the energy saving potential in building improvements and considers the building sector crucial to meeting its climate change strategy goals. Despite shortcomings and delays in its implementation, EPBD remains perhaps the most ambitious, transformative, and influential policy worldwide that addresses energy use in buildings. EPBD has succeeded in overcoming political and technical differences among member states and has established a common goal to improve building energy performance in the European Union.

All 27 EU member states and numerous non-member countries with a combined total population of more than half a billion people are subject to the EPBD's requirements. Its comprehensive scope includes building codes for new construction and renovation, certificates for energy performance, inspection of heating and cooling systems, and a target of permitting only the construction of nZEBs starting in 2020 (2018 for public authorities). Many EU member states also see improving building energy performance as a way to boost their economies and improve energy security (reducing reliance on energy imports) as well as to reduce consumer energy bills, especially in low-income households. Some countries also value the competitive benefits of encouraging homegrown technological solutions that help the transition to low-carbon economies.

Among the lessons learned, the EU experience demonstrates how long the process is to train the work force necessary to implement a labeling program. It took member states from a few to up to six years to implement the EU directive on labeling, in part due to the need to establish a political consensus. Government and industry associations can facilitate training and ensure future high-quality energy assessments by providing well-designed training and guidance tools and software. European experience also shows that labeling program benefits are enhanced when these programs operate in tandem with other policies and as part of a package of measures. Many countries have financial incentive schemes in which the performance criteria are determined by a label requirement.

Overall, a wide variety of incentive programs has been implemented in Europe. Some yield measures with large savings but that last for only a limited time (five to fifteen years) while others yield fewer short term savings but that continue much longer (50 to 100 years). Moreover, not all policies yield immediate energy savings that are directly measurable; nonetheless, these policies may be instrumental in transforming the market and changing behavior. We believe that all measures should be considered and implemented to spur both immediate and long-term incremental changes. Challenges remain for policy makers to design packages of incentive instruments that produce immediate as well as long-term savings. Importance should also be given to implementing measures that spur learning effects and reduce the price of renovating and constructing more energy-efficient buildings.

Although the European Union has demonstrated a degree of political will in enacting energy-efficiency policies among its member states, many challenges remain, and execution is often hampered by other national political considerations. Moreover, even if all EU member states have the same general aim, Europe is composed of geographically and climatically diverse countries that have very different cultures and resources. The differences in approach to and aggressiveness of implementation programs and policies result in different degrees of energy savings. Despite these differences, there are some encouraging developments in which experience and best practice have crossed national borders, and countries that have historically been lagging are catching up with their European counterparts.

The EU Parliament and Council are about to pass a new energy-efficiency directive that will complement the EPBD by involving private-sector actors in realizing energy efficiency improvements in the building sector, accelerate renovation rates, and deepen the scope of retrofits and thus overall and cost-effective energy savings. This will also spur learning effects that will lead to reduced costs for renovating buildings.

Energy use per dwelling in the EU residential sector (which accounts for 75% of the EU building stock and approximately two-thirds of building energy use) is gradually decreasing thanks to a combination of improved energy performance and reduced average property size. However, energy consumption in the commercial sector continues to increase, driven largely by higher electricity loads for heating, ventilation, and air conditioning (HVAC), lighting, and office equipment. To date, Europe has developed relatively fewer incentive schemes that target and limit growth of energy use in the commercial sector as compared to the residential sector.

At the same time, some EU countries have struggled to increase rates of participation in energy-efficiency programs, particularly in renovation of existing buildings. This is likely the next challenge that EU and European national policy makers will confront. Many barriers prevent building owners and occupants from taking advantage of energy-efficiency programs. Policy makers face resistance and inertia when it comes to changing people’s behavior and influencing their willingness to invest in improving the energy performance of the building stock. Therefore, policy makers have much work still to do to translate political will into realized savings.

Chapter 4 – Best Policy Practices in China: Indicators and Issues

This chapter summarizes indicators as well as issues related to best practices in China's building energy codes, building energy labels, and building energy incentives.

4.1. Building Energy Codes

The subsections below describe indicators of best practice and issues related to China's building energy standards.

4.1.1. Best Practice Indicators

Regional building codes to account for climate and usage variations: China has adopted regional residential building energy codes that reflect different climate zones and heating/cooling energy usage patterns as well as a national commercial building energy code. In addition to these building codes, there are national technical codes on building retrofits and lighting design.

Significant improvement in code compliance: National average reported building code compliance rates from the Ministry of Housing and Urban-Rural Development (MOHURD) annual inspection surveys have increased significantly from 5% design compliance and 2% construction compliance in 2001 to 54% design compliance and 20% construction compliance in 2004, to over 90% compliance for both construction and design in 2010, based on government surveys in selected urban areas. Although these reported rates do not represent compliance levels in every city, the trend of significantly rising compliance rates over time nevertheless highlights very significant improvements in code compliance in China. The improved compliance can be linked to strengthening the loop inspection system for code implementation, instituting a detailed Code of Acceptance checklist for inspections in final approval phase for projects, and establishing strict non-compliance penalties.

4.1.2. Issues

Outdated baselines: An important question about China's building codes is whether the codes' baseline values, which are "typical" conditions of inefficient 1980s buildings, are accurate and appropriate to use as a baseline against which to measure energy reductions. These inefficient 1980s buildings were constructed before one could even purchase insulation in China. Using these conditions as a baseline results in large overestimates of the energy-savings impact of efficiency standards. The claimed 35% energy savings (from the late 1990s and early years of this century) and more recent 50% savings (65% for several big cities) give the impression that very large savings have resulted from China's efficiency standards. This is misleading for two reasons: (1) today's energy use is compared to the energy use of buildings with very inefficient heating equipment and no insulation other than that provided by the material with which the building was built and (2) the energy savings are based solely on design. The second factor – the design standard – is commonly used throughout the world. However, for China the design standard is set using typical operating and comfort conditions in the United States. This dramatically overestimates energy savings.

Monitoring as a basis for updating baselines: The government is now funding a large number of building energy monitoring projects. The results of these projects can be used to establish an improved baseline for revised building codes and for more accurate calculations of energy saved as a result of standards. In addition, more consistent review and revision of building codes – some of which have not been updated for more than 10 years – are needed to improve code stringency and impacts.

Rural codes: A major issue in China is the design and implementation of codes in rural areas and improved implementation and enforcement in second- and third-tier cities. To achieve these objectives, the government needs to decide whether codes for urban buildings should apply to rural buildings considering their different architectural, design, building materials, lifetimes, and occupant behavior. For standards to be implemented and enforced in rural areas and second- and third-tier cities, there is a need to strengthen (or create) regulatory capacity relating to buildings.

4.2. Building Energy Labels

The subsections below describe indicators of best practice and issues related to China's building energy labeling.

4.2.1. Best Practice Indicators

Well-designed national green building labeling program: China's recently created national Green Building Evaluation and Labeling program embodies important successful elements of labeling programs. The label accounts for both design and actual operational energy consumption with the use of both theoretical and operational energy ratings. Rated green buildings must meet all criteria for labeling by meeting minimum scores for each category, in contrast to the LEED requirement of a combined score that enables good performance in one category to offset poor performance in another.

Dedicated government support driving growth of green building labeling program: Starting from the green building labeling program's inception in 2008 and continuing through 2011, the Chinese government exhorted builders to participate in the labeling program. During this phase of the program, hundreds of professionals in design institutes and in the private sector as well as an even higher number of construction professionals learned the techniques for meeting label levels of three stars or higher (up to five stars). The second phase of the program, initiated in 2012, provides government incentives for qualifying buildings (at the two-star level or above) to support the government's target of 1 billion m^2 of new green buildings by 2015.

4.2.2. Issues

Distinguishing among similar label programs: Building energy labeling programs are a new area of building energy policy in China, and a number of "bugs" need to be worked out. Differentiation of the two programs is needed to prevent consumer confusion that is already evident For example, users often do not know the advantages and disadvantage of the domestic (five-star) and the international (LEED) rating system for green buildings. These differences are important because the cost of qualifying a building for a rating is thousands of dollars. Along the same lines, the similar use of stars as a rating in both the green building labeling and building energy-efficiency labeling programs need to be identified and distinguished, and the costs of both have to be lowered to make the programs more relevant to building stakeholders. Understanding the relationship between existing local green building energy labeling programs and the national evaluation standard and program will be particularly important after the launch of the Green Building Action Plan, in which the scope of the green building labeling programs will be defined.

4.3. Financing and Incentive Programs

The subsections below describe indicators of best practice and issues related to China's building energy incentives.

4.3.1. Best Practice Indicators

Key incentive programs driven by specific quantifiable targets: China's major building energy-efficiency incentive programs have all been created to support and meet very specific targets, such as the 150 million m^2 retrofit target and the 50 million incandescent lamp replacement target. These targets not only help drive the incentive programs, but also serve as indicators against which the success and impact of a specific incentive or subsidy policy can be measured. Both the heating retrofit and efficient lighting subsidies have exceeded their targets, resulting in significant overall energy savings and emission reductions as well as reports of improved living conditions. Newly introduced incentive programs for the 12^{th} Five-year Plan include specific targets for heating retrofits, commercial building energy intensity reduction, and new green building construction.

Subsidies designed to increase uptake of efficiency measures by significantly reducing up-front costs: China's building efficiency incentives cover a meaningful portion of the up-front costs of efficiency measures, (e.g., 15 to 20% of total energy retrofit costs). These incentive amounts are made possible by large investments from the central government as well as some innovative local cost-sharing mechanisms.

4.3.2. Issues

Leveraging private investment: A key to successful government energy-efficiency incentives, particularly in developing countries where private investment in energy efficiency is limited, is their ability to leverage private investment. China has been successful in leveraging for energy-efficiency investments in industry, but, until now, it has been difficult or impossible to leverage such investments for buildings.

Using energy management companies: In an effort to overcome this problem, China is just beginning to use energy service companies (ESCOs) – or as they are known in China, Energy Management Companies – as a means of providing incentives for building energy efficiency. ESCOs have proven effective in leveraging private capital for energy efficiency (in the United States, Japan, and Europe) as have electric and gas utilities (United States). It is too early to know whether the attempt to use energy management companies as the delivery vehicle for building energy efficiency will prove to be successful in eliciting private (generally customer) investment in China.

4.4. Conclusions

China's rapidly expanding building sector is an increasingly important energy consumer of energy and has in recent years become the focus of government efforts to improve building codes, introduce labeling programs, and increase energy-efficiency incentives.

In the area of building energy codes, China has continued to expand and update its regional residential building codes and commercial building code while establishing a "loop system" of implementing building codes for new construction. This loop system of implementation directly involves provincial and local authorities, whose participation and commitment are crucial to effective code implementation. The Chinese central government's growing emphasis on code enforcement and compliance has driven improvements in reported national average compliance rates during the past 10 years, but detailed compliance information and data are still limited. Challenges stem from the lack of specialized knowledge and training among building experts and implementation officials and weak institutional capacity and infrastructure for enforcement and compliance monitoring in smaller cities. Going forward, additional capacity building (institutional, technical, staff) is thus needed to further improve code implementation and enforcement, particularly in smaller cities and rural areas.

In addition to mandatory building codes, China has recently developed green building and building energy-efficiency labeling programs tailored to its national context. These labeling programs represent the central (and in some cases local) governments' recognition of the need for market-based as well as regulatory measures to promote building energy efficiency. China's MOHURD has taken the lead in establishing a domestic green building label and a building energy-efficiency label, both of which are voluntary but beginning to emerge in the building market. The green building labeling program in particular is and will likely continue growing rapidly in coverage, with concerted government efforts to establish demonstration projects and financial incentives. Both labeling programs evaluate theoretical and operational energy consumption, but limited availability of building experts and high transaction costs hinder greater adoption of these labels. In addition, both labeling programs are new and face typical challenges of a new program, including lack of public awareness as well as ambiguity and unclear distinction between the two programs and resulting consumer confusion between the two labels.

The central government has also provided leadership in establishing financial incentives to support heating reform in existing construction as well as adoption of energy-efficient technologies and building-integrated renewable energy technologies. Setting clear provincial targets and allocating funding by specific task and region have enabled China to track and measure the achievements of its residential retrofit incentive programs, and adopting cost-sharing structures between different levels of government has resulted in effective city-level heating retrofit incentive programs. Going forward, new incentive programs will likely need to begin tapping into new sources of funding by better leveraging private investment in energy efficiency. In terms of scope, China has expanded its building incentive programs beyond heating retrofits to promote efficient lighting, building-integrated renewable technologies, and energy-efficient materials. However, the scope could be further expanded to spur greater market-based energy-efficiency activity. Specifically, incentives can play an important role in attracting the market entry of energy service companies and contract companies, which have had relatively limited role in promoting building energy efficiency in China.

Developments across China's building codes, labels, and incentive programs highlight that China's central and local governments have recognized the need to adopt both regulatory policies (i.e., building codes) and market-based and financial policies (i.e., building energy labels and incentives) to improve building energy efficiency. Adherence to strict program targets (e.g., retrofit targets) and development of innovative mechanisms (e.g., cost sharing) have produced effective building energy-efficiency programs in China.

At the same time, given the unprecedented rate of growth in new construction and the relatively new policy focus on building energy efficiency, China's building energy-efficiency codes and labeling and incentive programs still face major challenges. Insufficient institutional and technical capacity pose challenges for developing more stringent and up-to-date building codes, and uneven enforcement and monitoring undermine the implementation of the codes. Existing disparities between urban and rural building energy-efficiency levels and in the levels of policy support between central and local governments have also limited the effectiveness of all three types of building energy-efficiency policies in China. Moreover, the connections among the three types of building policies in China have been limited thus far; their effectiveness could be improved significantly with greater cross-cutting policy linkages and adoption of complementary policies (e.g., linking incentives with building energy labels). As China's building sector continues to expand in tandem with growing urbanization and rising income levels, these barriers and challenges will need to be addressed to maximize the overall level of efficiency in all Chinese buildings.

Chapter 5 – Best Policy Practices in India: Indicator and Issues

This chapter summarizes indicators as well as issues related to best practices in India's building energy codes, building energy labels, and building energy incentives.

5.1. Building Energy Codes

The subsections below describe indicators of best practice and issues related to India's building energy codes.

5.1.1. Best Practice Indicators

Development of advanced building energy codes for commercial buildings: The Indian Bureau of Energy Efficiency (BEE) with the assistance of international consultants developed a national model energy code for commercial buildings, the Energy Conservation Building Code (ECBC). This code and associated surveys represent an initial and early effort by India address the issue of rapidly increasing energy use in commercial buildings.

Initial plans to implement ECBC at the state level: Implementation is planned start in some of India's fastest-growing, economically strongest areas. Several state and central agencies are in the process of incorporating the code into guidelines and requirements for public buildings; eight states are required as of 2012 to make the code mandatory for all new and major retrofits of commercial buildings.

Concentration on both mid-career and pre-professional capacity building using state-of-the-art tools: To improve code compliance, and ensure that building owners understand their building's energy use intensity and designers understand whether their projects comply with the ECBC, three web-based software tools have been developed for use by code officials and building professionals. A partnership among 18 universities is developing a building sciences curriculum that is intended to provide training directly applicable to the ECBC and for related purposes.

5.1.2. Issues

Need to watch efforts of leading local jurisdictions: The effort to develop ECBC-compliant local by-laws is the most important obstacle facing building energy efficiency efforts in India. Although several states are purported to already have such by-laws, there is little public documentation of these accomplishments. The by-law development trajectories of two cities, Hyderabad, Andhra Pradesh state, and Ahmedabad, Gujarat state, will be instructive as to the needs of even advanced, well supported, wealthy cities in developing local by-laws. The efforts of these cities should be tracked by future research because both are experiencing construction booms but face their own particular development circumstances that are impacting the development of local level ECBC-compliant by-laws. Neither of these efforts can yet be labeled as successes, but the development of these two different ECBC compliance strategies is likely to be instructive regarding the varying needs and limitations of local governments in India, even amongst large cities. Undoubtedly, lessons from both will be important for the national ECBC effort. The most important questions to be targeted by future studies are:

- Should local level administrators pursue partial compliance or incremental regulatory developments rather than full, all-at-once ECBC implementation?
- Are local developer partnerships absolutely essential to attaining ECBC compliance, given the capacity limitations of local governments for building inspections?
- Are local-level inspectors an appropriate means of enforcing codes, or should third-party code enforcer programs be pursued?
- Where are the greatest weaknesses in the supply chain for building energy-efficiency measures?

Working toward a low-rise residential building code: India has yet to develop an energy code for low-rise residential buildings. This may be a rational choice considering the growing importance of commercial and high-rise residential buildings covered by the ECBC and the need to work within administrative and technical capacity constraints. However, it appears that middle-income and wealthy residential households, especially in urban areas, are quickly increasing their energy consumption as incomes rise, and this will continue into the medium-term future. Regulating energy use in residential buildings will require amendments to India's Energy Conservation Act, which does not currently allow BEE to establish residential building codes. Before this occurs, basic research needs to be conducted to better characterize this sector and strategies for the integration of residential buildings into the ECBC.

Evaluating code stringency according to local benefits: Similar to building energy codes in China, the ECBC may not accurately reflect common building usage patterns, especially in regard to the whole building performance compliance methodology. A survey being conducted in India (ECO-III) that includes ongoing building monitoring efforts is expected to provide information that will permit the localization of the ECBC.

5.2. Building Energy Labels

The subsections below describe indicators of best practice and issues related to India's building energy labels.

5.2.1. Best Practice Indicators

Locally relevant labeling systems: India's GRIHA and the LEED green building rating systems are the most popular building labeling systems in the country.[8] Between the two, the GRIHA system is more closely linked with typical India building operational characteristics such as significantly reduced demand for cooling. The national government and several state governments support GRIHA, with four states

[8] LEED uptake has been dramatically higher in the private sector, and GRIHA uptake has dominated the government sector, so they are not equivalently popular in all sectors.

requiring GRIHA rating for government buildings and the national government requiring GRIHA compliance in all new national government buildings.

Labels gaining initial market footholds by appealing to high-premium market sectors: LEED buildings are still more costly than regular buildings.[9] However, despite high costs, LEED received strong initial support and, in 2010, India ranked second in LEED-registered building floor space only to the United States. As of the writing of this report, LEED has registered more than 1.1 billion m^2 of LEED building projects. Part of LEED's appeal is its international character and recognition as a high-quality standard by international and domestic corporations. The Indian Green Building Council has used this recognition well to increase market reach, especially in new business districts attracting multinational corporations. Gaining a foothold in these high-visibility projects will undoubtedly work to expand LEED's market appeal.

Label programs as a source of capacity development: The ability of labeling programs to deliver targeted training on energy-efficient design and operations should not be ignored. GRIHA and LEED have been significant sources of training on green building and building energy issues, with GRIHA training 400 professionals as of the end of 2010, and the Indian Green Building Council listing 160 LEED accredited professionals.

5.2.2. Issues

Effects of multiple labeling programs on consumers: The existence of three labeling systems (the two described above plus a small Energy Star program put forward by BEE) will undoubtedly lead to consumer confusion at a time when most consumers are unaware of building energy use issues. The experiences of EU countries, especially countries with little history in building energy-efficiency regulations, suggest that the approach of developing a standardized building energy performance labeling program should be investigated for lessons that may apply to India's efforts.

Electronic information management for greater label utility: The recent advent of electronic systems that store and make available all local building and land permits in some states should be investigated to see whether database-integrated label programs can be used to collect and distribute building energy intensity information.

Research on leading sectors: Another potential avenue for research is to understand the motivations for the relatively stronger uptake of building labels such as LEED and GRIHA by companies that finance and build their own buildings, such as the ITC Hotels Chain that has achieved LEED-platinum certification for their entire line of luxury hotels in India.

[9] Recently some LEED projects have reported marginal costs between 2 and 5%.

5.3. Financing and Incentive Programs

The subsections below describe indicators of best practice and issues related to India's building energy incentives.

5.3.1. Best Practice Indicators

Incentives for all actors: Incentives and financing mechanisms for building energy efficiency are few and uncoordinated in India and require further development and testing. An early leader in this effort is the Indian Ministry of New and Renewable Energy's GRIHA-based incentives. This program stands out as a means of increasing building energy-efficiency awareness through simultaneously targeting multiple actors in the building supply chain. The package combines incentives for developers, owners, and local-level administrators, all of whose support is necessary at this stage in dramatically increasing the market for efficient buildings.

5.3.2. Issues

Data on the effectiveness of incentive programs: Incentives and financial mechanisms for building energy-efficiency are few and haphazard in India. Government incentive programs are strongest, and the finance industry appears to be a long way from widespread efficiency financing because of concerns about a lack of demand. No program reviews for any incentive scheme could be found, so there are no means of evaluating the cost effectiveness of these policies. Most importantly, little is known about the effect of existing building energy-efficiency incentives on actual building energy use.

Data on the benefits and costs of energy-efficient buildings: Anecdotal evidence suggests that project developers are unsure of the costs of efficiency measures, and the real estate market generally does not appreciate the value of higher-efficiency buildings. Basic research is needed to understand the economic benefits of energy-efficient buildings in India, including energy cost savings, rental and sale premiums, and occupant comfort benefits, so that investment payback times can be better understood by developers. In particular, market research should be undertaken to isolate owner and building types and geographic areas that might be more willing to take on efficiency projects and then to prioritize incentives targeting this subsector.

Industrial incentive programs: Both banks and utilities in India are working with the government in delivering energy-efficiency programs for industrial firms where these programs offer social benefits, such as providing better grid stability through demand-side management (DSM). These experiences should be researched to understand the extent to which the commercial building and residential sectors hold potential to offer the same kind of DSM services.

5.4. Conclusions

During the past 10 years, professionals within India's national government; consultants from India's academies, think tanks, and corporations; and international experts have worked together to quickly build a commercial building energy-efficiency improvement strategy for the country. These efforts have resulted in a comprehensive model building code and several tools and strategies to tune the code to India's local circumstances. Although implementation is just now moving beyond initial pilot projects, these code infrastructure development successes are noteworthy and deserve acclaim.

The next step is implementation on a large scale. Developing implementation capacity will be a significant challenge and will require further concerted efforts by all stakeholders, especially governments at all levels, to align incentives and drive initial market demand for inputs such as skilled labor and certified materials. To provide a secure foundation for further policy development and ensure successful implementation, national government resources should be deployed to characterize building energy use in greater detail and to keep codes and tools current according to new building energy use data. Concurrently, capacity development efforts need to be ramped up to use tools to train current university students as well as mid-career building inspectors and other political stakeholders at the local level. These efforts should absolutely be supported by careful, systematic, well-documented research into the results of such expenditures, both for the benefit of India as well as the rest of the world. In addition, the perspectives and needs of stakeholders such as developers, manufacturers, and banks should inform capacity development efforts to maximize knowledge sharing among all parties.

Labeling programs may benefit from consolidation; however, this will be difficult because LEED and GRIHA appear to be direct competitors, and the BEE Energy Star program has yet to realize significant market demand. If label consolidation is not possible, the national government could instead push label programs to prioritize operational energy use intensity measurements and to transparently incorporate specific energy use information into labels. Financing mechanisms that base incentives on the level of certification achieved, such as the approach used by MNRE, should be expanded.

In general, much stronger financial incentives and bank financing support for whole-building efficiency efforts will likely be needed to drive market demand to levels necessary for widespread building energy-efficiency measure uptake. The expansion of incentive programs should follow the MNRE's lead in targeting multiple actors in the building supply chain, including the suppliers of building efficiency inputs.

The current urban building construction boom in India is likely to continue into the long-term future; this presents both opportunities and challenges. On the one hand, it means that India still has some time to improve current policies and work toward creating integrated policy packages. On the other hand, urbanization is a difficult and expensive process, and urban leaders will likely have to balance many different priorities with limited financial resources. Building energy policies from other regions may only offer limited lessons as India faces dramatically different physical, economic, and political contexts than historical code leaders such as Europe and the United States. However, successful implementation of codes in India is of global interest. Well-documented experiences over the coming years will undoubtedly provide vital lessons to the global community regarding the high-speed development, deployment, and iterative refinement of building energy-efficiency policies relevant to industrializing countries.

Chapter 6 – Case Studies of Best Practices

This chapter summarizes major features of selected case studies of best practices in building energy codes, building energy labels and building energy incentives in the United States, the European Union, and China. We emphasize the lessons learned from these vignettes.

6.1. Indicators of Best Practices from U.S. Case Studies

We have chosen to describe and assess three U.S. case studies: the ENERGY STAR Buildings Program, programs in the state of California, and New York City's PlaNYC program for a greener city, including reduced greenhouse gas (GHG) emissions.

6.1.1. ENERGY STAR Buildings

The ENERGY STAR buildings program created and implemented by the U.S. Environmental Protection Agency (U.S. EPA) certifies a building as "energy efficient," meaning in the top quartile of existing buildings. To provide a basis for this certification, U.S. EPA developed a tool (Portfolio Manager) that, after being fed large data sets of characteristics and energy use of commercial buildings, provides a basis for comparing the actual energy performance of any one specific building to peer buildings. This process, along with the accompanying ENERGY STAR label, provides important information to inform decisions on the desirability of retrofits for specific buildings. Portfolio Manager represents a shift from theoretical energy savings (i.e., estimates based on calculations) to the real world (i.e., actual savings based on energy bills and metered data). This approach helps owners recognize savings from improved operations and maintenance (O&M) and encourages continuous focus on sound building energy management.

By engaging commercial real estate firms, private companies, institutions, and public agencies that own or operate massive building fleets, U.S. EPA and its partners have increased the reach of the program. The calculators, tools, and customized messages developed to demonstrate the value of energy efficiency and the metrics that resonate with each target audience have been crucial in driving the program's success.

Finally, the ENERGY STAR Buildings Program demonstrates the value of creating a unified platform (or brand) and a set of tools that the larger energy-efficiency community and a broad set of market actors can disseminate and further develop through their own innovations. A few examples that show the program has been widely leveraged include: growth in utility programs using the ENERGY STAR Buildings platform, adoption of state and local government policies mandating benchmarking, and a marked increase in the number of companies providing benchmarking services as a way to engage their customers.

As a result of these efforts by U.S. EPA and its partners, the energy performance of more than 200,000 commercial buildings, representing more than 25% of commercial sector floor space in the United States, has been benchmarked. Participation continues to grow. The introduction of a credible, accepted national benchmarking tool has made it much easier for state and local governments to adopt mandatory benchmarking and disclosure policies.

6.1.2. California's Statewide Leadership on Energy Efficiency

California has a long history of leadership in energy efficiency stemming from its sustained commitment to comprehensive efficiency policies and, more recently, climate change policies. Over the years, the state has revised and expanded its suite of efficiency policies and programs to keep up with the evolving economic and social trends driving energy use. Coordination among the agencies responsible for administering these policies—the California Energy Commission, the California Public Utilities Commission, and the California Air Resources Board—has been important to the success of these policies.

Mandatory building energy codes for new buildings and appliance efficiency standards that are more stringent than the national standards were first enacted during the 1970. Mandatory benchmarking and disclosure requirements for commercial buildings, now taking effect, will begin the process of systematically addressing existing commercial buildings.

Electric and gas utility ratepayer-funded efficiency programs offer incentives and other types of market support to accelerate the adoption of new technologies and practices, continually feeding the pipeline for more stringent codes and standards. The state's commitment to efficiency has created a policy environment that allows for more rapid and stronger advances in codes and standards levels than in most other states or at the federal level.

The state's commitment to energy efficiency also encourages a broader view of the role of ratepayer-funded programs and the benefits of greater coordination between voluntary programs and mandatory requirements. California's utilities actively use ratepayer funds to identify new opportunities for stronger codes and standards and to advocate for their adoption at the state and federal levels as well as by working with builders, code officials, and the construction trades to improve code compliance and enforcement in California.

The California Energy Commission estimates that energy-efficiency investments in California (including Title 24 building codes and Title 20 appliance standards along with utility efficiency programs) have resulted in an estimated $56 billion in electricity and natural gas savings through 2006, with an additional $23 billion in savings anticipated through 2013. These savings have yielded almost $5 billion in net benefits from avoided generation, transmission, and distribution and natural gas usage – more than $900 million in 2008 alone. Between 2006 and 2008, utility programs generated savings at a cost of less than $0.03/kWh compared with $0.08/kWh for base-load power.

The success of innovative policy and program approaches introduced in California has encouraged state energy officials across the United States to pursue similar policies and programs. California's leadership in energy and environmental policy continues as the state works to meet aggressive goals for zero-net-energy new construction and building retrofits.

6.1.3. PlaNYC: Greener, Greater Buildings Plan

PlaNYC is a comprehensive strategy to address climate change and community revitalization in New York City and an example of how government leadership can leverage private-sector support. Nearly 30 major New York City institutions agreed to match the government's PlaNYC goal to reduce its GHG emissions by 30% by 2017. PlaNYC led to the adoption of the city's Greener, Greater Buildings Plan (GGBP). The city estimates that laws enacted to date under the GGBP will reduce GHG emissions in 2030 by 7.5%. In addition, code changes implemented in the wake of PlaNYC will further reduce GHG emissions by an estimated 4% by 2030.

Early results show that compliance with the initial private-sector benchmarking requirements was much greater in New York City (nearly 70%) than in other cities where requirements were not enacted as part of a comprehensive package, thus drawing much less public awareness and media attention. By comparison, initial compliance with benchmarking requirements in Seattle and San Francisco is estimated to be approximately 30%.

The success of New York City's Green Codes Task Force reflects the importance of collaboration among local government, the non-profit advocacy community, and industry leaders. Because the Mayor and City Council Speaker initiated the project, it attained legitimacy, recognition, and industry buy-in from the outset. The city's Urban Green Council also played a critical role as an independent advisor and convener for the project. That organization has strong ties with both the city government and industry and is viewed as having a practical approach to achieving environmental goals.

Architects and engineers have been essential in identifying ways to improve the code. The real estate industry has provided important feedback on the feasibility of implementing changes in construction and ongoing building operations. Adding credibility to the recommendations, Urban Green Council produces a report that explains and provides support for the rationale for each recommendation. The report also provides statutory language and implementation guidance. This last step, of developing easily understandable explanations along with providing code-level language was one of the most resource intensive yet valuable steps in the process.

6.1.4. Conclusions

The U.S. case studies highlighted here demonstrate that state and local commitments to energy efficiency—to meet goals for environmental protection and economic stability as well as to address local challenges—have led policy makers to pursue innovative policies and more comprehensive approaches to energy efficiency in buildings. Many advocates use examples of comprehensive sets of policies and programs in states[10] and cities[11] to press for stronger programs at the federal level. These case studies also show the important role the federal government has played in providing a national platform for energy efficiency—the ENERGY STAR brand—as well as credible, consistent tools and a foundation for state, local, and utility-level program and policy development.

[10] California is the most widely recognized as having created and implemented highly successful energy efficiency policies and programs. However, many other states are also recognized as leaders, including Vermont, New York, Massachusetts, Texas, Connecticut, Wisconsin and others.

[11] In addition to New York City, Austin Texas, Sacramento California, Seattle Washington, and Ann Arbor Michigan are all examples of cities with innovative and successful energy efficiency programs.

6.2. Indicators of Best Practice from EU Case Studies

The subsections below describe lessons learned from three EU case studies: the KfW program in Germany, programs in Austria, and EU near-zero-energy buildings programs.

6.2.1. The German KfW Program

Germany took advantage of the existence of the KfW development bank, using it as a vehicle to support high-efficiency new construction and building renovation. As was the case in other European Union (EU) member states, the EU's carbon dioxide (CO_2) emissions reduction and energy-saving targets, including a raft of energy-saving directives, provided much of the impetus for Germany's KfW program.

The key to KfW's success is the recognition that investment in energy-saving measures provides a net benefit to the government. Rather than considering subsidies as a drain on public resources, the German government takes a holistic perspective, and the stimulus provided through loans and grants pays for itself more than four times over, as a result of additional tax income resulting from the efficiency improvements as well as reduced social costs in the form of increased production of energy-saving materials and the associated employment that this industry generates.

Although other countries might not have an equivalent to the KfW development bank, this program can be replicated. The renovation of the existing global building stock that is necessary to reduce energy use and GHG emissions will require substantial investment that can only be provided by the private sector. Using the model of the KfW program, governments can provide the incentives to leverage private investment by:

- Providing a framework for improving building energy performance through a combination of progressively tighter minimum efficiency standards, financial incentives such as those delivered through KfW, and supporting measures to build capacity and raise awareness;
- Devising loan/grant schemes of sufficient scale and lifespan that they become part of the recognized infrastructure of the country/territory;
- Reducing risk (and hence financing costs) by providing a clear framework for the program, including certification of experts to assess and implement the investments, as well as providing guarantees for the products installed;
- Enabling building owners and investors to borrow at below-market rates for investments that have a high energy-performance rating;
- Weighting incentives against investments that achieve the deepest retrofits and thus deliver maximized savings;
- Working with lenders to leverage their contacts with individuals and businesses;
- Taking a holistic view of the net impact of incentives on public finance, i.e., factoring in tax and employment benefits from increased investment in the building stock;
- Increasing the visibility of the higher property values of high-energy-performance buildings, thereby further strengthening the economic case for building owners/investors (this feature was not part of the German KfW scheme).

6.2.2. European Near-zero-energy Building Programs

For decades, a number of European countries have increased the stringency of building codes and standards to lower energy use in new buildings. During the past five years, particular attention has been given to the goal of near-zero and ultimately net-zero energy use. Countries such as Denmark, Germany, Austria, Switzerland, and Sweden, historically the most progressive in the area of energy efficiency, have continued to be leading players. In Denmark, standards to achieve near-zero energy use in all new buildings by 2020 have already been approved by Parliament. Voluntary standards such as Passive House and Minergie P have been instrumental in driving this agenda in Europe. These two standards have increased the number of high-performance residential and non-residential buildings at costs that are not prohibitively more expensive than those of standard buildings. Adoption of such voluntary standards as de facto mandatory requirements by particular localities, cities, or regions also helped to encourage national governments as well as EU authorities to commit to a future where, within a decade, all new buildings across the region will be constructed in compliance with near-zero energy requirements.

Economic, social, environmental, energy security, and technological factors have all played a part in stimulating individuals, organizations, nations, and now the entire European Union to recognize the long-term benefit of drastically reducing energy use by and CO_2 emissions from new buildings.

6.2.3. The Austrian Approach

Within Europe, Austria has one of the most proactive and comprehensive approaches to reducing energy use in buildings, which has resulted in significant energy-efficiency improvements during the past 20 years. However, despite the success of Austria's historic programs and initiatives, the rate of improvement needs to dramatically increase if the national objective of eliminating fossil fuel use in the buildings sector is to be realized. The new energy strategy adopted by the Austrian Council of the Ministers in 2010 targets a 3% annual retrofit rate for the building stock by 2020, up from the current rate of 1%.[12] As a move toward this goal, the government introduced several new housing and construction measures. Given Austria's federal structure, these measures will be delivered regionally through a formal agreement between the federal government and Austria's states (Länder).[13] Public procurement guidelines include ambitious standards for new buildings and retrofits. Meanwhile, higher thresholds for obtaining housing subsidies were introduced for single- and multi-family buildings to accelerate the phasing-out of oil heating and to improve energy efficiency in building renovation through new regulations on space and water heating. The government measures focus on heating and insulation measures in buildings built between 1945 and 1980. For new buildings to qualify for subsidies,

[12] http://www.climatepolicytracker.eu/austria

[13] The Federal Constitutional Law allows treaties or agreements between the federation and the Länder or among the Länder on matters within their respective spheres of competence. There have been many such agreements related to energy efficiency.

single-family buildings will be expected to meet an annual threshold of 36 kWh/m^2; multi-family buildings will have an annual threshold of 20 kWh/m^2. Furthermore, the 2011 budget included €100 million for thermal renovation of buildings: €70 million for private households and €30 million for businesses.

Although Austria's focus on improving the energy performance of buildings predated its accession to the European Union in 1995, the country's program is now to a large extent based on implementing the suite of EU Directives that target improving energy efficiency. Nonetheless, the Austrian government continues to aim for its long-term goal of a fossil-free building sector by 2050, continuing Austria's leading role in cutting GHG emissions from buildings. Of particular note is Austria's leadership in the construction of very-low-energy buildings.

6.2.4. Conclusions

Although the EU case studies highlighted here differ in the ways in which they save energy in buildings, they are all significant initiatives supported by national institutions with reinforcement by EU legislation.

EU legislation on energy saving in buildings is increasingly the most significant driver of efficiency improvements in new buildings. The renovation market, however, is less well served by mandatory national or EU policies. Because the overwhelming majority of building energy use will be in the existing stock for the foreseeable future, it is vital that the best practices for the renovation market such as those described in Germany and Austria continue in those countries and serve as a basis for new initiatives (no doubt altered to fit local conditions) in other countries.

6.3. Indicators of Best Practice from China's Case Studies

We describe two best practice case studies for China: comprehensive approaches at the provincial or municipal level of government and local building energy codes.

6.3.1. Comprehensive Building Efficiency Policy Approaches

Beijing's success and leadership in implementing wide-ranging building efficiency policies have resulted in substantial savings over the 11th FYP, including:

- 20.6% reduction in average hating energy intensity per square meter
- 21% of total residential building stock meeting the more stringent local building code
- 1.62 million m2 of certified green buildings
- Retrofits completed for over 140 million m2 of residential and commercial buildings
- 18.2% of annual new construction has integrated renewable technologies

Altogether, Beijing's ambitious policies on the green buildings labeling program, building integrated renewable technologies and energy efficiency retrofits could result in substantial energy savings on the order of saving 10% of the city's total annual energy consumption over five years.

Ningbo has taken a carrots and stick approach to promoting building efficiency. Ningbo has effectively integrated third-party professionals into its building code implementation and enforcement structure, resulting in average design and construction compliance rates of over 98%. Ningbo has also offered total financial incentives of 155 million Yuan (USD $23 million) to develop 50 to 100 building renewable demonstration projects over only two years.

6.3.2. China: Leading Local Building Energy Codes

The consistent development and revision of more stringent building energy codes in Tianjin and Beijing have resulted in significant energy savings. In Tianjin, more stringent heating intensity reductions adopted in 2004 and 2007 have saved 870 GWh, or 0.2 Mtce annually with relatively short simple payback of 5 to 7 years. In Beijing, full implementation of more stringent building codes adopted in 2012 is expected to save 1.72 Mtce and reduce 4.76 Mt CO_2 emissions by 2015.

6.3.3. New Low Energy Commercial Buildings

Three examples of newly constructed or recently retrofitted commercial buildings demonstrate the enormous – and often cost-effective - energy savings potential of properly designed, whole-systems buildings with the latest technology options in China. The Guangzhou Pearl River Tower reduced its annual energy consumption by 58%, with 10% higher incremental construction cost and short payback period of 4.8 years. The Shenzhen Institute of Building Research building achieved overall energy savings of 66% and total investment actually decreased by 33% relative to comparable construction costs in the area. The retrofit of Sanyang industrial complex in Shenzhen also demonstrated that retrofits can save as much as 65% compared to the existing building code baseline.

6.3.4. Conclusions

As building energy efficiency receives increasingly greater attention from national policymakers, some provincial and city-level policymakers have gone further in launching comprehensive building policy approaches that include more stringent local building standards, local building evaluation and labeling programs and incentives for efficiency retrofits and integrated renewables. These local leaders have all demonstrated longstanding commitment to consistently updating and strengthening building standards, allocating local funding to incentives and establishing unprecedented building efficiency and integrated renewable policies and regulatory institutions to support implementation.

Specific lessons learned from these successful case studies of building energy efficiency policies and low energy buildings include:

- **Significant energy savings can be achieved by adopting more stringent local building codes:** Tianjin and Beijing have shown that it is possible to achieve significant energy savings on the order of 30% heating intensity reduction per square meter and total savings of 1.72 Mtce over the 12^{th} Five-Year Plan period, respectively, on a local level by continually adopting more stringent local building standards
- **Local mechanisms for strengthening code enforcement and raising compliance can be effective:** Ningbo and Shanghai have proven that code compliance can be bolstered through strong monetary deterrents to non-compliance and integration of third-party professionals in code implementation structure
- **New ultra-efficient buildings capable of achieving significant energy savings have demonstrated that cost-effective low energy buildings are possible in China:** several new commercial buildings – designed both domestically and by international firms - and a recently retrofitted commercial complex demonstrate the emergence of new ultra-efficient buildings capable of achieving significant energy savings at a reasonable cost in China

Overall, these case studies demonstrate different aspects of China's continuing progress in raising the efficiency of its building sector through improved and even innovative policies, strengthened institutions, and adoption of cutting-edge technologies. Together these case studies illustrate that local actions can have significant energy and emission reduction impact even as China continues to undergo economic development and as national policies are iteratively refined. For rapidly growing countries like China that are facing challenges to successful coordination and implementation of national building efficiency policies, local actions can thus be an important first step to achieving sizable energy savings and demonstrating the elements needed for national-scale implementation.

Chapter 7 – Regional Comparisons

7.1. Status of Policy Development in the Four Regions

Government programs in the United States and the European Union are actively implementing and updating building energy standards for new construction, developing and disseminating whole-building energy labels, collecting building energy use data, and targeting the specific needs of market subsectors through tailored incentive and financing programs. Leading jurisdictions in Europe and the United States are distinguished by their successes in aligning the interests of key stakeholders, especially through energy utility regulation in many U.S. states and public-private bank partnerships in certain European countries. Both regions are actively pursuing net-zero-energy buildings, whose development would be a watershed innovation for the new construction sector.

At the same time, existing buildings dominate energy use by buildings in these developed regions, and many challenges impede the speed and scale of retrofit efforts. The European Union is addressing this issue by requiring energy ratings for all buildings and units on the market, but both regions have found it difficult to successfully establish stable means of financing deep retrofits that produce significant energy savings.

In both China and India, booming new construction industries are combined with less governmental and professional experience in the development and implementation of building energy-efficiency policy packages than is the case in the United States and European Union. The energy intensity of new construction is falling in the United States and the European Union; it is rising in China and India. The potential energy savings from efficiency in these two countries are huge because most of the building stock that will exist in 2050 will be built between now and then.

In India, subsidized energy prices greatly reduce the economic attractiveness of energy efficiency in buildings. Subsidies are likely to continue for the foreseeable future. Therefore, without government support, there is no sustainable business model for private purveyors of energy efficiency in India.

For both China and India, the strength of government policy (which, in some cases, will induce responses from private firms) will be the primary determinant of the pace of deploying energy-efficiency measures. Governments in both countries are giving increased attention to energy use in buildings. In China in particular, the strength of central and provincial government efforts and the recent priority placed on improving energy efficiency in buildings is beginning to drive investment in this area.

7.1.1. Building Energy Codes

Centralized efforts in all four regions have resulted in sophisticated building energy codes along with requirements that these codes be integrated into local laws. At the same time, in all four regions, local capacity is limited, resulting in a lag between development and implementation of standards. All regions allow local regulations to be stricter than regional or national standards.

In the United States and the European Union, progressive jurisdictions that have rapidly adopted new or especially stringent codes have been the testing grounds, and less active jurisdictions have learned from these experiences while developing the administrative and workforce capacities to implement new codes. In China, policy initiatives in the 10^{th} and 11^{th} Five-year Plan (2000-2010) rapidly increased code-implementation capacity. India is in the initial stages of building this capacity. Both counties are actively considering changing their underlying approach to standards although for different reasons. India's code, developed with guidance from United States experts, is very ambitious and incorporates some requirements that are better suited to the United States than to India. China's standards, partly as a result of advice from U.S. experts, are based on comfort conditions that prevail in the United States and are not applicable in China; relying on these assumptions is not likely to significantly reduce energy use in Chinese buildings. In both countries, standards for rural buildings are non-existent. Both countries are increasing administrative capacity and stakeholder awareness.

Table 7-1 compares the successes, barriers, and next steps in energy-efficiency code development in the four regions.

Table 7-1. Status of Energy-Efficiency Code Development and Implementation in the Four Regions

	**SUCCESSES:**	Leader and laggard member states have worked together and all member states now have new and retrofit energy codes; country-level climate change plans are increasingly focusing on the building sector; there is wide consensus on the development of net-zero-energy building codes for 2018 and 2020.
	BARRIERS:	Retrofit codes are not often enforced in many member states; compliance rates are relatively unknown.
	NEXT:	Publication of near-zero buildings roadmaps; testing of code improvements in progressive member states; development and testing of mandated retrofit policy.
	**SUCCESSES:**	Most states have new construction codes; national-level model codes have been developed with high degree of industry support and inspiration by leading jurisdictions such as California. Some states are integrating code compliance development efforts into utility program evaluation.
	BARRIERS:	Federal government cannot mandate that states develop codes; retrofit codes are rare; code compliance varies widely and compliance data are generally lacking.
	NEXT:	Development of capacity and programs for all states to meet goal of 100% code development and 90% implementation by 2017; development of code compliance best practices.
	**SUCCESSES:**	National government has developed building codes for new construction and retrofits in all sectors in most climate regions; leading jurisdictions such as Shanghai, Tianjin, Beijing, and other major cities have developed advanced codes; capacity has developed rapidly by means of a triple-checking system that has produced dramatically increased compliance rates.
	BARRIERS:	Codes as developed may not be appropriate for local comfort conditions; there are no rural codes.
	NEXT:	Reevaluation of codes according to domestic thermal comfort standards; updating of older codes to take new technology into consideration; spreading lessons from leading code jurisdictions such as Beijing and Tianjin; verification of compliance rates and evaluation of capacity development best practices.
	**SUCCESSES:**	Government has developed first commercial building energy code for new construction and retrofits; there has been some local regulatory development; code has been implemented in government buildings.
	BARRIERS:	There are no low-rise residential or rural buildings codes; codes may be too advanced for capacity levels; local level integration is time consuming; enforcement of building codes is rare; and product testing is almost non-existent.
	NEXT:	Developing leading jurisdictions for code development and implementation; implementing best practices through concerted action to gather stakeholders and inform market.

7.1.2. Building Energy Labels

Building energy labeling programs formulated at the national level have supported local authorities in promoting energy efficiency in all four regions studied. In the United States and the European Union, labeling programs have provided incentives for buildings that exceed standards. Labeling is also a useful element in training programs for building code officials and other building energy professionals.

Table 7-2 describes the status of building energy labeling programs in the four regions.

Table 7-2. Status of Building Label Development and Implementation in the Four Regions

	**SUCCESSES:**	Energy labeling mandatory for all buildings at time of sale or lease; rating labels increasingly include retrofit recommendations; real estate market premiums apparent in some countries; training programs established with sharing of best practices; computerized records for quality assurance and data-assisted policy design; early development of low-energy building endorsement standards push codes toward nearly net-zero-energy buildings.
	BARRIERS:	Newness of labels in some countries may prevent realization of market premiums in short term; lag in certifier training hindered program deployment; quality of certification and design of different labels in countries not yet proven.
	NEXT:	Evaluation of mandatory labels for best practices and consumer understanding; sharing of best practices on multiple means of training certifiers; empirical analysis of effectiveness of asset versus operational ratings for different building types.
	**SUCCESSES:**	Some endorsement labels (e.g., ENERGY STAR™) are credible to a large fraction of consumers and are commanding market premiums; label programs increasingly deliver information on the value of savings and retrofit options; ENERGY STAR commercial programs often use nationally developed models to standardize mandatory and voluntary programs; survey-based databases assist benchmarking.
	BARRIERS:	Many energy labels tied to incentive programs with uncertain real estate market demand; label market is saturated with many different labels; label programs not being fully used to develop standardized national buildings benchmarking database.
	NEXT:	City and state-level mandatory label expansion and program testing.
	**SUCCESSES:**	Enthusiastic development of locally relevant labels; early application of LEED and China 5-Star Building Energy-Efficiency Rating system programs to require labels in government buildings and some other areas; high uptake of labels in leading jurisdictions.
	BARRIERS:	Jurisdictionally fractured government code development with authority vested in multiple regional and municipal agencies; Potential for consumer confusion between green building and energy-efficiency labels and rating systems; LEED-dominated real estate market with limited penetration of government-sponsored energy labels.
	NEXT:	Clarify label regime through efforts to consolidate programs; expand on programs such as Jiangsu's by tying labels to government incentives.
	**SUCCESSES:**	LEED has achieved some penetration with strong growth in recent years; a locally relevant label (GRIHA) has been developed; programs require domestically developed labels in government buildings; building energy ratings have been used to create benchmarking database.
	BARRIERS:	Label competition may be an issue; "green" labels dominate and do not clearly indicate energy use; there is limited market demand for building labels.
	NEXT:	Letting the market decide which is best (local labels likely to win with government support).

The European Union Energy Performance in Buildings Directive (EPBD) mandates that all buildings and individual units possess and display energy labels, called energy performance certificates (EPCs), at the time of sale or lease. EPCs are designed to be easily understood, and many include advice on how to make improvements as well as the value of the improvements. Some countries in the European Union require continuous education for inspectors, recertification of labeled buildings, and computer-based checking for certification errors.

Most labels in United States are voluntary. However, a few cities and states using the ENERGY STAR program have begun to implement mandatory rating schemes for buildings with some requiring disclosure at the time of sale or lease and others requiring disclosure on publicly-available websites. Existing mandatory commercial building ratings use the ENERGY STAR benchmarking tool; residential programs require disclosure of utility bills or home energy audit reports. .

With the exception of mandatory requirements for energy labels for government buildings, almost all building label programs in China and India are voluntary.

In the United States and the European Union, rating systems are often tied to financial incentives. In the United States this is exemplified by the ENERGY STAR commercial building programs, which used as a basis for incentives through utility ratepayer-funded programs. Europe's increasingly popular zero-energy buildings policies have relied on voluntary standards and accompanying labels, through programs such as Effinergie and Passive House. In Germany, having a building rated is the first step in attaining a loan or grant from the KfW system.

All regions have multiple labeling programs with similar objectives. This can be a barrier to consumer acceptance and understanding of labels. The European Union labels mandate has been most effective at encouraging standardized and simplified labeling within countries.

7.1.3. Building Energy Incentives

The United States and the European Union have experimented with a plethora of incentive schemes and financing mechanisms. Most come in one of three forms: loans from private and government-associated banks; grants and loans from public utilities or third parties distributing utility ratepayer funds; or tax rebates from government funds. In many cases, the most successful programs tap different funding streams through a single deliverer. An example is the KfW scheme in Germany, which offers government-backed loan financing, grants, and tax rebates through retail banks. Additionally, the best incentive programs ensure that the deepest energy savings are given the highest incentives (called "tiering"). Incentive programs are also policy delivery mechanisms in that they can substantially raise stakeholders' awareness of building energy-efficiency opportunities, especially in the residential construction sector.

Many incentive programs are part of a coordinated energy and climate-change strategy. The New York City, Jiangsu province, California state, and Austria case studies are examples of incentive programs that are either a part of a broader strategy or are explicitly linked to other policies.

Incentive programs funded by governments often rise and fall as governments change or public money becomes scarce. The recognition of this phenomenon has led to creative financing approaches. The KfW program in Germany demonstrates how building energy efficiency incentive programs can generate net-positive income for the government. Some of the most successful efficiency incentive policies in Europe and the United States increasingly rely on well-regulated non-governmental entities (investor-owned utilities in the United States and to a certain extent commercial banks in Europe) to distribute incentives. The concurrent development of energy and climate change goals, building codes, and energy-efficiency incentives, all administered by a small cohort of state-level regulatory agencies, has proven particularly effective in California.

Financing and incentive mechanisms in China and India are more circumscribed than those in the United States and the European Union, but efforts in China are rapidly growing and becoming more comprehensive. Chinese government grants and subsidies are starting to compel comprehensive retrofits. The government has recently mandated a 10 to 15% reduction in the energy intensity of commercial buildings in urban areas. Full government funding is supporting very large-scale retrofits of government buildings. In early May 2012, China announced green building incentives whose amounts increase as a building's green label rating increases from two to three stars.

Table 7-3 compares the successes, barriers, and next steps in energy-efficiency financing mechanisms in the four regions.

Table 7-3. Status of Financing Mechanisms in the Four Regions

	**SUCCESSES:**	Most successful tax breaks have been linked to utility mandates for energy savings; retail banks are enthusiastically joining some programs like the KfW scheme in Germany; tiered incentives are increasingly the norm; packages delivered by many national governments incorporate all types of incentives and target specific markets; the KfW scheme demonstrates net positive income.
	BARRIERS:	Replicability of KfW scheme will depend upon willingness of local banks; utility programs are largely untested in most countries; establishing sustainable revolving funds is difficult.
	NEXT:	Experiments with new types of incentive programs; spread of certification scheme best practices.
	**SUCCESSES:**	Demand-side management (DSM) programs tied to utility energy-efficiency mandates have been very successful in states where utility profits are decoupled from sales; national model commercial program templates substantially ease burdens of local program administrators; tying incentives to certification schemes has increased certification rates.
	BARRIERS:	Many state regulatory commissions and utilities oppose DSM because it raises electricity rates (as distinct from customer bills); deep retrofit project-level cost recovery is uncertain, especially in residential market.
	NEXT:	Testing and analysis of novel approaches being tried out (PACE, on-bill financing programs, etc.); standardization of program evaluation processes.
	**SUCCESSES:**	Large incentives for industry during past five years have created the infrastructure and skills to implement similar programs for buildings; packaging of incentive information within building codes and regulations appears to be a good strategy to increase awareness and uptake.
	BARRIERS:	Previous incentives in residential housing were not tiered well; diverse building stock results in high transaction costs; most programs are limited to easy-to-implement lighting and renewable-energy-measure-based subsidies.
	NEXT:	Funding through energy service companies; utility energy saving mandates in new Five-year Plan; continued expansion of incentive programs beyond low-income housing and government buildings.
	**SUCCESSES:**	Lighting program and certain renewable energy programs are most developed; domestic label program (GRIHA) and incentives were linked early in their development.
	BARRIERS:	Building incentive programs are very limited and constrained by complexity of Indian bureaucracy, limited funds, relatively low priority, and limited government awareness.
	NEXT:	Developing data regarding costs and benefits of energy savings measures for more building types and climates, followed by increased financing.

Chapter 8 – Findings and Recommendations

This report addresses the single largest source of greenhouse gas emissions and the greatest opportunity to reduce these emissions. The IPCC 4th Assessment Report estimates that globally 35% to 40% of all energy-related CO_2 emissions (relative to a growing baseline) result from energy use in buildings. Emissions reductions from a combination of energy efficiency and conservation (using less energy) in buildings have the potential to cut emissions as much as all other energy-using sectors combined. This is especially the case for China, India and other developing countries that are expected to account for 80% or more of growth in building energy use worldwide over the coming decades. In short, buildings constitute the largest opportunity to mitigate climate change and special attention needs to be devoted to developing countries.

At the same time, the buildings sector has been particularly resistant to achieving this potential. Technology in other sectors has advanced more rapidly than in buildings. In the recent past, automobile companies have made large investments in designing, engineering, and marketing energy efficient and alternative fuel vehicles that reduce greenhouse gas emissions. At the same time, the buildings sector – dependent on millions and millions of decisions by consumers and homeowners – face a large variety of market barriers that cause very substantial underinvestment in energy efficiency.

How can the trajectory of energy use in buildings be changed to reduce the associated CO_2 emissions? Is it possible to greatly accelerate this change? The answer to these questions depends on policy, technology, and behavior. Can policies be crafted and implemented to drive the trajectory down? Can the use of existing energy efficiency technologies be increased greatly and new technologies developed and brought to market? And what is the role of behavior in reducing or increasing energy use in buildings?

These are the three overarching issues. The information assembled in this study and the knowledge derived from it needs to be brought to bear on these three questions. And thus we turn to some of the insights from the study, presented in the form of findings and recommendation. Of the many findings that could be presented we have chosen the few that we consider to be particularly important. Others reading this report would undoubtedly choose a different set. The reader is encouraged to do so.

8.1. Findings: Policy

8.1.1. Building Energy Standards

Building energy standards are ubiquitous in the United States, the European Union, and China. They are the most potent of all policies in reducing energy use from heating and cooling of buildings. Almost all of the standards thus far promulgated in three regions have been cost-effective. There is a long (multidecade) tradition of building standards in all of the regions. This is especially true of the north of Europe with extreme cold weather and countries wealthy enough to invest in energy efficiency.

To date, most standards have been applied only to new buildings. The problem of high energy use of existing buildings – of great importance in the two regions (the United States and the European Union) in which the building stock is growing slowly – has not been well addressed and standards have played little role. There is increasing interest and activity in applying standards at point of sale.

The most important issues in making standards more effective are (1) increasing training (of code officials, builders, and other building professionals), (2) the rigorous updating of the standards to promote the development and use of new, efficient technology, (3) announcing new codes early on so that the industry can prepare for more stringent codes and, (4) demonstrating the feasibility of constructing progressively more efficient buildings that are cost effective.

8.1.2. Building Energy Labels

Whole building energy labels have been particularly effective in three ways. They provide the necessary knowledge to the building owner or occupant to motivate decisions to invest in energy efficiency (for buildings receiving low ratings). Some of the labels recommend measures for reducing energy use (e.g., the European Union). The effectiveness of this application of labels is strongly dependent on consumers' view of their trustworthiness.

A second application of labels is to provide information about the building's energy-efficiency or energy use at the point of transaction (e.g., as required for example by France). The premise is that such knowledge is likely to be useful and used when the building is sold or rented.

The third use of labels is in our judgment the most important. The combination of standards (setting a floor on efficiency or energy use), a label (serving as a measuring stick), and financial incentives (to improve building performance beyond existing standards) is an extremely powerful means of increasing energy efficiency. If all three policies are well integrated with each other (e.g., California), they can drive efficiency aggressively and over a long period of time. The incentive and labeling policies will promote state of the art energy efficiency on which updates to standards can be based. This is effective as a policy design for new buildings but also can be applied to retrofits of existing buildings.

8.1.3. Building Energy Incentives

The fundamental issue of incentive programs is how to maintain funding, particularly if the funds come from governments. There are many innovative approaches to the problem that have potential for success. There are at least two approaches that have been successful on a large scale: utility demand side management (DSM) in the United States (funds from ratepayers who are the beneficiaries of the lowered total cost of supplying energy for the utility system) and in Germany (the KfW program where the increased taxes resulting from the program cover the costs of administering the program plus the cost of the incentives).

8.1.4. Policy Packages

As noted in section 8.1.2, combining incentives with labels and standards produces a particularly effective means of reducing energy use in buildings as well as encouraging the development and use of advanced energy-efficiency technologies. Three prime examples of the strong synergy among the three policies are California's utility and standards programs, Germany's KfW loan program, and several innovative municipal programs in China. The approach of packaging policies that can be implemented in many different configurations (e.g. levels of standards and incentives; different rating systems; agents responsible for implementation; form and identity of beneficiary of the incentives, etc.) has the potential for greatly expanding the reach and impact of the individual policies.

8.2. Findings: Technology

8.2.1. Opportunities with Existing Technologies and Systems

The biggest opportunity for saving energy in buildings in the coming decade(s) in all four regions (even those with the highest rate of construction) is adopting already available energy efficiency technology. The existence of many underutilized energy efficiency technologies and the associated market barriers strongly justify government policies.

Systems rather than technologies offer the greatest promise of energy savings. They typically underperform and in the process use excessive amounts of energy. This is particularly the case for space conditioning systems in large buildings. Improving system performance has large potential for energy saving in the near time.

For those developing countries with large numbers of poor people in cold regions, the single most important means for reducing greenhouse emissions for heating (cooking and water heating in all climates) is the replacement of inefficient biomass and/or coal burning stoves with modern fuels and equipment.

8.2.2. Creating Future Technologies

In spite of the plethora of underutilized high-efficiency technology today, research and development (R&D) is needed to achieve technologies and systems with lower costs or better performance. There are numerous R&D opportunities to achieve these goals.

Current R&D programs unfortunately give very little emphasis to systems as distinct from technologies. Passive solar houses, with a combination of many technologies[14], illustrate the importance of systems in reducing energy use. Integrated design[i] is arguably the most important system (in reality, a "system of systems") for designing large buildings with very low energy use. An especially good example of the results of an integrated design process is the seven-story building housing the Institute for Building Research (IBR) in Shenzhen China. The building delivers substantial energy savings (greater than 50%) at construction cost lower than that of comparable buildings.[15] We believe that the integrated design process, with one knowledgeable person or organization having control over all aspects of the design process (architectural and engineering), construction, commissioning, and use of the building played an important role in the success of this building.

Thus R&D needs to focus much more strongly than it does today on designing, creating, testing, and producing techniques to assure effective performance of systems.

8.3. Findings: Behavior, Comfort Preferences, and the Operation of Buildings

Research going back to the 1970s has shown the variation of energy use as a function of occupant behavior. Studies of identical houses in close proximity to each other showed a factor of two difference in heating energy use between houses with the lowest and highest energy.[16] Numerous measurements and simulations have confirmed this variation or greater in commercial and residential buildings in the United States, China, Europe, and elsewhere throughout the world.[17] The body of this work shows that the effect of behavior and operational practices on energy use in buildings can be and often is greater than that of technology. Unfortunately, policies and programs have not demonstrated an ability to capture a significant portion of this occupant-related variation in energy. A miniscule portion of research on energy efficiency addresses how behavioral issues can best be addressed to achieve long-term energy savings.

8.4. Policy Research Needs

There is a need for experimentation, demonstrations, policy research, data and/or analysis on:

- Impacts of policies on heating and cooling energy use and costs (treated broadly[18]) based on quantitative and reproducible research.

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[14] Importantly, the passive house as any complex system needs to be operated properly to be successful.
[15] Current estimates are that the construction cost may have been 1/3 less per square meter less than that of a comparable building.
[16] Stated more precisely, the factor of two is the ratio of the highest decile of heating energy use to the lowest decile.
[17] Annex 53 International Energy Agency (IEA), with participants from Asia, Europe, and the United States, has been studying this phenomenon for the past several years with a report scheduled for 2013.
[18] Including costs to consumers, energy suppliers, builders, the environment, etc.

- The effects of behavior on energy use in buildings and policies that encourage energy-conserving behavior.
- Well-documented costs and energy savings of buildings with very low heating and cooling energy.
- Quantitative effects of employing multiple policies (policy packages) to reduce building energy use.
- Sharing policy experience on building energy efficiency policies in actionable forms to developing countries.
- Effective methods to communicate information not widely known or understood to policy makers and the public.

8.5. Recommendations

Earlier[19] we identified the high-level issues that are the intellectual challenge underlying the research on which this report is based. It is our intent that the recommendations collectively provide insight into the issues. They are repeated below.

> *How can the trajectory of energy use in buildings be changed to reduce the associated CO2 emissions? Is it possible to greatly accelerate this change? The answer to these questions depends on policy, technology, and behavior. Can policies be crafted and implemented to drive the trajectory down? Can the use of existing energy efficiency technologies be increased greatly and new technologies developed and brought to market? And what is the role of behavior in reducing or increasing energy use in buildings?*

To increase the effectiveness and energy savings of building energy standards, we recommend that governmental organizations with authority over energy use in buildings should:

- As a matter of highest priority create (if they do not already exist) or strengthen building energy standards and their enforcement in measureable ways.
- Regularly update the standards as new technology or practices are demonstrated to cost-effectively save energy for space conditioning in buildings.
- Provide sufficient advance notice of the specifics and timing of the updates so that industry can prepare for the updates.
- Assure that demonstrations of improved practices and advanced systems and technology take place frequently and are of sufficient quality to support standards updates.

To increase effectiveness of labels, organizations responsible for them should:

- Assure that they are designed and promulgated to be easy to use.
- Are consistent with actual energy use or efficiency of the building to which it is applied.
- Are communicated to consumers, builders, and other building professionals in a manner to assure their trustworthiness.

[19] Third paragraph of this Chapter.

For financial incentives programs to have large and sustaining impacts, they need to be long-lived and at assured minimal levels.

Endnotes:

Explanation of Integrated Design

[i]The integrated design process may be defined as one in which the design variables that interact with one another are treated together (i.e., iteratively), producing a design that comes close to achieving the objectives established for the design (“optimal”). The sequence of steps that is typically followed today often leads to solutions that are far from optimal. For example, HVAC capacity and equipment are often decided before the major contributors to the internal loads of a building are known.

Significant interactions take place among all design elements of a building affect heating and cooling loads (e.g., window size, placement, and thermal characteristics; window shading types and placement; lighting locations, efficacy and local controls; building orientation; number and wattage of plug loads; and the volume of outside air that is circulated into a building).

Advanced technology options (e.g., on- site generation, passive ventilation, thermal mass with night ventilation, chilled ceiling displacement ventilation, dehumidification and day-lighting) need to be taken into consideration. Control strategies and operating conditions of the equipment in the building strongly affect the effectiveness of the design and technology choices for the building.

Finally, all of these complex design and engineering issues must themselves be integrated with decisions on structural issues, space planning, site context, materials selection and other issues, all within the context of tight budgets and schedules.

To address these interactions among the different components of a building, integrated design and operation requires cooperation among the major decision makers in a building project—architects, engineers, and builders—to evaluate the projected energy consumption for a variety of designs. Building professionals must also enjoy a comfort level in using results of computer tools to underpin important design decisions. Software that is understandable to everyone involved is needed, so that the group’s collective knowledge is codified and used as different problems and solutions are addressed in the design, construction, and eventually the operation of the building.