WORLD BANK WORKING PAPER NO. 204

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Global Experiences and Lessons from Early Adopters

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Foreword

Urbanization and growing wealth in developing countries portend a large increase in demand for modern energy services in residential, commercial, and public-service buildings in the next two decades. Pursuing energy efficiency in buildings is vital to energy security in developing countries and is identified by the Intergovernmental Panel on Climate Change (IPCC) as having the greatest potential for cost-effective reduction of CO_2 emissions by 2030 among all energy-consuming sectors.

Building energy efficiency codes (BEECs), together with energy efficiency standards for major appliances and equipment, are broadly recognized as necessary government interventions to overcome persistent market barriers to capturing the economic potential of energy efficiency gains in the residential, commercial, and public-service sectors. Implementation of BEECs helps prevent costly energy wastes over the lifecycles of buildings and energy systems in space heating, air conditioning, lighting, and other energy service requirements. But achieving the full potential of energy savings afforded by more energy-efficient buildings also requires holding people who live or work in buildings accountable for the cost of energy services.

Mandatory energy-efficient design requirements for buildings were first introduced in Europe and North America in the late 1970s and have proven to be an effective policy instrument. Several developing countries began similar efforts in the 1990s, and many more joined the pursuit in the last decade. Compliance enforcement has been the biggest challenge to implementing BEECs. Even in industrialized countries, enforcement remains uneven and inconsistent because of variations in local government political and resource support, robustness of the enforcement infrastructure, and conditions of the local construction market. With few exceptions, compliance enforcement of building energy efficiency codes in developing countries is either seriously lacking or nonexistent.

To help expand the World Bank Group's support to the adoption and implementation of BEECs in developing countries, the Energy Sector Management Assistance Program (ESMAP) and the Carbon Finance Unit of the World Bank launched a collaborative effort in 2008 with the objectives of (1) evaluating global experiences and extracting good practices in implementing BEECs, and (2) developing a carbon finance methodology for supporting programs and projects that invest in more energy-efficient buildings. A new carbon finance methodology has been submitted to the Small Scale Working Group under the Executive Board of the Clean Development Mechanism.

This report summarizes the findings of an extensive literature survey of the experiences of implementing BEECs in developed countries. It also includes case studies of four developing countries—China, Egypt, India, and Mexico—and the state of California in the United States of America. It aims to inform both the World Bank Group and its client countries about global best practices and emerging lessons from developing countries in the design and implementation of BEECs. The report also serves as a primer on the basic features of BEECs and the commonly adopted compliance and enforcement approaches.

The key challenges to improving compliance enforcement in developing countries include the level of government commitment to energy efficiency, the effectiveness of government oversight of the construction sector, the compliance capacity of domestic/local building supply chain, and the financing constraints. These challenges are surmountable in countries where economic growth is sustained and energy efficiency is pursued as a key element of national energy strategy.

The process of transforming a country's building supply chain toward delivering increasingly more energy-efficient buildings takes time and requires persistent government intervention through uniformly enforced and regularly updated BEECs. The report notes, in particular, that recent development in *green buildings* through voluntary rating systems, such as the Leadership in Energy and Environmental Design (LEED) certification, are effective market-based initiatives inducing the building construction sector to move toward greater energy and environmental sustainability. Nonetheless, mandatory BEECs cannot be negated in any economy due to deep-seated market barriers.

Increased international support is called for to strengthen the enforcement infrastructure for BEECs in middle-income developing countries. For low- and lower-middle-income countries, there is an urgent need to assist in improving the effectiveness of government oversight for building construction, laying the foundation for the system to also cover BEECs.

It is our hope that this report will be a useful reference for the energy and urban operation staff of the World Bank Group and will help them engage client countries in policy dialogues and project designs in the development and implementation of BEECs.

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Acronyms and Abbreviations

AC	Air conditioning
AEAEE	Asociación de Empresas para el Ahorro de Energía en la Edificación (Association of Enterprises for Energy Savings in Buildings, Mexico)
ANSI	American National Standards Institute
ARRA	American Recovery and Reinvestment Act
ASHRAE	American Society of Heating, Refrigerating, and Air-conditioning Engineers
BCA	Building and Construction Authority (Singapore)
BCAP	Building Codes Assistance Project
BEE	Bureau of Energy Efficiency (India)
BEEC	Building Energy Efficiency Code
BHCI	Building Heat Consumption Index (China)
BIS	Bureau of Indian Standards
BPO	Business-process-outsourcing
BSC	Buildings Standards Commission (California)
BWRO	Building Wall Reform Office (China)
CalCERTS	California Certified Energy Rating & Testing Services
CASE	Codes and Standards Enhancement (California)
CBECS	Commercial Building Energy Consumption Survey
CBPCA	California Building Performance Contractors Association
CDM	Clean Development Mechanism
CEC	California Energy Commission
CEN	European Committee for Standardization
CENEf	Center for Energy Efficiency (Russia)
CEPT	Centre for Environmental Planning & Technology
CER	Certified Emission Reduction
CEV	Código de Edificación de Vivienda (Regulation for housing construction, Mexico)
CFE	Comisión Federal de Electricidad (Federal electric utility, Mexico)
CFL	Compact fluorescent lamp
CHEERS	California Home Energy Efficiency Rating System
CHP	Combined heat and power
CIDC	Construction Industry Development Council
CO	Construction co-responsible
CO_2	Carbon dioxide
CONUEE	Comisión Nacional para el Uso Eficiente de la Energía (National Energy Efficiency Agency, Mexico)
CONAE	Comisión Nacional para el Ahorro de Energía (Energy Efficiency Agency, Mexico)
CONAVI	Comisión Nacional de Vivienda (National Housing Agency, Mexico)
CPUC	California Public Utility Commission

C&S	Codes and standards
DOE	U.S. Department of Energy
DRO	Director in Charge of Construction (Mexico)
DSM	Demand-side management
DIT	Technical suitability report (Mexico)
ECBC	Energy Conservation Building Code (India)
ECO	Energy Conservation and Commercialization
EE	Energy efficiency
EEHC	Egyptian Electricity Holding Company
EESL	Energy Efficiency Services Limited (India)
EIA	U.S. Energy Information Administration
EIA	Environmental Impact Assessment
EPA	U.S. Environmental Protection Agency
EPBD	Energy Performance of Buildings Directive (European Union)
EPC	Energy Performance Certificate
EPC	Energy Performance Coefficient (Netherlands)
EPI	Energy Performance Indicator (India)
EPN	Energy performance standard (Netherlands)
EPS	Expanded polystyrene
ESCO	Energy service company
ESMAP	Energy Sector Management Assistance Program
EU	European Union
EUI	Energy use index
FHA	Federal Housing Administration
GBS	Green building standard
GBC	Green building code
GDP	Gross domestic product
GEF	Global environmental facility
GHG	Greenhouse gas
GMIS	Green Mark Incentive Scheme (Singapore)
GNI	Gross national income
GPR	Green point rating
GRIHA	Green Rating for Integrated Habitat Assessment (India)
GWh	Gigawatt hour
HBRC	Housing and Building Research Center (Egypt)
HERS	Home Energy Rating System
HRBEE	Heat Reform and Building Energy Efficiency
HVAC	Heating, ventilation, and air conditioning
ICC	International Code Council
IDB	Inter-American Development Bank
IEA	International Energy Agency
IECC	International Energy Conservation Code
IESNA	Illuminating Engineering Society of North America
IFC	International Finance Corporation
IGBC	India Green Building Council
IMT	Institute for Market Transformation

INFONAVIT	Mexican National Fund for Workers' Dwellings
IOU	Investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
IRC	International Residential Code
IRR	Internal rate of return
ISHRAE	Indian Society of Heating Refrigerating and Air-Conditioning Engineers
IT	Information technology
KEMCO	Korea Energy Management Corporation
KfW	Kreditanstalt fuer Wiederaufbau (German Development Bank)
kVA	Kilovolt-ampere
kWh	Kilowatt hour
LBNL	Lawrence Berkeley National Laboratory
LCC	Life-cycle cost
LCCA	Life-cycle cost analysis
LED	Light-emitting diode
LPG	Liquefied petroleum gas
LEED	Leadership in Energy and Environmental Design
MDI	Multilateral development institution
MJ	Mega Joule
MNRE	Ministry of New and Renewable Energy (India)
MoHURD	Ministry of Housing and Urban-Rural Development (China)
MOEF	Ministry of Environment and Forests
Mtce	Million tons of coal equivalent
Mtoe	Million tons of oil equivalent
MW	Mega Watt
NAPCC	National Action Plan on Climate Change (India)
NBC	National Building Code (India)
NGO	Nongovernmental organization
NMX	Normas Mexicanas (Mexican Standards)
NOC	No-objection certificate
NOM	Normas Oficiales Mexicanas (Official Mexican Codes)
NPV	Net present value
OECD	Organisation for Economic Co-operation and Development
O&M	Operations and maintenance
OTTV	Overall Thermal Transfer Value
PECC	Programa Especial de Cambio Climático (Special Climate Change Program, Mexico)
PG&E	Pacific Gas and Electric
PNASE	Programa Nacional para el Aprovechamiento Sustentable de la Energía (National Program for Sustainable Energy Use, Mexico)
PNNL	Pacific Northwest National Laboratory (U.S.)
PPP	Purchasing power parity
PVC	Polyvinyl chloride
R&D	Research and development
RE	Renewable energy

RESNET	Residential Energy Services Network
RICS	Royal Institute of Chartered Surveyors
RSE	Resident site engineers
SBC	System benefits charge
SDA	State designated agency
SEER	Seasonal Energy Efficiency Ratio
SEP	State energy program
SHGC	Solar heat gain coefficient
SPE/I	Special plans examiners and inspectors (U.S.)
SWH	Service water heating
TDV	Time dependent valuation
TERI	The Energy Resource Institute (India)
TJCC	Tianjin Construction Commission
TJDRC	Tianjin Development and Reform Commission
TJEPB	Tianjin Environmental Protection Bureau
TJUPB	Tianjin Urban Planning Bureau
TWh	Terawatt hour
UNFCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
USA or U.S.	United States of America
USAID	U.S. Agency for International Development
USGBC	U.S. Green Building Council
UT	Union territory (India)
VAT	Value-added tax
WEC	World Energy Council
WMRO	Wall Materials Reform Office
WBF	Wohnbauförderung (Public Concessionary Financing Scheme for Residential Buildings, Austria)

Definitions

Source: http://resourcecenter.pnl.gov/cocoon/morf/ResourceCenter/article/1295 and this report, unless otherwise noted.

Alteration	Any construction, renovation, or change in a mechanical system that involves an extension, addition, or change to the arrangement, type, or purpose of the original installation.
Building envelope	A building envelope includes all components of a building that enclose conditioned space. Building envelope components separate conditioned spaces from unconditioned spaces or from outside air. For example, walls and doors between an unheated garage and a living area are part of the building envelope; walls separating an unheated garage from the outside are not. Although floors of conditioned basements and conditioned crawlspaces are technically part of the building envelope, the code does not specify insulation requirements for these components.
Building official	The officer or other designated representative is authorized to act on behalf of the authority having jurisdiction.
Cavity insulation	Insulation installed between structural members such as wood studs, metal framing, and Z-clips.
Combined heat and power (CHP) (also **Cogeneration)**	**The concurrent production** of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy. **A type of distributed generation**, which, unlike central station generation, is located at or near the point of consumption **A suite of technologies** that can use a variety of fuels to generate electricity or power at the point of use, allowing the heat that would normally be lost in the power generation process to be recovered to provide needed heating and/or cooling; http://www1.eere.energy.gov/industry/distributedenergy/chp_basics.html
Commissioning	When a building is initially commissioned it undergoes an intensive quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning ensures that the new building operates initially as the owner intended and that building staff are prepared to operate and maintain its systems and equipment; http://cx.lbl.gov/definition.html

Compliance	Compliance is whether and to what extent individuals/companies do adhere to the provisions of a regulation. Compliance depends on implementing policies ordered, and on whether measures follow up the policies. Compliance is the degree to which the actors whose behavior is targeted by the regulation, local government units, corporations, organizations or individuals, conform to the implementing obligations; http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-annex1.pdf
District heating	A system supplying heat produced centrally in one or several locations to a non-restricted number of customers. It is distributed on a commercial basis by means of a distribution network using pressurized hot water or steam as a medium. Often, the heat is also used for service water heating and industrial purposes, such as process heat. Although mostly understood to mean large centralized urban heating systems, many national statistics also include very small heating systems; http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/12/15/000094946_00112105321115/Rendered/PDF/multi_page.pdf
Fenestration	All areas (including the frames) in the building envelope that let in light, including windows, plastic panels, clerestories, skylights, glass doors that are more than one-half glass, and glass block walls. A skylight is a fenestration surface having a slope of less than 60 degrees from the horizontal plane. Other fenestration, even if mounted on the roof of a building, is considered vertical fenestration.
Glazed wall system	A category of site-assembled fenestration products, which includes, but is not limited to, curtain walls and solariums. **Glazing** Any translucent or transparent material in exterior openings of buildings, including windows, skylights, sliding doors, the glass area of opaque doors, and glass block. **Glazing Area** The area of a glazing assembly is the interior surface area of the entire assembly, including glazing, sash, curbing, and other framing elements. The nominal area or rough opening is also acceptable for flat windows and doors. **Glazing U-Factor** Based on the interior-surface area of the entire assembly, including glazing, sash, curbing, and other framing elements. Center-of-glass U-factors cannot be used.
Green building	Requires compliance with several sustainability criteria over the life-cycle of a building: energy efficiency, water efficiency, good indoor air quality, use of environmentally sustainable materials, and use of the building lot or site in a sustainable manner

Heat pump	One or more factory-made assemblies that include an indoor conditioning coil, compressor(s), and outdoor coil or refrigerant-to-water heat exchanger, including means to provide both heating and cooling functions. Ground source heat pump (GSHPs): space conditioning systems that employ a geothermal resource—the ground, groundwater, or surface water—as both a heat source and sink. GSHPs use a reversible refrigeration cycle to provide either heating or cooling. (A heat sink is a body of air or liquid to which heat can be transferred.) GSHPs operate in much the same manner as air-source heat pumps. Both use a compressor to move refrigerant around a closed loop, transferring heat between an indoor and another coil where heat is absorbed or rejected; http://www1.eere.energy.gov/femp/procurement/eep_groundsource_heatpumps.html
Infiltration	The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building caused by the pressure effects of wind or the effect of differences in the indoor and outdoor air density or both.
Integrated Design Process (IDP) of buildings	Optimizing the orientation and shape of buildings and providing high-performance envelopes for minimizing heating and cooling loads. Passive techniques for heat transfer control, ventilation, and daylight access reduce energy loads further. Properly sized and controlled, efficient mechanical systems address the left-over loads. IDP requires an iterative design process involving all the major stakeholders from building users to equipment suppliers, and can achieve 30-75% savings in energy use in new buildings at little or no additional investment cost; http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-annex1.pdf
Labeled	Devices, equipment, appliances, assemblies, or materials to which have been affixed a label, seal, symbol, or other identifying mark of a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items and by whose label the manufacturer attests to compliance with applicable nationally recognized standards.
Mechanical system	The system and equipment used to provide heating, ventilating, and air conditioning functions as well as additional functions not related to space conditioning, such as, but not limited to, freeze protection in fire-protection systems and water heating.
Net-zero energy building	A residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies; http://www.nrel.gov/docs/fy06osti/39833.pdf

Opaque	All areas in the building envelope, except fenestration and building service openings such as vents and grilles. **Opaque Areas** Opaque areas include all areas of the building envelope except openings for windows, skylights, doors, and building service systems. For example, although solid wood and metal doors are opaque, they should not be included as part of the opaque wall area (also referred to as the net wall area).
Passive solar design	Structural design and construction techniques that enable a building to utilize solar energy for heating, cooling, and lighting by non-mechanical means; http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-annex1.pdf
Performance approach	A performance approach (also known as a systems performance approach) compares a proposed design with a baseline or reference design and demonstrates that the proposed design is at least as efficient as the baseline in terms of annual energy use. This approach allows the greatest flexibility but may require considerably more effort. A performance approach is often necessary to obtain credit for special features such as a passive solar design, photovoltaic cells, thermal energy storage, fuel cells, and other nontraditional building components. This approach requires an annual energy use value. There are several commercially available software tools that perform this analysis.
Prescriptive approach	A prescriptive approach lists the minimum R-value or maximum U-factor requirements for each building component such as windows, walls, and roofs. For lighting systems in commercial buildings, a prescriptive approach would simply list the allowable watts per square foot for various building types. For mechanical systems and equipment, a prescriptive approach would list the minimum required equipment efficiencies.
Rebound effect	After implementation of efficient technologies and practices, part of the savings is taken back for more intensive or other consumption, e.g., improvements in car-engine efficiency lower the cost per kilometer driven, encouraging more car trips or the purchase of a more powerful vehicle; http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-annex1.pdf
R-value	A measure (h ft2 °F/Btu or (m2 K)/W) of thermal resistance, or how well a material or series of materials resists the flow of heat. The R-value is the reciprocal of the U-factor.

Room air conditioner	An encased assembly designed as a unit to be mounted in a window or through a wall, or as a console. It is meant to provide direct delivery of conditioned air to an enclosed space, room, or zone. It includes a prime source of refrigeration for cooling and dehumidification and a means for circulating and cleaning air. It may also include a means for ventilating and heating.
Seasonal energy efficiency ratio (SEER)	The total cooling output of an air conditioner during its normal annual usage period for cooling, in Btu/h (W), divided by the total electric energy
Thermal bridge	A component, or assembly of components, in a building envelope through which heat is transferred at a substantially higher rate than through the surrounding envelope area.
Thermal mass	A measure of a building's capacity to store and regulate internal heat. Buildings with a high thermal mass take a long time to heat up but also take a long time to cool down. As a result they have a very steady internal temperature. Buildings with a low thermal mass are very responsive to changes in internal temperature- they heat up very quickly but they also cool down quickly. They are often subject to wide variables in internal temperature. The best materials for storing heat are those that are very dense, heat up slowly, and then give out that heat gradually. Brick, concrete and stone have a high thermal capacity and are the main contributors to the thermal mass of a house; http://www.theyellowhouse.org.uk/eco-prin/princip.html
Trade-off approach	A tradeoff approach involves trading enhanced energy efficiency in one component against decreased energy efficiency in another component. These tradeoffs typically occur within major building systems (e.g., envelope, mechanical) or in commercial lighting.
U-factor	A measure (Btu/h ft^2 °F or W/(m2 K)) of how well a material or series of materials conducts heat. U-factors for window and door assemblies are the reciprocal of the assembly R-value. The smaller the number, the less the heat flow.
Ventilation	The process of supplying or removing air by natural or mechanical means to or from any space. Such air shall be permitted to be conditioned or unconditioned.
Window-wall ratio	The window-wall ratio is the percentage that results from dividing the total glazed area of the building by the total wall area.

Executive Summary

Key Messages

Mandatory building energy efficiency codes (BEECs), when practically formulated, continuously updated, and actually enforced, are both effective and economic in overcoming persistent market barriers and delivering more energy-efficient buildings.

Price incentives and market information, such as charging users for energy services based on consumption and at cost-recovery prices and providing cost–benefit analysis of energy efficiency improvements, are essential to achieving energy savings afforded by BEEC-compliant buildings.

Adoption of enforceable BEECs is essential at the beginning of the process of transforming a country's construction sector toward delivering increasingly energy-efficient buildings. It is important for developing countries to start with realistic goals and to be conscious about the compliance cost implications. A practical and mandatory BEEC will initiate a positive feeding loop of enforcement, supply of technologies and materials, development of compliance capacity, and expanded enforcement that is reinforced over time.

Successful implementation of BEECs is a multifaceted and resource-intensive process that can take many years to achieve. Government interventions and persistency are critical to making energy efficiency a pillar of building construction. Enforcement failures may be directly attributed to the lack of indigenous technical, institutional, and market capacities. But the fundamental issue often is the lack of necessary government support and commitment to enable the development of those capacities. Such political and organizational mobilization has to be country-driven and supported by champions at local, regional, and national levels.

The main challenge for middle-income developing countries is the political commitment to adopting and enforcing broad-based BEEC compliance. The incremental cost financing for compliance with their BEECs can and should be largely borne by the building/home owners. International assistance should be primarily targeted at strengthening the enforcement and compliance infrastructure.

Development and implementation of BEECs in low- and lower-middle-income countries should be selective and initially targeted at the market segment where economic benefits are great and enforcement is most likely to succeed. In many of these countries, government oversight of urban building construction is often hampered by an inefficient or inadequate construction permit system and a large informal construction sector. International assistance will need to first focus on enabling the government to effectively manage the construction sector.

Greater attention should be given to development and implementation of appropriate BEECs in warm-climate developing countries. There is a large gap in the adoption of BEECs between cold-climate and warm-climate developing countries.

New approaches must be adopted to make carbon financing and other international clean technology financing mechanisms useful for mainstreaming BEECs in developing countries.

BEECs are legal requirements regulating the energy performance of building designs and their compliance during construction. Global experiences in the past 30 years or so indicate that enforcement of mandatory BEECs in new constructions and for the altered portions of existing buildings is an effective and necessary government policy intervention to reduce energy wastes during the life cycle of new buildings, mainly through reduced demand for active energy use in space heating, space cooling, ventilation, lighting, and service water heating. Most industrialized countries introduced BEECs in the late 1970s and have achieved broad-based enforcement. Many developing countries began to introduce BEECs in the 1990s. With a few exceptions the enforcement practices are still lacking, hindered by major institutional and economic barriers and limited by underdeveloped technical capacity.

This report summarizes the findings of an extensive literature survey of the implementation experiences of BEECs in developed countries (including a case study of California), as well as from case studies of four developing countries—China, Egypt, India, and Mexico. The report is written with the objective of informing the World Bank Group's energy and urban operations staff and its clients about the good practices from developed countries and emerging lessons from developing countries in the development and implementation of BEECs, focusing primarily on compliance enforcement in new building constructions. In developing countries, preventing the lock-in effect in new buildings are of greater and more urgent concern than energy efficiency retrofits in existing buildings in terms of impacts on future energy consumption.

Main Findings and Conclusions

There is an urgent need to assist fast-growing developing economies where active space heating and/or space cooling are normal practices and where the formal building construction sector plays a large role in urban development. The plug-in energy loads of buildings and related energy use and efficiency, such as those of appliances and office equipment, can be addressed over time and with flexibility and well-targeted policies and programs. But the built-in energy loads—such as those for space heating, space cooling, and lighting—are intrinsically related to building design and construction and are best (or must be) addressed during the design and construction process.

The urban building stock in developing countries is expected to more than double by 2030. Demand for energy services in buildings in developing countries will rise substantially in the next two decades, driven by population growth, urbanization, and increased and expanded wealth. Per capita energy use in buildings, indicative of the level of energy services, is much higher in developed countries than in developing countries. For example, per capita fuel and electricity uses in residential, commercial, and public-service buildings in Japan, one of the most efficient economies in the world, are about 2 and 15 times higher, respectively, than in China. Many of the large developing economies, such as China and India, are expected to grow significantly in wealth, driving up energy demand in buildings. The International Energy Agency projected that global final energy consumption in buildings would grow by 30 percent from 2007 to 2030 if prevailing practices and trends continued. Most of that increase is expected to come from fast-growing developing countries.

Increase of energy services in buildings in developing countries should and can be supported with dual attentions to shoring up energy supply and scaling up energy efficiency. The 2007 assessments of the Intergovernmental Panel on Climate Change (IPCC) find that (1) among all greenhouse gas–emitting sectors, buildings have the largest global mitigation potential in the period leading up to 2030, primarily through cost-effective energy efficiency measures; (2) substantial reductions in energy use in buildings can be achieved using mature technologies for energy efficiency that already exist widely and that have been successfully used; and (3) a significant portion of these savings can be achieved with reduced life-cycle costs. The last point is significant because many investments in energy efficiency in buildings are beneficial just for the sake of reducing energy costs. Climate change mitigation is a co-benefit.

Energy-efficient building design implemented together with efficient heating and cooling systems/equipment represents the largest technical potential for energy savings in residential, commercial, and public-service buildings. For developing countries, a key point of interest is to avoid locking in unduly high life-cycle energy cost when investing in new buildings and associated energy systems. In China's cold and severe cold regions, the heating load of apartment buildings can be reduced by at least 50 percent with cost-effective and readily available thermal insulation measures and high-performance windows, compared with traditional buildings. In India, new large commercial buildings can achieve nearly 40 percent energy savings cost-effectively, compared with existing national benchmark buildings.

Removing or lowering the market barriers to delivering of more energy-efficient buildings requires government intervention through mandatory BEECs. There have been no exceptions even in the most develop economies in the world. Mandatory BEECs compel the supply chain to begin to develop and produce more energy-efficient buildings and to integrate energy efficiency requirements into standard practices. The main market barriers, universal to all economies, include the following:

- *Issues with visibility and relevance of energy cost signals.* When building/home purchase decisions are made, the future costs of heating, cooling, and lighting services in buildings are relatively unimportant, since they generally are fairly small sums on a monthly basis. Moreover, subsidies in or unaccountability of energy costs existing in many countries can further blunt or even wipe out incentives to invest in energy efficiency. The complexity of buildings, mixed with occupant behavior, also makes it difficult to convey credible and clear-cut cost and benefit information.
- *Split incentives among key stakeholders.* In the building sector, investment decisions, including those regarding the energy features of a building, are usually made by developers and investors, not by those who will occupy the building later and be responsible for paying the energy bills. Consequently, energy efficiency features are not installed and occupants do not reap the benefits. Split incentives prevent basing investment decisions on life-cycle costs and, consequently, the realization of the benefits of energy efficiency investments.
- *Lack of information and knowledge.* Information about energy efficiency options is often incomplete, unavailable, expensive, and/or difficult to obtain or trust.

Even developers, design professionals, and contractors are not always aware of the energy efficiency technologies available. Even when they are aware of the technologies, they can be reluctant to take a chance on the technology and include it in building design. Many construction companies lack the knowledge to correctly apply new technologies.

- *Complexity of delivering more energy-efficient buildings.* The process of delivering a building project is among the most fragmented in delivering a commercial product. A project developer needs to deal with independently operated professional and trade units such as architects, engineers, and various construction and installation contractors, as well as suppliers of materials and components, and finally with code enforcement agencies to deliver a building that meets the needs of the clients/customers in safety, function, and energy efficiency. Since the interests of the market participants are often not aligned, the results are often suboptimal, at best.

Although not intentionally designed, the biggest shortcoming of BEECs is that they do little if anything to raise demand for more energy-efficient buildings or to encourage the supply chain to do more than what is necessary to comply with the requirements. Therefore, market incentives are also vital to encourage commercial deployment and market recognition of energy efficiency innovations that surpass the requirements of BEECs.

BEECs have become a widely adopted energy efficiency policy, much more so in cold-climate regions than in warm-climate regions. But there is a significant gap between the development of a BEEC and its actual implementation and enforcement, even in many developed countries. Most industrialized countries have mandatory BEECs. Among developing economies and economies in transition, BEECs are most prevalent in Eastern Europe and East Asia. Many of the countries in these regions are in cold climate zones and require heating. The most urbanized region in developing countries, Latin America and Caribbean, shows a lack of BEECs, and even where they exist, they are not implemented.

Systematic surveys on the compliance situation of BEECs are rare and results are hardly comparable. Given that the definition of compliance and the relative importance of different components vary significantly, the compliance figures revealed in partial data and anecdotes need to be taken with caution. But they do suggest that compliance and quality of enforcement is much less than perfect in most countries that enforce their BEECs. For example, compliance rates in the U.S. states range from low double digits to near 100 percent. Noncompliant items can be large or small. For example, a survey in Denmark in 2000 found that in 43 percent of the surveyed buildings insulation of internal pipes and water tanks had been missing. BEEC compliance is generally significantly poorer in developing countries where BEECs are either mandatory or voluntary. China is among a few developing countries where BEEC compliance has reached a significant level. National inspections conducted by the central government indicate that construction compliance in large Chinese cities has reached 80 percent in 2008.

Despite the somewhat disappointing compliance record, progress can be observed in terms of actual energy performance of buildings. New buildings today consume much less energy than older buildings from before the 1970s energy crisis. Both in Western Europe and the United States, energy efficiency improvements through BEECs since the 1970s amount to about 60 percent. But, it remains a fact that there is a substantial compliance gap almost everywhere and that energy savings and emission reductions are much smaller than they could be if BEECs were universally complied with. The extent of the lost opportunities is not known, since there is very little measuring of actual energy performance of buildings after construction is completed.

Most industrialized countries have managed to mainstream BEECs, meaning basic practice of energy efficient design and construction is a norm, not an exception. Although compliance still is suboptimal, there are good practices and important lessons among the pioneering countries in Europe and the United States:

- The countries and states that have done well in compliance are often those that have involved key stakeholders in the development of the BEEC, have devoted sufficient resources to support enforcement, made strong efforts to train and educate the key stakeholders in BEEC compliance, and adopted systematic approaches/procedures for enforcement. These countries and states also generally introduced complementary policies that provide incentives for supplying and acquiring energy-efficient buildings and information to all stakeholders about the benefits of such buildings.
- As BEECs become more complex and demanding, having a range of compliance options is important for most effectively addressing the varying needs of different building projects and preferences of different users. This movement from a fixed menu of options to flexible approaches that achieve the same overall energy savings is a natural evolution of BEEC enforcement in response to increasingly sophisticated buildings and diverse requirements of clients.
- Regularly updating the BEEC provides for incremental improvements and allows adjustments to improve implementation. The Energy Performance of Buildings Directive (EPBD) requires that BEECs in European Union (EU) member states are updated at least every five years. Many member states have shorter updating schedules. The national model BEECs and most state BEECs in the United States are updated every three years. Periodical updates provide a means to incrementally improve the stringency of the requirements and to incrementally expand the scope of the requirements, so that the changes are not so challenging to implement.
- A BEEC with more-uniform format and structure across various countries in an economically integrated region (EU) or within a large country (United States) facilitates performance evaluation and consistency in compliance. There will always be local differences in stringency based on climate, but having a more-uniform code format and structure allows designers and contractors, manufacturers, and suppliers to more easily identify the requirements for a particular locale regardless of which country or state it is in. It also has the benefit of spurring greater intraregional flow of technologies and innovations by leveling the playing field across previously segregated markets.

- Government must take the leadership role in implementing BEECs and promoting market transformation in building construction. Having the local government leadership will increase the likelihood that the BEEC is implemented in the city/county. Having the state and national government leaderships will increase the likelihood that the BEEC is implemented in the country. The EPBD of the EU is a good example of collective leadership.
- The public sector retains responsibility in most countries for enforcement of building codes in general and BEECs in particular. Faced with increasingly complex BEECs and insufficient resources for code enforcement at the local level, many countries have allowed contracting out some of the review and inspection duties that require substantial expertise to certified/accredited third parties. Since builders frequently hire third parties, mechanisms need to be put in place to ensure that third parties have incentives to carry out their work properly. These include spot checks by public-sector enforcement officials, loss of certification/licensing, penalties, and liability for mistakes.

The experiences from some of the early adopters of BEECs in developing countries are both sobering and encouraging. They reveal a broad spectrum of achievements and failures and underlying factors. China, India, Egypt, and Mexico are at different stages of implementing BEECs and have adopted varied approaches. Each represents an interesting case to inform the needs, challenges, and potential solutions to help mainstream BEECs in developing countries:

- ***China*** is on the verge of mainstreaming BEECs in new building construction in urban areas, thanks to national government leadership and persistent efforts over two decades. Even though compliance enforcement is still inconsistent and enforcement in medium and small cities is believed to be much more problematic than in large cities, implementation of BEECs is now commonly accepted practice in the construction sector, and incremental costs have been essentially internalized. The convergence of the following factors in the last five years or so has been important: (1) Improved and standardized system of BEEC compliance enforcement and procedures; (2) Broad-based capacity of the construction industry to meet the technical requirements of BEECs; (3) Widely available quality building materials and components for BEEC compliance; (4) Much increased ability to afford and willingness to pay for the incremental costs of BEEC compliance; and (5) Strengthened capacity and motivation of local governments to enforce BEECs.
- ***Egypt*** appears to face daunting challenges to implement two fairly sophisticated BEECs introduced in 2006 (residential buildings) and 2009 (commercial buildings) in an environment where basic building code requirements are not effectively enforced. Demand for and interest in energy efficiency is low because of widespread energy subsidies, especially for residential users. A new simplified general building law and the interest of the green building community, which is just now forming in Egypt, might provide a new motivation in constructing more-energy-efficient buildings. But strong national government leadership and support are needed for developing basic compliance and enforcement procedures required at the local level, in

training and capacity building of actors in the building supply chain, and in removing general energy subsidies.

- ***India***, currently focusing on implementing its first and initially voluntary Energy Conservation Building Code (ECBC) for large commercial buildings (2007), is making a big effort to put in place the measures and procedures and to develop the compliance capacity necessary to successfully implement the BEEC locally. By focusing on large new commercial buildings first, the efforts are likely to yield relatively quick progress in compliance if local governments pursue enforcement seriously. A BEEC for residential buildings would face substantial barriers, since many residential buildings are informally built and almost all residential electricity consumers are heavily subsidized. Providing some incentives for the developers of high-end large residential building complexes to apply the requirements of the ECBC might establish precedents for eventual adoption of a BEEC for residential buildings. In general, pushing for the wide adoption of and compliance with increasingly strict energy efficiency standards for appliances and lighting would substantially and cost-effectively curb the enormous growth in residential electricity consumption.
- ***Mexico*** developed a mandatory commercial building code in 2001 but has largely failed to implement it due to a lack of interest of local governments to incorporate its requirements into their local building regulations. More recently, the National Housing Agency CONAVI developed a national model regulation for residential construction, which contains sustainability requirements. Developers wanting to participate in CONAVI's subsidized low-income housing development program will have to satisfy those requirements. This represents an attractive approach to leverage market uptake of more energy efficient buildings. By engaging concerned state and municipal agencies, this federally supported program could pave the way for them to incorporate energy efficiency requirements into their building regulations and enforce compliance.

Expanding the scope and scaling up the implementation of BEECs in developing countries will be a gradual process requiring removal of relevant political, institutional, technical, and financial constraints. Each country will have to deal with its weaknesses in these areas with approaches that suit its own situation. Global experiences indicate that implementation of BEECs is likely to have more success in countries and localities where the construction sector is well managed in terms of government oversight of building safety and quality, the building supply chain is well established in terms of technical and engineering capacity, the market for commercially produced buildings is well developed, and there is broad and firm political commitment to improving energy efficiency. Weaknesses in these areas are often the main challenges to developing countries:

- *Challenge 1: Maintaining firm political commitment to energy efficiency.* Expanding modern energy supply infrastructure and energy access remains an investment priority in developing countries. That often leaves energy efficiency with little political attention. This is a critical mistake for countries of many income levels. Convincing the people of the importance of energy efficiency in national energy security provides a political mandate for the government to begin necessary steps to introduce and ramp up energy efficiency policies and programs as the specific needs are identified, such as the implementation of BEECs. The effect of such commitment has been well demonstrated in China and is emerging strongly in India.

- *Challenge 2: Establishing an effective government oversight system for building construction.* In many developing countries, government supervision of the construction sector for traditional safety requirements is ineffective due to the combination of overly complicated and costly permit application and review process and a lack of resources to handle the required due diligence. For these countries the implementation of BEECs is unlikely to succeed without improving the credibility and inclusiveness of the building permit and inspection system.
- *Challenge 3: Developing the compliance capacity of the building supply chain.* Compared with the prevailing commercial construction practices in many developing countries, implementing modern measures to reduce/minimize building heating, cooling, and lighting loads requires a host of new design skills and approaches, new or improved materials/components and construction techniques, as well as additional supervision, inspection, and testing/certification requirements.
- *Challenge 4: Financing incremental costs of more energy-efficient buildings.* Few decision makers and consumers in developing country would disagree that more energy-efficient and comfortable buildings are desirable. But with tight budget constraints for both governments and private citizens, tradeoffs often have to be made between more housing and more energy-efficient housing. Low-income countries often have priority in maximizing the floor area for a given amount of housing investment. Efforts to promote adoption of BEECs in developing countries should consider such constraints, together with the potential of tapping into international development financing mechanisms, including those addressing climate change mitigation and adaptation.

Recommendations and International Assistance Strategies

From the experience of developed countries and early adopters in developing countries, such as China, Mexico, and more recently Egypt and India, it is clear that government intervention and persistency are critical to making energy efficiency a pillar of building construction. Several conditions are particularly important to foster in the context of developing countries. International development institutions such as the World Bank could offer valuable assistance.

Expand and Strengthen the Political Support for Energy Efficiency

Engaging developing countries in substantive discussions of their energy efficiency strategies and actions requires convincing evidence and analysis of the costs and benefits of pursing those activities. Considering the importance given to energy efficiency by the international community, it is useful to conduct more in-depth and actionable sector-level energy efficiency assessments for developing countries. The multilateral development institutions (MDIs) or bilateral assistance agencies could help expand and strengthen the political support for energy efficiency by increasing the in-country knowledge and awareness of the critical issues, practical solutions, and cost–benefit implications of promoting energy efficiency in general and BEECs in particular.

Improve the Effectiveness of Government Supervision of Building Construction Sector

BEECs are a new dimension of government oversight of the building construction sector. But the elements of successful implementation are similar to those for implementing the general building codes. It is difficult to imagine good compliance enforcement of BEECs if the building construction in general is poorly managed and governed. Improving the effectiveness of government supervision of the building construction sector can be addressed as follows:

- *Simplify the building law, streamline the permit process, and make it more predictable and user-friendly*. Many countries have simplified their building laws. For example, Egypt reduced the number of procedures to be complied with and the time it takes to clear each procedure. However, many countries still show wide divergence locally (for example, states in India).
- *Strengthen the compliance and enforcement infrastructure by* committing requisite government resources and through involvement of nongovernment entities for regulatory due diligence. China has developed a government construction oversight system that depends heavily on third-party services for compliance of building codes, including BEECs. Mexico's building code compliance involves the private sector, as well.

Develop Technical and Engineering Capacity of the Building Supply Chain

The local availability of materials and equipment that can reliably fulfill the requirements of the BEEC is frequently an issue that can slow down the progress of BEEC implementation. Strong and persistent push for BEEC compliance sends unambiguous signals to local manufacturers about the type of products in demand. The next steps would involve the development of standards for materials and equipment, the set-up of testing facilities and protocols and the development of a certification system. It is advisable that international assistance involved in the demonstration projects during the first years after BEEC adoption to pay special attention to the potential and viability for domestically producing the materials and components for BEEC compliance, as well as market development strategies to increase the supply and assure the quality of such products domestically or at regional level (involving multiple countries).

In parallel, different trades in the building supply chain need to be trained and updated about compliance requirements and good practices in every phase of building construction. National-level commitment and involvement are important in resource-constrained developing countries for establishing and sustaining systematic programs to educate new generation of architects and engineers, train professionals, inform the public, disseminate good practices, and standardize procedures. International assistance programmed into such nationally orchestrated efforts is likely to have greater systemic impact and value. China has taken this approach and achieved good results under the leadership of the Ministry of Housing and Urban-Rural Development. Although currently focusing on large commercial buildings, India is embarking on a similar approach under the leadership of the Bureau of Energy Efficiency to help its building construction sector to adapt to the compliance requirements of the ECBC.

Capacity building for the building supply chain needs to extend to those tasked with enforcement of the building code, such as site plan and building design reviewers, and construction and equipment inspectors, whether they are government employees or third parties. Although China relies heavily on certified third parties for compliance enforcement, all city governments maintain a division in their construction department with responsibility of overseeing and supporting BEEC implementation. These similarly tasked government administrative units form a national network for the capacity building and market development assistance supporting the implementation of BEECs.

For developing countries that have made significant inroads in achieving compliance of their first BEECs, additional efforts should be made to support advanced energy efficiency programs. For BEECs to incrementally improve over time, it is desirable to have examples of greater energy efficiency. Utility incentive programs and green building programs can provide encouragement for progressive designers and developers to go beyond the minimum requirements in the current BEEC. Their experiences will then provide examples that can be pointed to as support for the next increment in the subsequent update to the BEEC.

Bridge the Gap in Incremental Cost Financing

Despite their life-cycle cost advantages, more energy-efficient buildings in general will cost more to build than their less-efficient counterparts. Mandatory BEECs essentially require home and building owners to pay for the incremental costs of more energy-efficient buildings. But this creates tension in developing countries where most of the population still is poor by developed country standards. In low-income countries, there are indeed hard tradeoffs between the current desire of having adequate housing and the long-term benefit of having energy-efficient housing. This constraint or dilemma can only be resolved with broad economic development and will take a long time for low-income countries.

There is a larger development issue in the pursuit of more energy-efficient buildings. In working toward the long-term goal of internalizing the incremental cost of more energy-efficient buildings, developing countries will need to rely on domestic policy reforms to set their economies on a sustained growth path. Directly relevant to energy efficiency promotion, it is essential that the policy reforms should lead to rationalization of energy pricing and billing, reserving subsidies for low-income households:

For mid-income developing countries, the incremental-cost financing for compliance with their BEECs can and should be largely borne by the building/home owners. China has essentially made that transition. The main issue for many middle-income developing countries is to finance the resource needs to enforcement broad-based BEEC compliance. User fees included in permit fees or payments of developers to third parties (as is the case in China) would be the usual sources. Utility DSM programs funded by energy efficiency surcharges could be useful in paying for capacity building, incentives, and monitoring and evaluation.

For low- and lower-middle income countries, the incremental costs of development and implementation of BEECs will be a major issue. It is thus important that these countries do what they can afford, targeting at the market segment where economic benefits are great and enforcement is most likely to succeed. India's initial effort on large commercial buildings is a good example. However, while smaller buildings may not be regulated until a later phase, it is important to begin addressing at least some of the energy consumption in all buildings in some manner. Initiatives may include supporting architecture designs (such as appropriate building orientation, shading, natural ventilation, and so on) that improve comfort without additional active energy service and energy efficiency measures that rely on locally available materials and benefit local manufacturing. A valuable companion program that could result in substantial benefits in the short to medium term would be the introduction and enforcement of energy efficiency standards for lighting and the most prevalent appliances.

The Global Environment Facility (GEF) has been a principal source of international financing for development and implementation of BEECs, focusing primarily on supporting national code development, pilots, and demonstrations. Carbon financing and other clean technology investment financing mechanisms could provide additional support for strengthening and broadening BEEC enforcement, and in particular encourage market-driven energy efficiency innovations from the private sector, such as the voluntary rating systems for green buildings.

Because of the complexity and high transaction cost of meeting the eligibility, monitoring and verification requirements of the Clean Development Mechanism (CDM), component based carbon-financing schemes focusing on the use of certified products, such as a special type of windows, insulation materials of certain defined physical properties, and/or more efficient air conditioners, could help spur the broader adoption of components of higher energy efficiency performance. Such an approach would be especially useful in new residential constructions where benefits of energy savings are highly disaggregated and building-level verification is much more difficult than large commercial buildings.

CHAPTER 1

Introduction

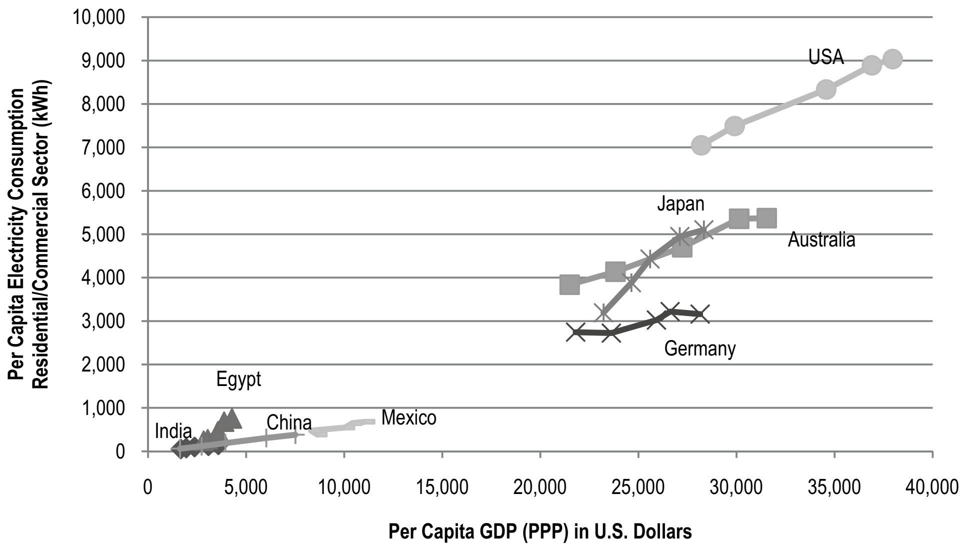
Energy Use in Residential, Commercial, and Public-Service Buildings

About one third of global final energy use is for provision of energy services in residential, commercial, and public-service buildings (referred to as *buildings,* hereafter). The commercial category is generally used as a simple term to cover a wide variety of buildings that house either commercial or public-service activities.[1] Building energy services include all the energy consumption associated with a building—such as space heating and space cooling, ventilation fans (interior supply and exhaust, parking garages), lighting (interior and exterior), refrigeration, cooking, water heating, elevators, and escalators, as well as operation of electric and electronic equipment.

There are major distinctions between developed and developing countries with respect to the energy mix and the types and levels of energy services in buildings. In low- and lower-middle-income countries, solid fuels (mostly biomass) often make up a large share of final energy use in buildings, while in high-income countries, network-supplied energy, such as electricity, natural gas, and district heating (in cold climate), dominates. Per capita energy consumption in buildings—indicative of the level of energy services[2]—is much higher in high-income countries than in low-income countries. This is true especially for electricity consumption (see figure 1.1). Fuel use, however, does not show such stark variation due mostly to the high and energy-inefficient use of biomass for cooking and water-heating (see figure 1.2). [3]

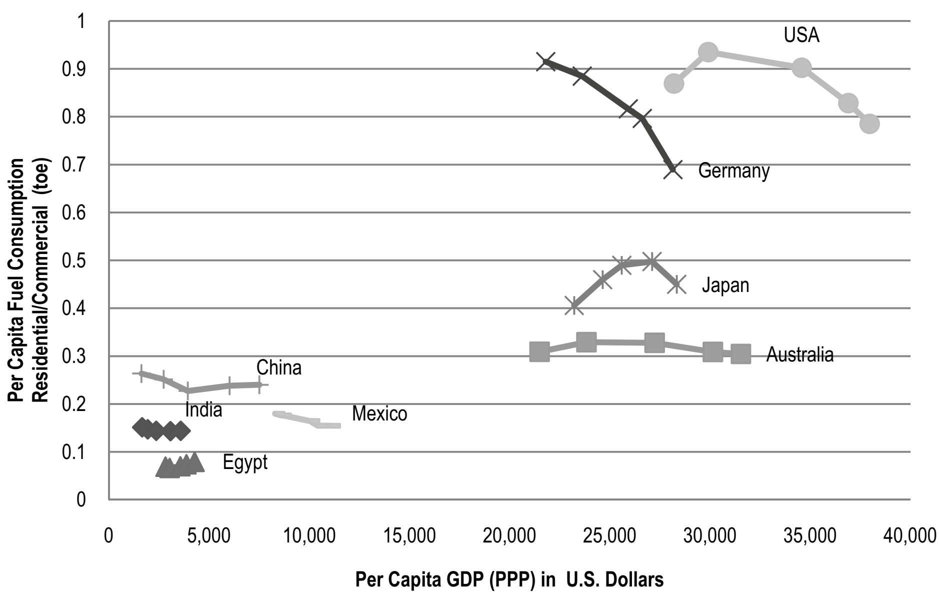
Energy consumption patterns by building energy service type are heavily influenced by climate conditions because of the demand for space heating and/or space cooling and are significantly affected by income levels, which underpin energy access and affordability. In general, for countries where a large portion of the population lives in cold climates, space heating usually is the single largest energy use in buildings. For example, in the 27 countries of the European Union, two thirds of energy consumption in the residential sector was for space heating purposes in 2005.[4] In China, space heating accounts for about 40 percent of primary energy use in buildings in urban areas, where over 40 percent of the population live in cold and severe cold climates.[5] In contrast, most of India's population lives in warm climates, and space heating in general is not necessary.

Figure 1.1. Per Capita Electricity Consumption in Buildings versus Per Capita GDP, 1990–2007 (2000 prices)



Source: IEA Energy Statistics.

Figure 1.2. Per Capita Fuel Consumption in Buildings versus Per Capita GDP, 1990–2007 (2000 prices)



Source: IEA Energy Statistics.

Cooling demand, especially in residential buildings, is highly sensitive to income levels, since air conditioning requires a relatively large amount of electricity. Although traditional architecture provides some moderation of extreme temperatures, complete control is a luxury that low-income households or more traditional businesses cannot afford. But cooling usually is a major growth area when income levels increase.[6] For example, air conditioning accounted for only 1 percent of primary energy consumption in India's residential sector in 2000 but is projected to increase to 8 percent by 2020.[7] In China, penetration of air-conditioning units in urban areas is projected to increase from about 30 percent in 2000 to 100 percent by 2015, or even earlier.[8] "The energy consumption of China's air conditioner users has increased dramatically, to a current level of more than 15 percent of national power consumption. In the summer, electricity consumed by air conditioning accounts for 40 percent of the peak load."[9]

Demand for energy services in buildings in developing countries, and network-supplied modern energy forms in particular, will rise substantially in the next two decades, driven by population growth, urbanization, and increased and expanded wealth. Developing countries are projected to contribute to about 94 percent of the world urban population increase from 2005 to 2030, by which time 60 percent of the world population will be urban.[10] Half of the building stock in developing countries by 2030 has yet to be constructed.

Many of the large developing economies, such as China and India, are expected to grow significantly in wealth during this period and beyond. If the historical growth pattern indicated in figures 1.1 and 1.2 prevails, the increase in demand for energy services would translate into large increase in actual energy consumption in buildings. Such an outcome could erode national energy security, reduce energy affordability for the poor, and strain the environment in developing countries. The International Energy Agency's reference scenario in the 2009 World Energy Outlook, which assumes continuation of current policies and no major technological breakthroughs, indicates a 30 percent increase of global final energy consumption in buildings, from 2,752 million ton oil equivalent (Mtoe) in 2007 to 3,595 Mtoe in 2030.[11] Most of that increase is expected to come from developing countries.

Increase of energy services in buildings in developing countries should and can be supported with dual attention to shoring up energy supplies and scaling up energy efficiency. The 2007 assessments of the Intergovernmental Panel on Climate Change (IPCC) find that (1) among all greenhouse gas emitting sectors, buildings have the largest global mitigation potential in the period leading to 2030, primarily through cost-effective energy efficiency measures; (2) substantial reductions in energy use in buildings can be achieved using mature technologies for energy efficiency that already exist widely and that have been successfully used; and (3) a significant portion of these savings can be achieved with reduced life-cycle costs.[12] This last point is important, as it indicates that regardless of climate change mitigation, many investments in energy efficiency in buildings are beneficial just for the sake of reducing energy costs over the lifetime of a building.

Energy-Savings Opportunities in Buildings [13]

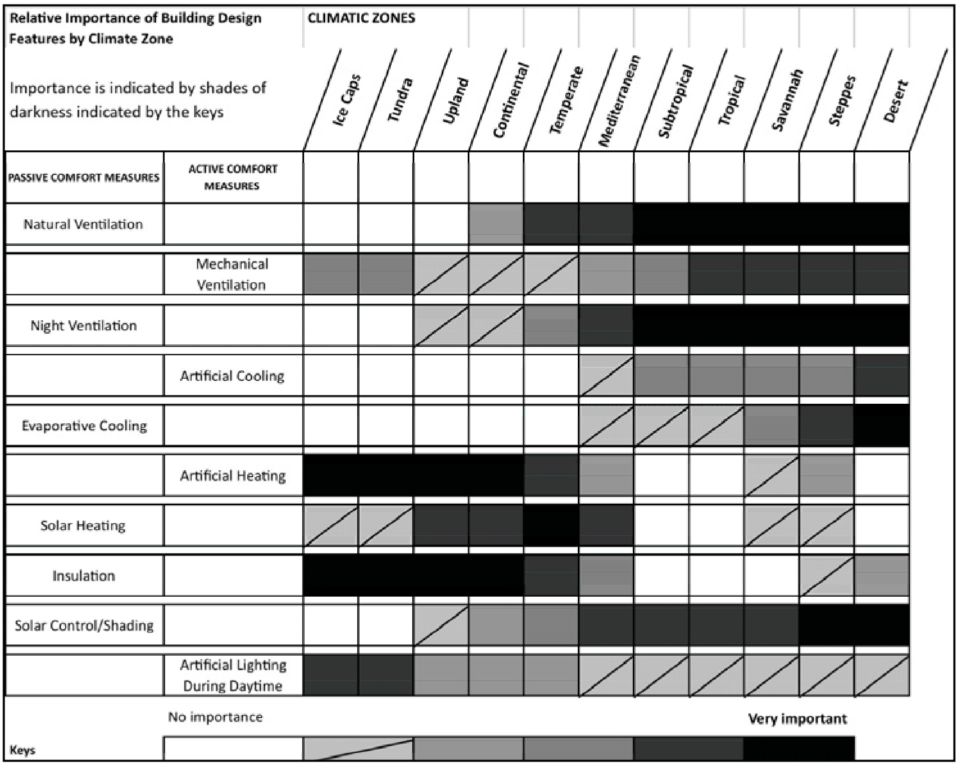
Energy savings can be achieved through technical improvements to buildings and energy-consuming equipment to reduce energy waste (increase energy efficiency) and by conservation behaviors that do not necessarily compromise desired energy services (such as turning off lights when one leaves the room or having thermostats automatically adjust temperatures for unoccupied hours). Viewed another way, it is important to address energy waste during occupied hours and during unoccupied hours. Proactive conservation behaviors and good operations and maintenance practices are critical to achieving intended energy savings of any technical improvements, many of which also have the side effect of softening conservation motivations. This report focuses on realizing technical improvements for energy efficiency in buildings. The following discussions reflect such a focus. Technical energy efficiency improvements that reduce energy consumption in buildings fall into three broad categories: reducing the load, using efficient systems to serve the load, and substituting renewable energy where possible.

Reducing the Load

Reduce space heating, space cooling, and lighting loads through energy-efficient building and site designs and their proper implementation. There are different design techniques for reducing building envelope heat losses to and gains from the outdoors. In heating-dominated climates, it is important to isolate the building from its environment by a well-insulated and airtight building envelope. In cooling-dominated climates, it is essential to minimize daytime solar gain through windows and lightweight roofs and walls. In other, more-moderate climates, the significance of thermal insulation is not as prominent and it is important for the building envelope to be relatively responsive to the environment so as to most efficiently address the varying needs for heating, cooling, ventilation, and lighting.

The relative importance of passive and active design elements in different climate conditions is illustrated in figure 1.3. Light-reflective roofs and exterior walls are relatively low-cost measures for reducing cooling loads in warm/hot and dry climates. Architectural details of individual buildings (form, orientation, and shading, for example), landscaping, and how the buildings are oriented in a particular construction site also affect heating, cooling, and lighting loads and need to be considered in site planning and building design. Water-heating loads can be reduced through the use of low-flow plumbing fixtures. Lighting energy use can be reduced by daylighting design with light shelves that bounce the daylight further into a space, combined with automatic lighting controls to dim or turn off electric lights in response to daylight.

Figure 1.3. Relative Importance of Building Design Features by Climate Zone



Source: Adapted from Jones (1998).

The potential for cost-effective reduction of heating and cooling loads using well-developed designs and broadly adopted technologies is large (see examples in box 1.1), especially in new buildings, which are most important in developing countries. For example, in China's cold and severe cold regions, the heating load of apartment buildings compliant with the current national BEEC, designed to save 50 percent energy, can be further reduced by 30 percent by increasing envelope insulation and using windows with lower thermal losses. In fact, the cities of Beijing and Tianjin, two of the largest construction markets in China, have enforced such requirements for all new residential constructions since 2005.

Using Efficient Systems to Serve the Load

Increase efficiency of space heating, space cooling, ventilation, water heating, appliances, other electric and electronic equipment, and lighting through technical innovation and improved operational performance. Commercial and public-service buildings equipped with heating, ventilation, and air-conditioning (HVAC) systems are increasingly popular in developing countries. Energy efficiency of HVAC systems is dealt with both at the building design stage (proper sizing and selection of highly efficient units that

Box 1.1. Examples of Cost-Effective Energy Efficiency Measures in Buildings

The IPCC report (Levine et al. 2007) provides examples of effectiveness (overall reduction of CO_2 emissions through various policy instruments) and cost effectiveness of various policy instruments for carbon mitigation. BEECs are rated as highly effective, but tend to have a medium cost-effectiveness, while appliance standards are both highly effective and highly cost-effective. For example, for the Netherlands it was estimated that the costs of GHG emission reductions through BEECs range from \$189/tonCO_2 to \$5/tonCO_2 for end users and \$46–\$109/tonCO_2 for society.

A recent study of green buildings (mostly office buildings) in multiple countries finds that these green buildings, on average, use 33 percent less energy than similar conventional buildings, and that the present values of energy cost savings over a 20-year period are about twice the amount of the incremental cost of implementing energy efficiency measures. [14]

For new residential buildings in Tianjin/China, Liu (2006) finds that the application of the 1997, as well as the stricter 2004, BEEC requirements are highly cost-effective, resulting in economic rates of return of about 16 percent in both cases.

Source: Authors.

minimizes life-cycle cost, and installation of controls) and through building commissioning and improving operations and maintenance. Acquisitions (saturation rates) of consumer appliances—including major items such as TV sets, refrigerators, air conditioners, clothes washers, and water heaters—are key indicators of rising living standard in developing countries. There is a general trend of moving up to larger-sized units as affordability increases. Technology innovations driven both by competition and regulation have helped continuous improvement of energy efficiency of major appliances. For example, the most efficient domestic models of air conditioners in China use 35 percent less electricity to deliver the same amount of cooling service than the least-efficient domestic models do. Voluntary energy rating programs for appliances, such as the Energy Star program in the United States, are valuable for increasing the use of more efficient appliances, which are typically not regulated by BEECs.[15]

Substituting Renewable Energy Where Possible

Utilize renewable energy resources for energy services in buildings. This refers to technologies that utilize natural heat sources and sinks directly (solar water heater, for example) or indirectly (heat pump technology, for example) so as to reduce consumption of fossil fuels and, at the same time, the life-cycle costs of relevant energy services. The suitability of such applications often depends on site-specific conditions. Strictly speaking, some of them qualify as alternative energy sources instead of energy efficiency.

Sizing up the global potential for energy savings in buildings is difficult and depends on many assumptions. The IPCC assessment report concluded that about 30 percent reduction of the projected baseline CO_2 emissions in buildings by 2030 can be achieved cost-effectively. One could infer that similar-sized reduction in energy demand is achievable as well. Energy-efficient building design, implemented together with efficient heating and cooling systems/equipment, represents the largest technical potential for energy savings in residential, commercial, and public service buildings.

For developing countries, a key point of interest is to avoid locking in unduly high life-cycle energy cost when investing in new buildings and associated energy systems. However, opportunities should not be missed when additional floor area is added on to existing buildings and when components (such as windows, heating and cooling equipment, lighting) are replaced in existing buildings. This helps develop the aesthetic that energy-efficiency is a feature of all construction, and it builds and broadens the market for energy-efficient products, thereby drawing in more product manufacturers and reducing the prices through greater competition.

The subject of this report, implementation of BEECs, is primarily concerned with reducing space heating, space cooling, and lighting loads, which in general are locked-in when buildings are constructed. To the extent that energy-consuming equipment and systems are installed during building construction (such as HVAC systems and service water heaters), they are either covered by BEECs or referred to in separate standards. Thus, implementation of BEECs has a major effect on the level of energy consumption throughout the life-cycle of new buildings, and is also important for major building renovations to address previously ignored energy efficiency opportunities.

Market Barriers and Building Energy Efficiency Codes

As concluded by the 2007 IPCC assessments, there is much evidence and high agreement that substantial cost-effective energy savings in buildings can be achieved using proven and mature technologies for both developed and developing countries. Cost-effective energy efficiency improvements in buildings by definition are financially attractive, usually paying for themselves within a few years. They also generate multiple co-benefits, ranging from improved comfort and health for the occupants to reduced air pollution for the general public. Then, why has the market uptake of energy-efficient buildings and equipment continued to fall far short of their cost-effective potential? There is a large body of literature analyzing the market barriers that are responsible for preventing market adoption of cost-effective energy savings. The IPCC building sector assessment has a good summary of the main barriers. The following discussions address these questions in view of the rationale for mandatory BEECs.

The market uptake of more energy-efficient buildings, (that is, buildings that require less energy to heat, cool, and light) are often hindered by four sets of factors:

1. *Issues with visibility and relevance of energy cost signals.* When building/home purchase decisions are made, the future costs of heating, cooling, and lighting services in buildings are a relatively unimportant factor, since they generally are fairly small sums on a monthly basis. The ways energy costs are accounted and paid for can further blunt or even wipe out any consideration there may be for investing in energy efficiency. For example, the lack of metering and consumption-based billing for heat and electricity removes any monetary incentive to conserve energy. For developing countries, there also is a latent demand for energy services that becomes apparent only when income rises to certain levels many years after the home purchases/constructions were made. The complexity of buildings mixed with occupant behavior also makes it difficult to convey credible and clear-cut cost and benefit information.

2. *Split incentives and principal agent problems.* In the building sector, investment decisions, including about the energy features of a building, are usually made by developers and investors, not by those who will occupy the building later and be responsible for paying the energy bills. Consequently, energy efficiency features are not installed and occupants will not reap the benefits. Split incentives prevent basing investment decisions on life-cycle costs and, consequently, the realization of the benefits of energy efficiency investments.
3. *Lack of information and knowledge.* Information about energy efficiency options is often incomplete, unavailable, expensive, and/or difficult to obtain or trust. Even developers, design professionals, and contractors are not always aware of the energy efficiency technologies available (see box 1.2 for an example). Even when they are aware of the technologies, they can be reluctant to take a chance on the technology and include it in building design.[16] Many construction companies lack the knowledge of correctly applying new technologies.
4. *Complexity of delivering more energy-efficient buildings.* The process for delivering a building project is significantly more complex than the manufacturing of a car or an appliance. The project developer needs to deal with independently operated professional and trade units such as architects, engineers, and various construction and installation contractors, as well as suppliers of materials and components, to deliver a building that meets the needs of the clients/customers in safety, function, and energy efficiency. To achieve satisfactory delivery of energy efficiency results, the members of the supply chain need to not only have the know-how to deliver their respective contribution but also to work in effect like a coherent team, so the energy-efficient designs are followed consistently throughout the construction

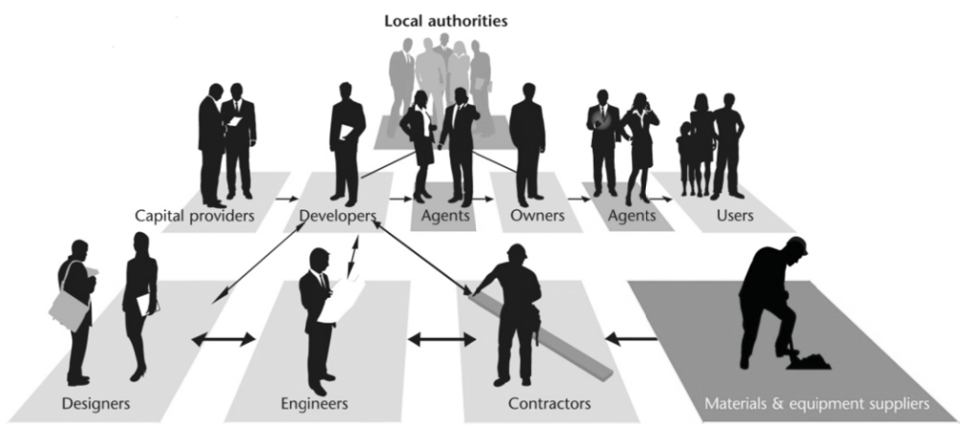
Box 1.2. Not Even Building Energy Efficiency Designers Always Know What Technologies are Available in the Local Market—Experiences from a Project in China

One morning in the office, we were talking with the design team about U-factors for window energy-efficiency. We suggested that it should be possible to find windows with lower U-factors. We got into a discussion about what technologies were being used in the windows. We asked about the low-emissivity coatings on the glass. The design team provided the emissivity, and we indicated that this emissivity was typical for a pyrolytic hardcoat low-e coating (apparently called an “online coating” in China) and that better performance was available using the sputter softcoat low-e coating (apparently called an “offline coating” in China). We were initially told that no glass suppliers in the city provided the offline coating; it was available only in other provinces. However, after a few telephone calls, by that afternoon, there were two different local glass suppliers who were all-too-happy to join our meeting and provide information to the design team about the sputter softcoat offline low-e coating that their companies were producing locally. The process was repeated when we talked about high-quality PVC frames for windows. At first, we were told that all the PVC products in China were too flimsy to use in tall buildings and that they all had mechanically fastened corners that leaked air over time. We mentioned the “welded” (heat-melted) corners that were typical in the United States for PVC-frame windows and that there are several 25-story buildings in Seattle with PVC window frames. The next day, a window manufacturer joined the meeting with a sample of his product that showed welded corners, and stating that these PVC windows had been installed in a 30-story building in the city and in a 35-story building in Shenzhen where windloads are high due to typhoons.

Source: Authors.

process. Since the interests of the market participants are often not aligned, the results are often suboptimal at best. Figure 1.4 provides an overview of the actors involved.

Figure 1.4. Actors in the Buildings Sector

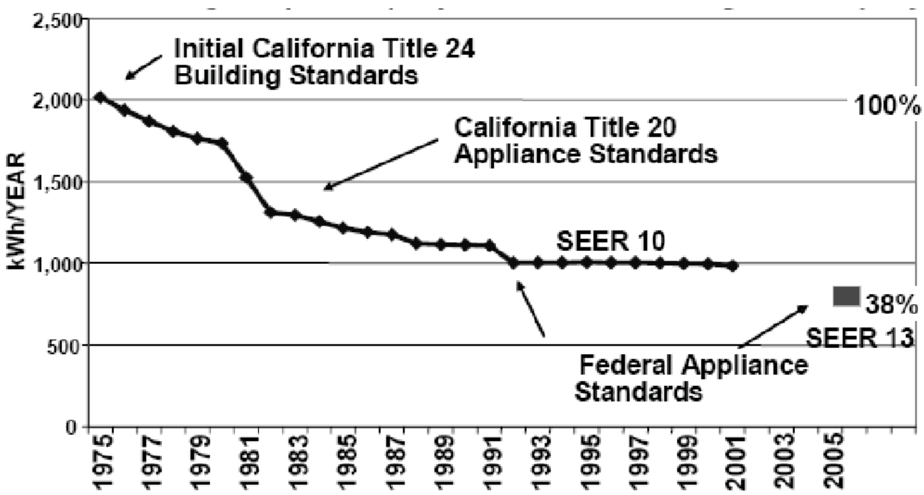


Source: World Business Council for Sustainable Development (2009).

In the presence of those barriers, market forces cannot be relied on to deliver the level of energy efficiency in new buildings justified by the minimization of life-cycle economic cost. Even in countries where the cost of energy is properly reflected in customers' energy prices and tariffs, investments in building energy efficiency fall way short of their potential. Policy and regulatory measures in the form of mandatory BEECs are required to break this logjam.

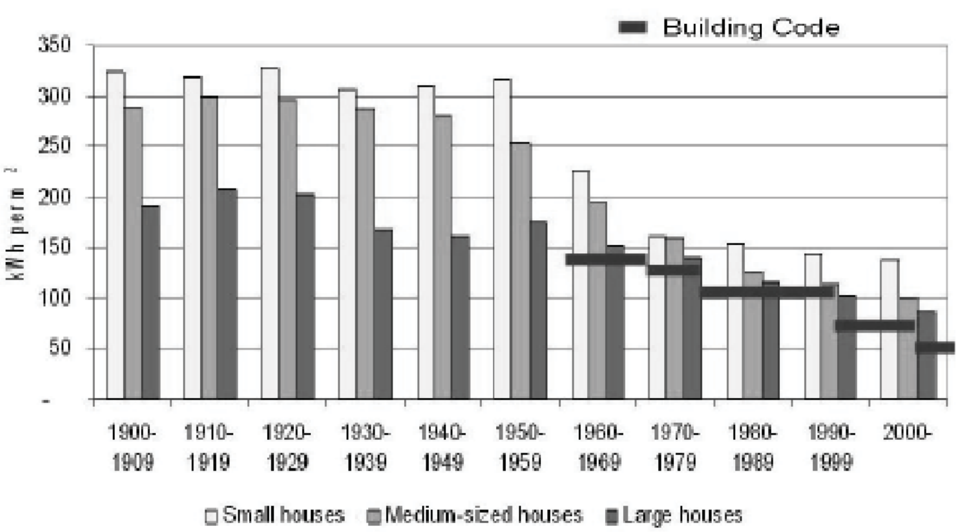
BEECs are legal requirements regulating the energy performance of building design and construction. Virtually all BEECs address the building envelope and the equipment and controls for HVAC systems within or associated with the building. Lighting is often also included in BEECs, particularly for commercial- and public-service buildings, as is service water heating (SWH). The effect of BEECs in reducing heating and cooling energy use has been significant in countries/regions where compliance with mandatory BEECs is high, such as in California or Denmark (figures 1.5 and 1.6).

Figure 1.5. Annual Usage of Air Conditioning in New Homes in California



Source: CEC Demand Analysis Office, cited in Goldstein 2006.
Note: SEER is the U.S. central air conditioner efficiency standard. SEER 13 is the minimum rating required as of January 2006. Units with a SEER 13 rating are 30 percent more energy efficient than those with a SEER 10 rating

Figure 1.6. Actual Energy Consumption in Single-Family Houses in Denmark, Relative to Energy Efficiency Requirements in Building Codes

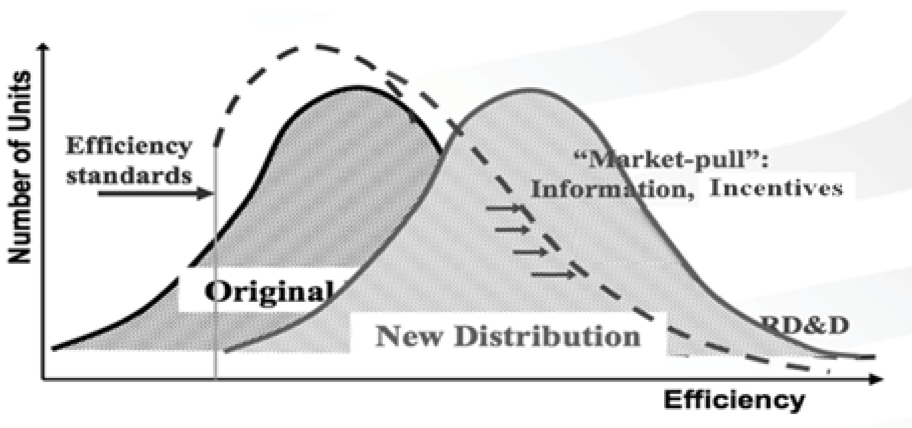


Source: Cited in Laustsen 2008, p.15.

The Role of Incentives

Mandatory BEECs are critical to compel the supply chain to begin to develop and produce more energy-efficient buildings and to integrate energy efficiency requirements into standard practices. This market transformation process is critical to overcoming the market barriers to investing in more energy-efficient buildings. Although not the intention by design, the biggest shortcoming of BEECs is that they do little, if anything, to shift demand or to encourage the supply chain to do more than what is necessary to comply with the requirements. The perpetual cycle of innovations driven by market demand and the desire of suppliers to tempt demand side interests is the ultimate goal of energy efficiency market transformation (see figure 1.7). BEECs alone cannot achieve that, since they only establish a floor for the required energy performance of buildings.

Figure 1.7. Push and Pull Strategy to Improve Energy Performance of New Buildings



Source: Authors, adapted from Harris/Mahone (1998).

Incentives are useful in (1) encouraging commercial deployment and market recognition of energy efficiency innovations that surpass the requirements of BEECs; and (2) overcoming the resistance to change in nascent markets because of unfamiliarity and lack of experience with new techniques and different materials, as well as the financial risks associated with higher construction costs in order to comply with BEECs. Incentives do not have to be monetary in nature. But they always carry outright or implicit financial benefits to market participants. Some practical examples of incentives and their direct and indirect benefits to their intended beneficiaries are summarized in table 1.1. Incentives do not need to be applicable to the entire building in order to provide benefits. Box 1.4 provides the example of market transformation for efficient windows.

Table 1.1. Incentives for Adopting or Exceeding the Requirements of BEECs

Type/Name of Incentive	Intended Beneficiary	Direct/Indirect Benefits	Example of Practice
(Partial) grants For design costs For homes/ commercial buildings beyond BEEC For demonstration of buildings complying with voluntary code For audits	Developer/owner	Reduce incremental costs (of design, of energy-efficient building materials, equipment and construction) Direct: reduce incremental costs; indirect: provide information on costs/ benefits of energy-efficient buildings Information on cost-effective energy-efficient renovation measures	United States (often through utility programs, e.g., in California) Singapore (Green Mark) Thailand (2002-05 for energy efficiency projects in designated buildings) Denmark, Tunisia
Subsidized loans/interest rates	Developer/owner	Reduction of first cost	Austria, Germany, Japan, Netherlands, Republic of Korea, Switzerland, United States
Energy-efficient or green mortgages	Owner Lender	Secure otherwise impossible mortgage Recognition; advantage in marketing; customer default risk reduction	United States, Mexico
Tax benefits (Reduced import tax duties or VAT rates or income tax deductions/credits for EE appliances/equipment	Developer/Owner	Reduction of first cost	United States
Nonmonetary incentives Expedited permits Relaxed zoning restrictions (size, density)	Developer	Reduced costs of doing business, increased earnings	United States (e.g., Hawaii, Seattle, Santa Monica) Republic of Korea Lebanon (for complying with voluntary BEEC)
Awards	Developer/builder	Public recognition and marketing advantage	China, United States (e.g., for Energy-Star buildings)
Rating systems	Developer/owner	Recognition; advantage in marketing; higher market value of rated building	Energy Star (United States), LEED and other green building rating systems in China, India, European Union countries, United States, and so forth.

Source: Compiled by authors.
Note: Most incentives to go beyond code are conditional on the building/appliance achieving a certain rating for the building or a certified percentage of energy savings beyond BEEC requirements. See, for example, for the United States, http://www.dsireusa.org/summarytables/finee.cfm.

Box 1.3. Transforming the Market for Efficient Windows

In the first decade of the twenty-first century, Energy Star windows* became a commodity product in the Northwest United States. Even though these windows were more energy efficient than required by the BEEC at that time, manufacturers found that it was possible to achieve the Energy Star threshold with a small increment of product improvement. Manufacturers wanted to reduce the number of product types that they supplied. Distributors and retail outlets did not want to stock multiple variations for each window. So, they all settled on the window product that complied with the Energy Star requirements. Consequently, a homeowner who knew little or nothing about window energy efficiency could not help but buy an energy efficient window when they went to the building materials supply store. Similarly, an architect could have an Energy Star window delivered more quickly than a less-efficient window because the Energy Star window was already available on the shelves, whereas a less-efficient window would take longer to obtain as it would need to be special-ordered. The result was a much-higher compliance rate for the window energy-efficiency criteria in the BEEC. Eventually, the window criterion in the BEEC was increased in stringency to match the Energy Star criterion.

Source: Authors.
* See http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup& pgw_code=WI.

In addition to regulatory instruments and incentives, information is the third type of instrument, complementing the other two. Awareness raising and information campaigns about the costs and benefits of energy efficient buildings can help create more demand-pull for energy efficiency by educating the general public and prospective buyers/tenants of energy efficient buildings. Information can be as simple as checklists, but also include metering of energy consumption and auditing of buildings. Advantages of advanced building techniques and materials can be demonstrated by voluntary certification and labeling for low-energy or green buildings, preparing the marketplace—consumers as well as the building supply chain—for more stringent BEECs. Requiring the public sector to take the lead in adopting BEECs and go beyond them would add to the market push for more efficient buildings. The results of such public-sector projects could be disseminated to provide information to other participants in the market for buildings.

Key Challenges to Implementing BEECs in Developing Countries

Global experiences indicate that implementation of BEECs is likely to have more success in countries and localities where the construction sector is well managed in terms of government oversight of building safety and quality, the building supply chain is well established in terms of technical and engineering capacity, the market for commercially produced buildings is well developed, and there is broad and firm political commitment to improving energy efficiency. Weaknesses in these areas are often the main challenges in developing countries when they embark on efforts to implement BEECs.

Challenge 1: Reaching Broad and Firm Political Commitment to Energy Efficiency and/or Climate Change Mitigation

In many developing countries, the focus on expanding modern energy supply infrastructure and energy access often leaves energy efficiency, especially demand-side energy savings, with little political attention. The critical issue in the beginning is not about budget allocation but about giving energy efficiency its due recognition as a pillar of the national energy strategy. Energy efficiency can have many benefits, from reducing the needs for disruptive installation of new energy transmission lines, to better outdoor air quality due to less coal burning, to providing more jobs and keeping more money in the local economy. It is not necessary that everyone agree on all of the benefits of energy efficiency, but rather, to take initial steps. This would then provide a political mandate for the government to begin necessary steps to introduce and ramp up energy efficiency policies and programs as the specific needs are identified, such as the implementation of BEECs. Once that has happened and people begin to see the benefits, a constituency will develop to support energy efficiency.

Challenge 2: Establishing an Effective Government Oversight System for Building Construction

Government supervision of building construction for urban planning and safety reasons is common practice around the world and usually a responsibility of local governments. A robust building permit and inspection system provides a good basis for incorporating supervision arrangements for BEECs. But its effectiveness often depends on the transparency and strength of the general governance framework, which are often weak in developing countries. Another particular problem in developing countries is the large share of informally constructed buildings (which, by definition, are not covered by the permit system) in overall construction activities.

Challenge 3: Developing the Compliance Capacity of the Building Supply Chain

Implementing modern measures to reduce/minimize building heating, cooling, and lighting loads requires a host of new design skills and approaches, new or improved materials/components and construction techniques, as well as additional supervision and inspections, compared with the prevailing commercial construction practices found in many developing countries. Standards for rating and certifying these new energy-efficient products will need to be established so that there is a level playing field for manufacturers to compete and take credit for their energy-efficiency advances, and so that developers and designers can have confidence in the claims being made for energy-efficient products. Multidimensional efforts will be needed in educating new generations of architects and engineers, training construction workers, supervisors and inspectors, and ensuring the availability and quality of new or improved materials and components.

Challenge 4: Financing Incremental Costs of More Energy-Efficient Buildings

The fact that constructing more energy-efficient buildings is a good thing is rarely—if ever—disputed in developing countries. But with tight budget constraints for both governments and private citizens, tradeoffs have to be made between more housing and more energy-efficient housing. For low-income countries, the priority is to maximize the floor area for a given amount of housing investment. This constraint loosens up as income grows and demand for amenities increases. Efforts to promote adoption of BEECs in developing countries should consider such constraint, together with the potential of tapping into international development financing mechanisms, including those of climate change mitigation and adaptation.

These challenges are surmountable in countries where economic growth is robust and sustained and the government takes energy efficiency seriously. But achieving measurable results will take time. The increasing success of enforcing BEECs in China is a good example of how low-income countries, by committing to energy efficiency early in their development process and through persistence, can make large progress in addressing the challenges over time as their economies grow stronger (see Chapters 5 and 6).

Notes

[1] Different countries may have different definition for the categories of buildings for statistical purposes and sometimes differently for application of building codes. In this report, the categories follow the general convention of energy statistics (that is, owner- or renter-occupied residences are residential buildings and buildings that house (non-industrial) commercial and public entities and activities are commercial buildings). Energy data are from Energy Statistics, International Energy Agency, http://www.iea.org/stats.
[2] Actual level of energy services delivered in low-income countries is further reduced because of generally lower level of energy efficiency in building applications, compared with high-income countries.
[3] However, note that the range is broad even within the developed countries, and the energy efficiency with which electricity and other energy is provided and used varies greatly.
[4] Eurostat http://nui.epp.eurostat.ec.europa.eu/nui/show.do.
[5] Tsinghua University Research Center for Energy Efficiency in Buildings (2008).
[6] Much of the air conditioning energy consumption could be avoided if the buildings used more thoughtful design and traditional construction methods (for example, window orientation, high thermal mass, recessed windows, overhangs over windows). Consequently, the increase in the use of electricity for air conditioning, for example in the United States, did not reflect an improvement in the standard of living. Some of the increase was to compensate for poor design that was worse than that of previous generations. See also figure 4.4 and related discussion.
[7] de la Rue du Can et al. (2009).
[8] Zhou/McNeil/Levine (2009).
[9] Zhou/Lin (2008).
[10] United Nations Population Division, World Urbanization Prospects: The 2007 Revision, http://esa.un.org/unup/index.asp.
[11] World Energy Outlook 2009, International Energy Agency, p. 251.
[12] Levine et al. (2007).
[13] This section draws from the materials of Levine et al. (2007).
[14] http://www.goodenergies.com/news/-pdfs/Web site Presentation.pdf. See also the discussion about the mixed record of green buildings in terms of energy efficiency at the end of chapter 2.
[15] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.
[16] Designers may be concerned that they might devote time to researching a technology only to have the time be wasted when the developer does not want to include the energy efficiency measure because they are unconvinced of its benefits. Designers are rarely funded to perform annual energy analyses to support informed recommendations on energy efficiency. It is too easy for designers to simply work off the specifications from the previous project and too easy for contractors to construct buildings in the manner that they have used in the past. Building energy efficiency codes can help address this problem by specifying certain measures in the prescriptive compliance options in the code. Since everyone will need to comply, designers then will not worry about whether they are out in front alone. Also, when measures are included in the prescriptive compliance options in the code, then designers do not need to develop a justification to convince a developer to include certain energy efficiency measures. The designer can simply tell the developer that it is required.

CHAPTER 2

Building Energy Efficiency Codes and Elements of Compliance

The Nature of Building Energy Efficiency Codes and Compliance Approaches

Government regulation of building safety (fire and structural safety codes) dates back to the nineteenth century in Europe and in the United States. Contemporary building codes in developed countries can be quite complex and cover a variety of issues that affect building safety, accessibility, indoor environment, and more recently environmental impact and energy use. Regulation of building energy performance through building codes became widespread in industrialized countries after the first oil price shock in the 1970s. Many of these building energy performance requirements were introduced and still remain as standalone codes or standards, recognizing the need to frequently update the requirements as technologies advance. But their enforcement generally falls under the purview of the existing enforcement apparatus of building codes. This report does not distinguish the lexical differences between codes and standards and the term building energy efficiency code (BEEC) represents the set of legal requirements regarding the energy performance of building design and construction.

Scope of Energy Efficiency Requirements

In general, BEECs cover the thermal performance of the building envelope and the energy efficiency of equipment and devices installed during building construction. They are intended primarily for new construction but frequently are applicable also to extensions and alterations of existing buildings.[1] Depending on the standard content of a finished building in a country or region energy efficiency requirements for installed equipment and devices are either directly covered by BEECs or referred to in separate energy efficiency standards, such as energy efficiency standards for different appliances. For example, in China, light fixtures, service water heaters, and room air conditioners are not covered in the residential BEECs because most Chinese apartments are sold without any interior finishing. Individual households are left dealing with the apartment level masonry, flooring, electric, and plumbing work. In contrast, in the United States, a salable new house or apartment must be in move-in condition with essential equipment such as lighting, service water heater, and HVAC system, which are all covered by BEECs.

Prescriptive versus Performance-Based Approaches

BEECs are often categorized as either prescriptive or performance-based according to the choice of compliance approaches. The actual situation is more complex and is presented in more detail in box 2.1. *Prescriptive requirements* in most BEECs are component specific and spell out minimum thermal performance levels of each building envelope component, such as maximum U-factors of roof, exterior walls, and windows, as well as sizing and minimum energy efficiency requirements for HVAC systems, service water heaters, and lighting systems, respectively. *A performance-based approach* in general refers to specifying the annual level of overall energy consumption (energy budget) in the targeted building and the methodology to calculate the sub-energy-budgets of different energy uses regulated by the BEEC, such as space-conditioning, lighting, and service water heating. Many BEECs require with either approach the installation of certain mandatory measures. For example, mechanical ventilation in low-rise residential buildings in California has to meet ANSI/ASHRAE Standard 62.2 for Ventilation and Acceptable Indoor Air Quality;[2] in the Republic of Korea, insulation has to comply with region-specific U-factors for building envelope and certain thicknesses of insulating materials.[3] Going from a true prescriptive to a full performance-based compliance approach increases the degree of flexibility allowed in meeting the energy performance requirements of BEECs. Such flexibility may be inconsequential for certain buildings or building types (for example, owner-occupied apartment buildings) but very important for others (for example, large office buildings). The skills and sophistications required to comply usually increase with flexibility. The design of buildings based on the performance approach as well as verification of their compliance requires calculation procedures for which many software packages have been developed.[4]

There are certain merits for developing countries to start with relatively simple prescriptive and component performance BEECs and increase the range of the compliance options as the supply chain becomes more capable of meeting energy efficiency requirements and the compliance enforcement capacity grows stronger over time. For uninitiated designers and builders, prescriptive requirements make compliance simpler to understand and execute. For product manufacturers, clearly defined energy efficiency requirements for individual components (such as windows) and equipment (such as furnaces) provide a firm baseline for their product development or retooling their product lines. For the nascent enforcement system, checking and inspecting prescriptive requirements help put in place the fundamentals of the compliance process.

Offering simple compliance options in a clear code language will better convey the intent of the BEEC to enforcement officials, as well as to others. This increases compliance as enforcement officials have a better grasp of the energy-efficiency features expected in a building. With this knowledge, they will be better able to assist designers and construction trades who are less knowledgeable about energy-efficiency, and enforcement agents will have greater confidence in enforcing the BEEC. Ultimately, and especially as the stringency increases, it is important that BEECs contain multiple compliance options so as to maximize effective compliance by satisfying the varying needs and preferences of different users. More comprehensive tradeoff compliance options provide flexibility for innovation for more sophisticated designers.

Box 2.1. Categories of Compliance Approaches for BEECs

A *true prescriptive* compliance approach provides specific details about materials to be used. For example, for the insulation of the building envelope or the insulation of pipes and ducts for HVAC systems required R-values are specified.

A compliance approach that specifies a rating for an assembly of materials is not really a true prescriptive compliance option, but a *component performance* compliance option. For the building envelope, a maximum U-factor for a wall or roof assembly or a maximum U-factor or solar heat gain coefficient (SHGC) for a fenestration product (window, door, skylight) are examples of such a compliance option. Designers and manufacturers develop an assembly of materials that comply with the BEEC criteria.

The next step up in complexity is the *partial subsystem performance* compliance approach. This option addresses more than one component of a building subsystem. For example, the overall thermal transfer value (OTTV) considers the heat gain through the opaque building envelope components as well as the glazed components, but it does not allow tradeoffs between maximum heat loss and maximum heat gain, nor does it consider the effects of air leakage on maximum heat gain and maximum heat loss.

A further step up in complexity is the *multiple subsystem performance* compliance approach. It addresses more than one building subsystem, but not the entire energy consumption of the building. For the building envelope and the mechanical system, there are multiple subsystem performance compliance options that specify maximum energy consumption for space heating and/or space cooling. In this case, the designer has the flexibility to make a trade-off between the building envelope and the mechanical system. For example, higher mechanical equipment efficiency can be used to offset an otherwise noncomplying building envelope with excessive heat loss and excessive heat gain from a large window area.

At the top end of the complexity range are the *total building performance* approaches that include all of the energy consumption for the overall building. The criteria are usually specified in terms of total energy consumption or total energy cost. Within these total building performance options, there are usually some constraints on assumptions that can be made so that the approach is not abused.

In the *fixed budget* approach, some BEECs specify performance using a fixed energy consumption value, such as kWh/m^2. In this case, in order to be fair for all projects, the BEEC must also specify all of the key calculation assumptions such as hours of operation, internal loads from people and equipment, temperature setpoints for space heating and space cooling, and so on. The downside to this approach is that these fixed assumptions necessary for compliance calculations may not correspond with the proposed building.

In the *custom budget* approach, some BEECs specify that the proposed building is to be compared with a baseline reference building that is similar to the proposed building but that complies with the prescriptive and component performance criteria.

A *points system* is a more-simplified version of a total building performance option. In this option, the developer of the BEEC has calculated the relative energy benefits of a variety of energy-efficiency measures. Each of these measures is included in the BEEC and is given a certain number of points. The designer must then show compliance with the BEEC by selecting enough energy-efficiency measures to achieve a certain minimum number of points.

Source: Authors.

More comprehensive and more sophisticated BEECs can also provide better direction to manufacturers to think about the big picture for building components in addressing heat energy savings as well as cooling energy savings and lighting energy savings. For windows, for example, this involved

- moving from requiring that windows be double-glazed
- to specifying a U-factor for the overall window assembly (achieve the performance level through better frames, or different air gaps, or inert gas fills, or low-emissivity coatings, or low-conductance spacers, and so forth.)
- to adopting criteria for U-factor and solar heat gain coefficient (minimize the heat loss at night and heat energy loads, but still control solar gains and reduce cooling loads during the day[5])
- to also including criteria for visible light transmittance.

Mandatory versus Voluntary BEECs

The decision to adopt a mandatory or voluntary BEEC should be made based on the capacity of the existing apparatus for enforcing the general building codes and the capacity of the supply chain to respond to the new energy efficiency requirements. Some countries already have building structural/fire codes, mechanical codes, and electrical codes in place, including the infrastructure to implement those codes. In this situation, the first BEEC can be adopted as mandatory (with an appropriate lead time) and the work added to that existing infrastructure. However, other countries without this background may choose to make the BEECs voluntary when they first adopt them so that all stakeholders can adapt to their application, including the building materials industry, and an enforcement infrastructure can be built up. BEECs then become mandatory. When political support for energy efficiency is strong, BEECs introduced as mandatory in the first place have the advantage of setting a clear path to transforming construction sector practices, although the journey can be long in developing countries. For example, it took China more than ten years to achieve a significant level of compliance of its first mandatory BEEC.

Development and Implementation of BEECs

Developing a BEEC is a rather elaborate *process* requiring a variety of data and analyses. The following activities can be distinguished as part of the BEEC development process:[6]

- Survey and comparison of international BEECs to identify relevant examples from other locations.
- Survey of local buildings to collect information about the building stock and its energy use and determine typical base case buildings to be used as benchmarks for developing and evaluating code requirements. Local climate data and information on the local availability and costs of construction equipment and materials need to be gathered as well.
- Technical, energy, and economic analysis, including computer-based simulations applied to base-case buildings to estimate energy savings and cost-effectiveness of proposed code requirements. Knowledgeable local designers and contractors are a key source of professional judgment and should therefore be consulted early on in the BEEC development and adoption process.
- Code document drafting, reviews, and revisions. The BEEC should include detailed and objective documentation (for example, technical data such as

equipment ratings or tables of default values), explicit standard requirements, including compliance forms (that are easy for inspectors to check), and alternate compliance options. In the case of performance-based compliance, a computer software performance method with specialized compliance software (computer simulations of building energy use) needs to be developed. Provisions for continued BEEC maintenance and regular code revision and updates should be made.

- Public review with key stakeholders. The inclusion of key stakeholders in the code development process allows issues to be sorted through and addressed before the BEEC is finalized. This will result in a better BEEC. It also greatly increases the likelihood that the key stakeholders will support the BEEC once it is adopted and work to see it utilized within their trade or professional organization.

After a public review of the final BEEC draft and inclusion of comments, it would be officially adopted as a voluntary or mandatory code. Four issues need to be considered for the development of a BEEC:

1. *Decide whether the code should emphasize simplicity (and thus easier application) or provide for flexibility to allow designers and architects to find effective ways to meet the code requirements*. In new code developments that cover all new buildings, often both prescriptive and performance-based compliance paths are introduced, allowing designers to choose. Especially for smaller, less complex buildings, the simpler prescriptive path is generally preferred.
2. *The code needs to be technically accurate.* The prescriptive and performance compliance options should be roughly equivalent, so that one does not become a loophole. Also, for energy calculations to more closely reflect reality, code requirements should take into account design flaws, such as thermal bridges due to metal framing around windows, metal studs in walls, and *projecting concrete balconies.*
3. *The code needs to take into account the local availability and costs of equipment and materials.*
4. *The code requirements should be beneficial for society as a whole.* This means that any additional costs of implementing the necessary measures, plus the costs of any supporting programs are balanced by energy savings and other benefits[7] over the lifetime of the building, if not less. The code developers should thus use a *life-cycle cost (LCC) analysis*[8] and specify those measures that have the biggest impact on energy savings for money spent. Box 2.2 provides an overview of methodological issues of cost-effectiveness of BEECs, complementing the examples in box 2.1.

Box 2.2. Cost-effectiveness Analysis—Methodology

Various **criteria** can be used to determine cost effectiveness. The following three are frequently used options.

Net present value (NPV) is positive—the present value of expected future savings in operating costs exceeds the present value of expected additional capital costs. Present values are determined by applying a discount rate to future costs and benefits.

Internal rate of return (IRR) is above a minimum threshold—the discount rate at which the present value of expected future savings in running costs equals the present value of the expected additional costs is above a certain level.

Payback period is below a certain time period—the number of years it takes for cumulative savings in operating costs to match the increase in capital costs is below a certain level. It is assumed that the benefit from having a dollar today is the same as having a dollar in the future, and so a discount rate is not applied to future cost savings. While the payback period is easy to calculate, it has serious drawback since it favors short-term profitable investments, while neglecting others that may have a higher net present value over a longer time frame.

Issues to be considered in cost-effectiveness analysis:

(1) Discount rate—Societal would be lower than private discount rate; for the former, a range of 3–10 percent is frequently applied (Levine et al. 2007)

(2) Lifetime of investment/residual value of investment needs to be taken into account

(3) Choice of baseline scenario and alternative scenarios—choices carry some uncertainty, for example, future changes in the cost of energy saving technologies, relative prices (between different forms of energy, and relative to other goods and services), rate of capital turnover, level of business-as-usual improvements in Building Energy Efficiency

(4) Non-energy benefits and costs are often not quantified, monetized, or identified, but they should be incorporated, at least for the societal analysis. Co-benefits of energy efficiency investments include:
- Higher independency from energy imports; improved energy security
- Mitigation of externalities like global warming
- Improved thermal comfort, better indoor air quality, higher productivity
- Employment creation (for example, a 20 percent reduction in EU energy consumption by 2020 can potentially create 1 million new jobs in Europe)
- Creation of new business opportunities; for example, a market opportunity of €5–10 billion in energy service markets in Europe
- Risk reduction:
  - Less risk of damaging building and construction infrastructure
  - Less poverty risk in case of steeply increasing energy prices
- Reduced societal costs from reduced energy demand from buildings during peak-load hours. In California, for example, this benefit needs to be included in evaluations of utility energy efficiency programs (see California case study in Appendix 5)

The literature review by Ürge-Vorsatz et al. (2009) shows that "the value of the co-benefits is substantial and may amount to 40 percent of saved energy costs." The same source also concludes that "individually, monetized barriers can reach as high as 20 percent of energy efficiency projects' costs and up to 10–15 percent of energy saved as a result of such projects with the highest magnitudes pertaining to market failures." (p. 310) A report by Katz (2003) estimates that the productivity and health benefits of green buildings far outweigh the value of energy savings. Other examples of cost-effectiveness are provided in box 1.1.

(Box continues on next page)

Box 2.2 (continued)

Table: Financial Benefits of Green Buildings (per square feet)

Category	20-year NPV
Energy Value	$5.79
Emissions Value	$1.18
Water Value	$0.51
Waste Value (construction only)—1 year	$0.03
Commissioning O&M Value	$8.47
Productivity and Heath Value (Certified and Silver)	$36.89
Productivity and Heath Value (Gold and Platinum)	$55.33
Less Green Cost Premium	**($4.00)**
Total 20-year NPV (Certified and Silver)	**$48.87**
Total 20-year NPV (Gold and Platinum)	**$67.31**

Table Source: Kats 2003, p. 84.
Note: Based on data from 33 LEED-registered buildings. The average incremental costs are estimated at 1.84 percent. On average, those buildings use 28 percent less energy than buildings complying with the relevant BEEC. Energy savings alone exceed the incremental construction costs. The by far biggest benefit of green buildings relates to improved productivity and health.

Cost-Effectiveness Calculation: Example from Florida

- Approximately 30 "off-the-shelf" improvement measures evaluated in three Florida climates (Jacksonville, Tampa & Miami)
- Three "packages" developed from results using least-cost analysis methods
  - ENERGY STAR® package (~15% savings)
  - Tax Credit package (~25% savings)
  - "Best Practice" package (~40% savings)
- Each individual measure compared against new home Baseline (2007 Code) on whole-home energy use basis
- Two cost sets developed:
  - Baseline feature costs
  - Energy efficient feature costs
- Incremental costs = Baseline cost—energy efficient cost
- Cost source: "2005 RSMeans Residential Cost Data, 24th Annual Edition", as modified (normally upward) based on best judgment of authors
- The "Participant Cost Test" is used which assesses the costs and benefits from the perspective of the customer installing the measures

The example shows that even a package that would deliver savings of about 40 percent compared to the current BEEC has lower cost than the current residential electricity rate.

- Levelized Cost of Conserved Energy (CCE) used as the cost effectiveness metric:

  CCE = Net cost of improvement * CRF

  where: $CRF = \dfrac{d}{(1- (1 + d)^{\text{life in years}})}$

  is the capital recovery factor and d is the discount rate = 4.5 percent

- Where CCE is less than the retail price of residential electricity, the measure or package of measures is considered cost effective (from the perspective of the residential consumer)
- Figure 3 shows that all three packages would be very cost-effective for residential customers to implement with the costs of conserved energy well below the current cost of electricity.

(Box continues on next page)

Box 2.2 (continued)

Figure: Levelized Cost of Conserved Energy for Different Energy Saving Packages in Florida

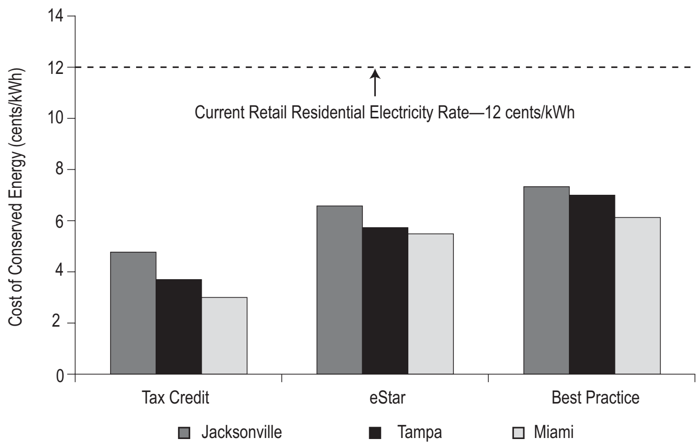


Figure Source: Based on Fairey 2007.

Box Sources: Australian Government Productivity Commission (2005). Hermelink (2009), Ürge-Vorsatz/Novikova/Sharmina (2009).

The development and later implementation and enforcement of a BEEC do not take place in an institutional vacuum. Implementation, enforcement, and the future sustainability of a code will be enhanced if the following arrangements are put into place during the development of a BEEC, especially if funding for the code development is from bilateral or multilateral sources:

- A project unit to manage the development process. The unit should be directly linked to the government unit/agency in charge of code development.
- Consultants to perform various market research and analysis tasks.
- Standing committee to have a strong involvement from local experts in the development process. This includes task forces to tackle specific points.
- Links with relevant organizations. This could be in the form of a working group of stakeholders that would review outputs and participate in firming up realistic and relevant recommendations.
- A public process for review and integration of comments.
- A structure to supervise the implementation process.
- An enforcement agency (if mandatory).
- A group that can maintain and update the code in the future.[9]

For BEECs to be actually applied and result in energy savings, the development of the code must be complemented by the buildup of an implementation and, eventually, enforcement infrastructure. For the *implementation* phase, the following components should be put into place:[10]

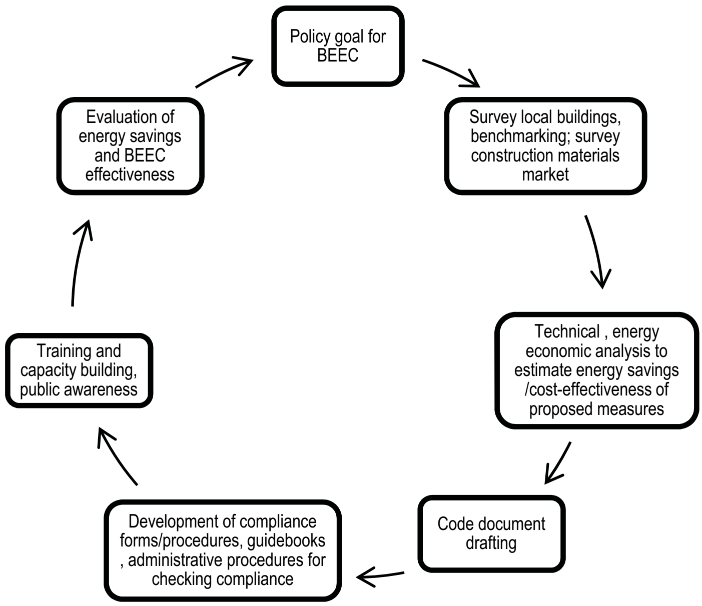
- BEEC administration and enforcement structure. The agency, or the subgroup within an existing agency, responsible for overall administration and enforcement of the BEEC, must be established with budget and staffing, even if ultimately enforcement is a local matter and most likely will take place within the structure of the department in charge of enforcing the general building codes. This agency would be responsible for the development and implementation of the remaining components.
- BEEC compliance process with development of compliance forms and procedures, user manuals or guidebooks, compliance tools and software, as well as administrative procedures for checking compliance and for documenting, recording, and publishing compliance results.
- Training programs and capacity building for code officials, designers, architects and engineers, manufacturers, and suppliers.
- Outreach and public information programs for the building and real estate industries and the general public.
- Demonstration building programs in the first phase of a adopting a new BEEC. These often provide incremental funding for the additional costs of designing more energy-efficient buildings, installing more efficient equipment and materials, installing monitoring equipment, commissioning the buildings, and monitoring and evaluating the buildings during their operation.
- Setting a firm date for implementation (with as much lead time as necessary) and then sticking with it, so that developers, designers, contractors, manufacturers, and suppliers all know when the new rules will take effect so that they can compete fairly with each other.
- Evaluation of energy savings and BEEC effectiveness. For future code revisions evaluation of actual results and experiences is important. This can include formal surveys, but should also be based on issues raised by designers and other involved parties.

The described development and implementation process (see also figure 2.1) is obviously complex, quite lengthy, and costly. In some developing countries, it has been supported with funding from bilateral and multilateral development agencies; frequently, however, such funding is available only for the BEEC development phase.

BEECs and the Building Industry

Interaction between BEECs and the building/construction industry goes both ways. When developing the BEEC, it should be taken into account whether required materials and components are produced in sufficient numbers and quality or whether production can be changed over to those materials fairly quickly.[11] Another issue to be taken into account is whether building components can be standardized easily and quickly to lower costs by promoting economies of scale and mass production and learning effects.[12] In many countries, minimizing the incremental costs of building according to code is crucial in determining BEEC requirements; see the Korea example in box 2.3.

Figure 2.1. BEEC Development and Revision Cycle



Source: Authors.

Box 2.3. BEECs and Construction Industry in the Republic of Korea

How has the building materials supply industry been able to cope with the introduction of the BEECs?

All the building materials and mechanical and electrical system in building energy code should be certified by authorized laboratories under KOLAS system (Korea Laboratory Accreditation Scheme). The performance of materials and systems are controlled by the law (for example, minimum requirements of each component and systems, high-efficiency energy system program such as Energy Star program in United States, and so forth.). The government is always monitoring and controlling the industry, and many programs exist for promoting high-energy efficiency for their products.

Has the building materials supply industry been able to produce materials complying with the code in sufficient quality and amounts?

Yes. The level of performance is decided through monitoring of market and industry capacity. In the case of insufficient technology and low quality, government assists industries through R&D programs and so forth. (for example, new and renewable systems, LED lighting, and so forth.). The real problem of deciding final performance level of building code is cost issue rather than technology.

Are materials such as insulation, windows, and so forth certified? What is the extra construction cost of buildings complying with the code, compared to noncompliant buildings?

Yes, all the materials should be certified. Extra cost to meet the energy code (exactly the cost added by new code compared to existing code) is usually considered under maximum 2 percent of total construction cost.

Source: Personal communication with Dr. Seung-eon Lee, Korea Institute of Construction Technology, February 27, 2009.

Once these questions have been answered satisfactorily and the BEEC requirements determined, it needs to be decided whether and which materials and equipment should be tested and certified. Certified building components (particularly fenestration products, insulation and HVAC systems) make compliance easier for developers and builders, but also allow easier compliance checks, since many products are too complex for visual verification.[13] Testing and certification require obviously that an adequate testing and certification infrastructure exists or can be built up relatively soon. Finally, compliance with BEECs also requires that construction trades build and install according to code. Most likely training will be necessary.

Enforcement of BEECs

Tools of Compliance

BEECs can be effective and decrease the specific energy use in the building sector only if they are broadly applied in the process of constructing new buildings or substantially renovating existing buildings. In addition to a comprehensive implementation program, this usually requires substantial efforts in enforcing a BEEC on the ground. The multitude of barriers to improving the energy efficiency of buildings (see Chapter 1) requires a variety of tools to ensure and encourage compliance. These tools can be put into the following three categories:

1. *Regulatory tools.* The form of enforcement of BEECs usually depends on how building control structures are organized in a particular country. Compliance with the code requirements is generally checked at one or several points of the planning and construction process: review of conformity of design and plans with the BEEC, inspection during construction and prior to occupancy of the building. Although the first is often done and a necessary procedure for the process to move ahead, the second and third checks are not required in many countries. The danger here is that there can well be a number of change orders during the construction process after the design has been approved and that the use of substandard components and materials could happen. Consequently, on-site verification of the construction is strongly recommended.

   The regulatory body responsible for the enforcement of BEECs is usually the local authority, less frequently a state or national agency. As with the enforcement of the general building code, the public sector sometimes contracts out to the private sector, with occasional spot checks by public inspectors. The advantages and disadvantages of different institutional arrangements for building code enforcement are discussed below (see table 2.1).
2. *Incentives.* Penalties and/or incentives can be used to improve the compliance with BEEC requirements (see also Table 1-1). Among the former are withholding of permits and certificates of occupancy or monetary fines if buildings are found not to comply with BEEC requirements. Incentives can include fiscal measures such as reduced VAT rates or tax credits for advanced energy-efficient building components or incremental cost financing for buildings that either comply with or surpass BEEC requirements, such as low-cost mortgages. For example, in Germany, owners of new homes with primary

energy consumption levels of at least 30 percent below those required in the 2007 BEEC can apply for low-interest loans or grants from the German Development Bank KfW.[14] It should be emphasized that the use of incentives to improve compliance does not mean that the need to verify compliance disappears—on the contrary, the use of public funds needs to be justified by monitoring and verification of BEEC compliance.

3. *Information.* Information should be provided to professionals and the general public, such as development of software tools and simulation models, design manuals, compilation of interpretation of BEEC, metering, audits and information/ checklists for buyers and consumers. Certification and rating systems for the regulated building components aid designers in specification of BEEC compliant materials, builders in compliance with the code and code officials in checking compliance. Building energy certificates are increasingly used to provide information to the public about the energy consumption status of buildings. They can be also used to monitor/evaluate compliance with the BEEC (for example, in Sweden; see Chapter 4),[15] or to provide the basis for payout of financial incentives (for example in Austria).[16] Performance-based BEECs can produce numerical scales for energy labeling and thus facilitate the use of other policy instruments.[17]

The compliance tools could also be used for monitoring and evaluating the general compliance and effectiveness of the BEEC on a local or national basis. This would be important if political targets for achieving certain penetration or energy savings and/or CO_2 emission reductions have been set.

Compliance Approaches and Enforcement Interactions[18]

Prescriptive BEECs that provide specific requirements for the building envelope and for some or all of the fixed equipment (heating, cooling, ventilation, service water heating, and lighting) are easy to apply by designers and builders, require relatively little information, and are relatively easy to check by reviewers and inspectors, particularly if equipment and materials have been tested and certified. Since prescriptive BEECs stipulate the minimum acceptable, a pass/fail criterion for one parameter per component can usually be applied. To ensure that materials have actually been installed correctly, inspection on site is required as well.

Performance-based BEECs that regulate the whole building performance, including all fixed services, allow the designer to optimize solutions, tailor them to the specific circumstances, and allow the use of innovative products. But they are also more complex to apply, require more information and usually computerized calculations. Although a pass/fail criterion is applied for the final output (energy use per m^2 or similar), many intermediate parameter values feed into this. It is easier to make mistakes (or to hide an incorrect figure), but also more difficult to understand and apply and to check. Building control staff need expertise and time to be able to check data and calculations.

Enforcement Options

Even though most countries do not integrate the BEEC into the general building code, most experts[19] agree that the enforcement of BEECs should be integrated into the regular enforcement system for the general building code with plan review and inspections as part of the routine construction process. This will, however, be effective only if there is a sufficient number of well-trained code enforcement staff in addition to compliance manuals, forms, and software. Separate enforcement would require the buildup of a separate enforcement infrastructure that would be even costlier and could easily double the number of inspections that need to be done before a building is allowed occupancy.

The institutional arrangements for BEEC enforcement generally depend on the system of building code enforcement in general. Traditionally, a *government agency* would be in charge of enforcement of rules and regulations. If it is adequately funded to hire sufficient staff and train them, compliance with the BEEC should be fairly high under this option. In practice, however, throughout the world funding for enforcing the energy aspects of a building code is inadequate almost everywhere. Typical sources for funding building code enforcement are permit fees that may, however, not be sufficient for thorough enforcement. In addition, many local authorities and their construction departments/inspectors pay much less attention to energy matters than to safety-related building features.

In more and more countries, the *private sector* is becoming involved in the process of issuing building and occupancy permits, including the enforcement of building codes. This is often part of reforms destined to reduce red tape and improve the business environment.[20] If the private sector is involved, companies and personnel need to be certified or accredited. There also should be rules that limit the potential of leniency or, worse, corruption, such as the prospect of losing certification or spot checks by government agencies. This option has a fairly low noncompliance risk, but it could be quite expensive for the developer/builder who frequently has to bear the costs. An alternative might be to pool resources from fees collected from developers and builders and have the municipality contract a third party to do inspections or spot checks. This would also avoid the pressure on third-party inspectors to satisfy the builders that have contracted them.

In some countries, the only enforcement tool is *self-certification* by the builder in the form of a compliance statement to the building owner or the government. Self-certification usually results in relatively low levels of compliance. This is not necessarily due to cheating, but simply the fact that there are many codes that designers and contractors must keep up with and it is simply unlikely that they will know all the requirements in the BEEC. If builders themselves are certified, this option could have a moderate noncompliance risk.

In table 2.1 the features and requirements of the three enforcement options are listed. In many countries, a mix of options can be found—for example, in China and in the United States, private inspectors support the enforcement by local public agencies.[21]

In systems with a low level of government policing, the noncompliance risk would be lower if owners had more motivation to insist that their new building includes the required energy efficiency features. But this motivation is usually lacking since owners would have to pay the costs of implementation and compliance, but are frequently unable to recoup these in the market. This could be changed by devising instruments that add market value to buildings with high energy performance, such as carbon trading or lower (property) tax rates linked to energy certificates.[22]

Table 2.1. Institutional Options for Enforcement of Building Codes, Including BEECs

	1. Government Agency	2. Private Third Party	3. Self-certification to Owner or Public Agency
Key features	Government department or agency wholly responsible	Private third party is certified by government.	Builder provides compliance statement to owner or government.
Support infrastructure needed	Government inspectors	Trained and certified third-party staff; some training of public-sector staff if spot checking.	Policing of compliance statements (unless it is left to owner to complain); perhaps certification of builder.
Cost to government	High but may be recovered from builder	Moderate	Low. Moderate if builders are certified.
Cost to owner/ developer	Low unless agency charges	High	Low
Information and infrastructure needs	Trained government assessors	Trained private assessors; Certification process	Knowledgeable builders and owners. Energy labels and certificates for buildings. Some trained public-sector staff if statements are policed.
Noncompliance risk	Low, provided adequate funding	Low. Third party depends on certification for income (but also on satisfied builders).	High, unless owner places high value on energy efficiency. Moderate if self-certification to government. Lower if builders are certified
Examples	United States: prevailing option	France, Mexico, China (with some public oversight), some in United Kingdom, some in United States, pilot in Turkey.	Germany (to owner)

Source: Adapted from BRE (2008), p. 29 (based on Maine Public Utilities Commission (2004)).

Almost universally, the main reasons cited for lack of enforcement are high enforcement costs and underresourcing of public agencies, including for staffing and staff training, inspectors' lack of qualifications and specialist knowledge, and finally, the perception that the energy-saving building regulations are not as important as safety-related regulations. The latter might make it more likely that municipalities put pressure on inspectors to turn a blind eye on "minor" imperfections. The results are leniency of inspectors and inadequate site inspections.

The solutions proposed for better enforcement of BEECs are quite similar in different regions of the world, including the following:

- Impose political energy savings or CO_2 reduction targets on all levels of government to heighten the importance of energy efficiency matters.
- Provide sufficient resources for enforcement by government agencies, with budgets supplemented by utilities,[23] carbon finance, and other interested parties.

- Make specialist training available for code officials and all trades involved in building issues, with budgets supplemented by utilities, carbon finance, and other interested parties.
- Establish a system of accredited third party enforcement, possibly in conjunction with government spot checking and significant sanctions against fraudulent approval.
- Provide information and incentives to builders and homeowners. Consider penalties for noncompliance in the longer term.

Toward Low-Energy and Green Buildings

There has been rising interest in pushing the technical innovations in building design and construction toward deep reduction of building energy demand combined with renewable energy supply (net-zero-energy buildings) and toward minimizing the overall environmental footprint of buildings combined with enhanced amenities (green buildings). Many voluntary low-energy or green building schemes build on general BEECs, requiring that buildings to be certified to achieve energy savings beyond that of buildings complying with the BEEC. The BEEC thus establishes a minimum requirement to be surpassed. For example, Kats/Perlman (2006) found that Energy Star–rated office buildings in the United States use 40 percent less energy than comparable nonrated buildings. Voluntary low-energy or green building rating schemes are important in demonstrating that technologies and building materials with superior energy performance are available, promote their standardization, and can be applied at relatively small incremental cost, thus advancing the market and demonstrating that energy efficiency can be further improved compared to the prevailing BEEC.

One must be careful about drawing conclusions about the energy efficiency of green buildings. Most of the green building programs allow the user to choose measures in several topic areas to achieve a certain number of points and they allow tradeoffs within each area. Certification is based on building design and modeling results, not on actual measurement post occupation. One complaint about the LEED program was that, prior to the 2009 update, there was no requirement that LEED buildings achieve a minimum improvement in energy efficiency. A 2008 study of 121 LEED buildings in the United States confirmed some of these concerns.[24] Measured performance results for 121 LEED New Construction buildings certified between 2001 and 2006 show that on average, LEED buildings are saving energy. But one quarter of the LEED buildings used more energy than average for comparable existing building stock, and some buildings even used more energy than the BEEC baseline. Those deviations between modeling and actual results are likely to come from a number of sources, including differences in operational practices and schedules, equipment, construction changes and other issues not anticipated in the energy modeling process. Energy modeling is a good predictor for actual energy consumption for the entire program; individual modeling predictions vary widely from actual project performance outcomes. Buildings with high process loads are especially problematic.

The 2009 LEED version now establishes minimum criteria for each topic area so that green buildings demonstrate improvements in more of an all-around manner. In particular, compliance with the most recent versions of the national model codes is required; in addition, at least two points have to be achieved under the "Optimize energy performance" criterion.[25]

The successful implementation of low-energy or green buildings and other new, innovative building concepts require that different actors of the building life cycle (architects, engineers, construction trades, and operators) cooperate closely. The energy aspects should be considered at the early design stage of the building process, and architects and engineers should work together from the start in multidisciplinary design teams. Training of builders and on-site supervision is of particular importance in low-energy, well-insulated and ventilated buildings, since energy consumption is more strongly influenced by construction practices (such as air tightness and the avoidance of thermal bridges) and by user behavior than in conventional buildings.[26]

Certification, labeling, and rating programs have been developed in many countries for energy-efficient appliances, and for many types of appliances they are mandatory, for example, air conditioners (ACs). Such programs have also been introduced in the building sector. In fact, low-energy or green building schemes that include labeling, rating and certification, are becoming quite popular all over the world (Appendix 7). Although most of those schemes have been developed and are administered by the private sector and are voluntary, they are paving the way for more aggressive public targets to reduce the energy consumption and environmental footprint of buildings.

To push the market further in the direction of low-energy or green buildings, many governments require that public buildings reach low-energy or green building standards and/or that all new buildings reach such standards within a period of 10 to 20 years. For example, the European Union is aiming at reaching the "near zero energy" standard (Appendix 7) for all new public buildings by 2018 and all new residential and commercial buildings by 2020. The State of California in the United States recently approved its first statewide Green Building Standards Code, effective January 1, 2011, including both mandatory and voluntary measures in five areas: (1) planning and design, (2) energy efficiency, (3) water efficiency and conservation, (4) material conservation and resource efficiency, and (5) environmental quality.[27] California has also stated the goal to achieve net zero energy for all new residential construction starting in 2020 and for all new commercial construction in 2030.[28]

In the opinion of the authors, green building standards have their place within an overall energy efficiency strategy for the building sector by providing examples of sustainable building practices that demonstrate that energy efficient and other sustainable building practices can be realized and provide a large number of benefits that outweigh their costs. In many developing countries green buildings are restricted to high-end commercial buildings designed by sophisticated designers, constructed by experienced companies, and frequently occupied by foreign companies. Unless a BEEC is developed and implemented that provides a broader basis for the application of energy efficiency practices in the building sector, exploitation of economies of scale in manufacturing energy efficient components, and build-up of the necessary infrastructure and enforcement infrastructure, it is doubtful that green buildings alone can achieve a market transformation.

Notes

[1] This statement is not true, for example, for BEECs in the United States. Although building codes have a substantial alterations threshold (that triggers requirements for seismic upgrades in existing buildings), BEECs do not have such a mechanism. For example, in both ASHRAE/IESNA Standard 90 furnace pump, the new furnace must comply with the BEEC requirements for furnaces. There is a special section with some special allowances for existing buildings. For example, if you open up a framing cavity, you must fill that framing cavity with insulation before you close it up again. You do not need to fur the wall out so that it is deep enough to accept the insulation required for new construction.
[2] For the extensive list of mandatory measures in the 2008 California Building Energy Efficiency Standards see http://www.energy.ca.gov/2008publications/CEC-400-2008-001/CEC-400-2008-001-CMF.PDF.
[3] For more details see, for example, PNNL (2009 Korea).
[4] See for example, the overview of BEEC software packages in APEC countries in PNNL (2009 Comparison).
[5] The least-costly way to achieve a low SHGC is to use darkly tinted glass or glass with mirror reflective coatings. However, this affects the amount of light and the daylight quality within the space. Consequently, the potential energy savings from daylighting are being sacrificed because the BEEC is not addressing the potential for lighting energy savings in addition to heating energy savings and cooling energy savings.
[6] Based on Deringer/Iyer/Huang 2004; see also Huang 2006, Goldstein 2006, and Baillargeon 2007.
[7] Not all of the benefits of energy efficient buildings can be readily quantified. For example, energy efficient buildings tend to have more comfortable spaces and less radiant discomfort due to better glazing products being used, and quieter spaces with less noise from the outside when multilayered glazing products are used. But, the difficulty of quantifying these benefits means that they are rarely included in economic analyses. Also, it can be a challenge to capture the benefits of integrated design in computer-based simulations. For example, it may be possible to eliminate a perimeter heating system and its associated cost due to choosing a better fenestration system and more insulation. However, many economic analyses are more simplistic, only factoring in the first cost increases for the better fenestration and the operational cost reductions due to energy savings, but neglecting the first cost savings of reducing the size of the heating system or eliminating it completely.
[8] "Life-cycle cost analysis (LCCA) is a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system. LCCA is especially useful when project alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings" (Fuller 2008).
[9] Based on Baillargeon (2007).
[10] Based on Deringer/Iyer/Huang (2004).
[11] For example, in the case of the Netherlands, Joosen (2007) observes that the first performance-based BEECs in the 1990s "required little deviation from standard building practice at that moment."

One reason cited for the lack of compliance with BEECs in Mexico is that "builders have an important amount of resources invested in very specific assembly lines that allow them to have costs at a competitive level. Having to comply may mean an investment in the equipment and training in the new processes and in the development of new supply lines for the new materials" (de Buen 2009a).
[12] Cp. Jakob/Madlener (2003) on experience curves for energy-efficient building envelopes in Switzerland.

[13] Hogan (2008).
[14] See http://www.kfw-foerderbank.de/EN_Home/Programmes_for_residential_buildings/Energy-Efficient_Construction.jsp. The threshold is lower (15 percent more efficient) according to the 2009 German BEEC, which is about 30% stricter than the 2007 BEEC (http://www.bmvbs.de/Bauwesen/Klimaschutz-und-Energiesparen-,2975/Energieeinspar-verordnung.htm).
[15] See Hjorth (2008). If there are long lead times for full occupancy, such as in China, they weaken the enforcement effect of energy labels; therefore, enforcement during construction is critical.
[16] http://www.wohnnet.at/thermische-sanierung.htm.
[17] See Hitchin (2008).
[18] Based on Hitchin (2008).
[19] For example, Taylor/Liu/Meyer (2000), Huang (2006).
[20] See World Bank /IFC "Doing Business" publications; http://www.doingbusiness.org/.
[21] See China and California Case Studies in Annex 1.
[22] Hitchin (2008).
[23] In some cases, utilities have provided support for public-sector enforcement of BEECs, particularly when the jurisdiction has enacted a BEEC that is stricter than national or state requirements and is expected to reduce utility peak loads. Support can be in the form of budget support to the enforcement agency; see Seattle case in box 4.6 and California Case Study, Annex 1.
[24] Turner/Frankel (2008).
[25] Based on USGBC (2007).
[26] From the lessons learned from the IEA solar heating and cooling program, see Hestnes et al. (2003).
[27] http://www.bsc.ca.gov/CALGreen/default.htm See also California Case Study, Annex 1.
[28] http://www.californiaenergyefficiency.com/docs/EEStrategicPlan.pdf.

CHAPTER 3

Global Status of Building Energy Efficiency Codes and Compliance

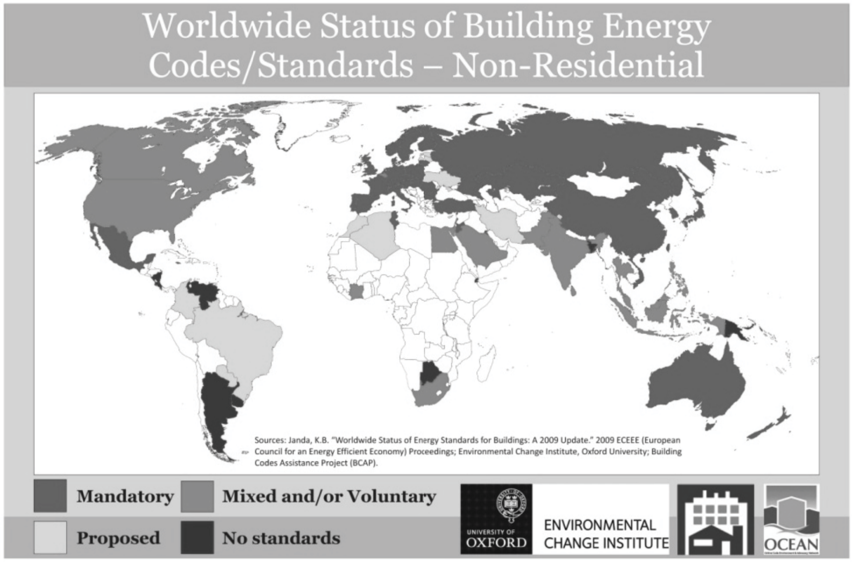
Most developed countries introduced BEECs for residential and non-residential buildings since the first oil crisis in the mid 1970s. In most countries mandatory building codes are developed and adopted at the national level, but they are enforced at the local level. Exceptions are several countries with a federal constitution, such as the United States, Canada, and Belgium where national codes are model codes that have to be adopted at the state level to become mandatory.

Status Quo of BEECs in Developing Countries and Economies in Transition

Few developing countries had any BEECs before the mid-1990s, among them several countries in Southeast Asia with voluntary codes for commercial buildings. A 1994 survey (Janda/Busch 1994) listed only 15 countries (11 developing and 4 transition countries) that had developed either mandatory or voluntary BEECs for residential and/or nonresidential buildings. Since then, the number has risen significantly. By 2007, 37 countries (developing and transition countries—8 of the latter are now EU members) had introduced BEECs (Janda 2009); see figures 3.1 and 3.2.

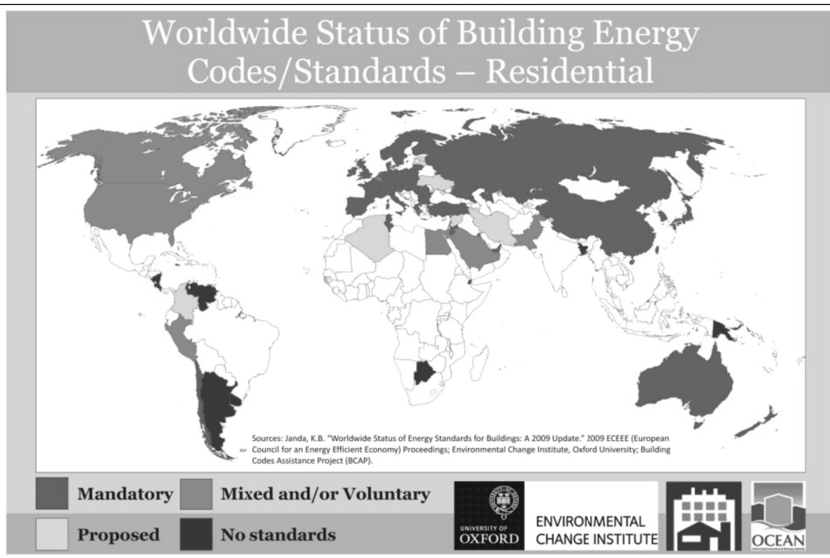
Table 3.1 provides information on the urban population in developing countries of various world regions, together with qualitative information on the development and implementation of BEECs and energy demand characteristics in the building sector for each region. Appendix 6 provides more details on BEEC development. Figures 3.1 and 3.2 and table 3.1 show that BEECs are most prevalent in Eastern Europe and East Asia. Many of the countries in these regions are in cold climate zones and require heating. The most urbanized region, Latin America/Caribbean, shows a lack of BEECs, and even where they exist they are not implemented. Buildings in this region require energy for cooling equipment only, except for southern parts of Argentina and Chile. Many countries have introduced standards for air-conditioning equipment to provide some improvement in energy efficiency for cooling purposes.

Figure 3.1. Status of BEECs in 81 Countries, 2009, Non-Residential



Source: Based on data in Janda (2009); http://bcap-ocean.org/sites/default/files/International Non-Residential Status Map.jpg.
Note: (1) Belgium, Canada, and the United States have mixed codes—national model codes are not mandatory, codes on the state level are. (2) All Baltic countries and Ukraine have mandatory codes. Japan's codes are nominally voluntary.

Figure 3.2. Status of BEECs in 81 Countries, 2009, Residential



Source: Based on data in Janda (2009); http://bcap-ocean.org/sites/default/files/International Residential Status Map.jpg.
Note: (1) Belgium, Canada, and the United States have mixed codes—national model codes are not mandatory, codes on the state level are. (2) All Baltic countries and Ukraine have mandatory codes. Japan's codes are nominally voluntary.

Table 3.1. Regional Status of BEECs in Low- and Middle-Income Countries*

	Urban Population (Million)			
	2005	2030	BEEC Development/Implementation	Energy Demand Characteristics
Africa	268	628	Voluntary BEECs have been developed in a few countries (South Africa, Côte d'Ivoire), but implementation is very limited.	Mostly cooling demand
Middle East and North Africa	172	288	BEECs have been developed in several countries (Morocco, Algeria, Tunisia, Egypt, Jordan, Lebanon, Israel), but they are mostly voluntary and implementation is very limited.	Cooling demand
Europe and Central Asia*	257	282	EU countries: required to follow EPBD and implement BEECs. Other countries: many have developed BEECs (Russian Federation, Ukraine, Turkey, Armenia,…), but compliance is limited.	Heating and in some countries also cooling demand, mostly in existing buildings
Latin America and the Caribbean	427	597	BEECs developed and mandatory in several countries (Mexico, Chile, Jamaica), but not implemented. Many countries have AC equipment standards (Mexico, Brazil, Chile, …).	Mostly cooling demand
East Asia and Pacific	790	1337	Longest and most extensive experience with BEECs; some countries (China) have enforced to some extent, others have developed BEECs, but they are either not mandatory or problems with implementation exist (Thailand, …).	Mostly cooling demand in southeast Asia; heating and cooling demand in northeast Asia
South Asia	433	858	Voluntary BEECs have been developed in a few countries (Pakistan, India), but implementation is very limited.	Mostly cooling demand

Source: Authors; see Appendix 6 for more details on BEEC developments. Population data from United Nations Secretariat, *World Population Prospects: The 2006 Revision* and *World Urbanization Prospects: The 2007 Revision*.
Note: Regions according to World Bank classification of low- and middle-income countries; http://data.worldbank.org/about/country-classifications/country-and-lending-groups.
* No data available for Kosovo.

After more than 20 years experience with BEECs and considerable administrative efforts on the national, provincial and local level, **China** has finally achieved some enforcement success, especially in larger cities (for details, see the case study in Appendix 1).

The Republic of Korea, while no longer a developing country, also appears to have had some success with actual implementation of BEECs. It introduced the first building code requiring thermal insulation in 1977. BEECs for different types of buildings were introduced in the 1980s and 1990s and unified in 2001. This BEEC, which was updated several times, is mandatory for all new construction of buildings with high expected energy consumption. To get a building permit, the building owner must submit an energy saving plan[1] for the building, signed by a licensed architect, a professional mechanical engineer, and an electrical engineer, to the local government office in charge of building regulations. Those plans are reviewed and approved by local authorities, with possible support for the review by KEMCO, the Korea Energy

Management Corporation. It was planned to examine and approve 1,450 energy-saving plans in 2005, 2,000 in 2006, and 2,500 in 2007. But during the first year (2003–2004), 2,564 plans had already been examined.[2] Local governments may audit the buildings after construction, and, if any of the items in the energy-saving worksheet is not implemented, revoke the permit and order the building to be rebuilt according to the original zoning restriction. About half of the new buildings sampled in a special inspection from 2003 to 2005 were found to have been built out of compliance with the 2001 BEEC.[3]

A mixed picture emerges for **Thailand.**[4] A BEEC was developed in the late 1980s (with USAID support), which uses an OTTV approach (see box 2.1), including requirements for the building envelope, air conditioning, and lighting. Based on a 1995 ministerial regulation, compliance with this BEEC is mandatory for designated[5] and government buildings. Designated factories and buildings have to submit energy audits with energy conservation targets and plans every three years. Several thousand audits were completed for existing designated buildings. They indicate that many buildings do not comply with BEEC requirements: 40 percent for envelope, 25 percent for lighting, and over 50 percent for air conditioning requirements. Even though factory and building owners could have received a 30 percent subsidy in 2002–2003 for carrying out energy saving projects identified in the audits, fewer than 60 percent of total facilities (about 4,500) had submitted reports. Starting in 2005 audit procedures have been simplified.[6] The staff of the technical departments of local building department administrations that issue building permits are responsible for checking the compliance of new buildings with the BEEC. It is reported that trained and skilled staff are generally very few. No detailed compliance forms or requirements seem to exist. Together with the findings from the energy audits, this suggests that compliance with the BEEC regulations is not very good. Under a Danida-supported project, the BEEC was assessed and a revision prepared.

Box 3.1. Overall Thermal Transfer Value (OTTV)—A Performance-Based BEEC

OTTV limits the maximum allowable Thermal Transfer Value (heat gain in cooling-dominated locations) for a building in W/m^2.

Its advantages are the ease of calculation and some flexibility of tradeoffs between certain parts of the envelope.

The disadvantage is that it does not account for interactions between envelope, internal gains. and equipment efficiency.

The OTTV was originally proposed for the United States (ASHRAE 90-75) and provides the basis for BEECs in Hong Kong, China; Singapore; Malaysia; and Thailand.

Source: ABC (2007).

In **Turkey,**[7] new buildings and modifications in existing buildings are required to be insulated according to the TS 825 Building Energy Efficiency standard, which was first introduced in 2000. It provides a method for calculating annual heat energy demand, sets U-factors for the components of the building envelope for each of the four climatic regions, and limits maximum annual energy consumption per square meter in new buildings. UNDP/GEF is providing support to the Turkish government to upgrade the BEEC according to EU requirements.[8] Technical assistance includes expansion of the standard to include all aspects of heat gain and loss within buildings, classification of buildings according to consumption levels, formation of units to prepare, execute, and evaluate energy performance regulations, develop computer software, and to supervise and improve databases and establishment of laboratories.

In the past, Turkey has experienced problems with the enforcement of the general building code. Estimates of the State Institute of Statistics indicate that at least 13 percent of buildings are constructed without construction permits. To address the problem, the government issued a regulation in August 2004, delegating the control of construction in 19 pilot provinces to authorized *Construction Controlling Companies.* About 450 companies were authorized to participate in the scheme, and until about 2007 they were contracted to inspect the construction of 80 million square meters of usable floor area.

In Latin America, in addition to Mexico (see the case study in Appendix 4), **Chile**[9] seems to be the most proactive country with regard to building energy efficiency. One of the drivers for developing a BEEC has been that the use of dirty fuels for heating has had negative impacts on occupants' health. In 2000, a thermal regulation for roofs was enacted, establishing maximum heat transmission values for each of the seven climatic zones. In 2007, it was extended to the rest of the building envelope (walls, windows, doors). The regulation is part of the General Ordinance of Urban Planning and Construction and is mandatory for all new residential buildings and retrofits. It was developed by the nongovernmental Construction Institute in a collaborative process with industry, consumer, and expert participation.

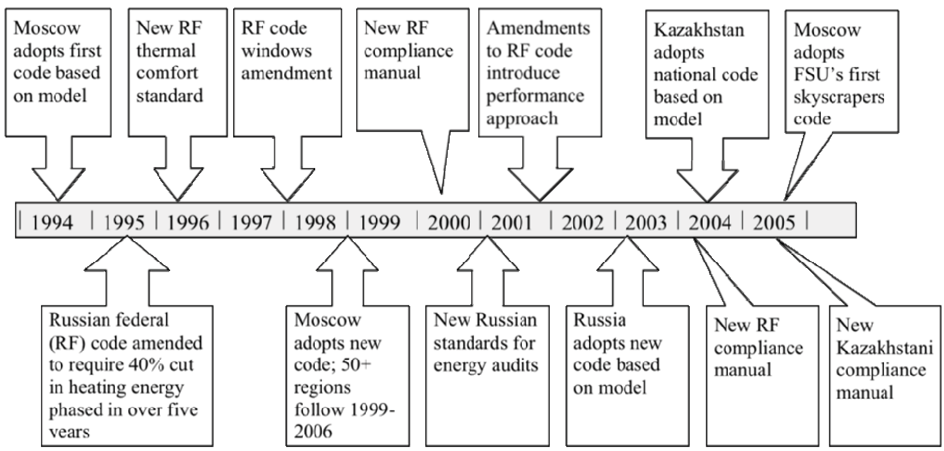
The standard is considered to be relatively lenient in comparison to international state-of-art.[10] Insulation is not even necessary, since brick masonry construction can satisfy the requirements. Nevertheless, many apartment buildings in Santiago are built with at least 10 or 20 mm of thermal insulation.[11]

Work has started on the development of a performance standard as an alternative to the prescriptive standard. It will take into account all factors that influence indoor climate and energy balance of a building. The necessary software has been developed and tested. The Ministry of Energy, within its "Programa País de Eficiencia Energética" (PPEE, Program Energy Efficient Country) and in collaboration with the Ministry of Housing and Urbanism, is supporting the development of a BEE certification system for new buildings. Other initiatives under the PPEE include pilot projects subsidizing the construction of new social housing units that go beyond the BEEC and the energy-efficient retrofit of existing housing, for which guides have been developed.

Eastern Europe has had BEECs already—before the 1990s. They were substantially weaker than BEECs in Western Europe, and the lack of newer technologies, especially for centralized heating systems, in combination with low energy prices, resulted in huge energy waste. After the breakup of the Soviet Union, many countries adopted more stringent BEECs.

In the ***Russian Federation*** a new model code was developed in collaboration between the Center for Energy Efficiency (CENEf), the Research Institute for Building Physics (known by its Russian initials as NIISF), the Institute for Market Transformation (IMT), and the Natural Resources Defense Council (NRDC), under the support of the U.S. Environmental Protection Agency (EPA). Since 1994, new BEECs were adopted across the Russian Federation and the Republic of Kazakhstan, predominantly based on this model code. Figure 3.3 shows the further development of BEECs in Russia and Kazakhstan.

Figure 3.3. Timeline of BEECs in Russia and Kazakhstan



Source: Matrosov/Chao/Majersik (2006).

A new performance-based federal BEEC became mandatory for all new and existing buildings across the whole Russian Federation in 2003. Technical standards, compliance manuals, and software and design guides were developed to support compliance. Buildings complying with this BEEC would achieve 40 percent reduction in energy consumption for heating, compared to buildings built under previous codes.[12]

The BEEC also requires the completion of an *Energy Passport* for each building, a document intended to verify energy performance in design, construction, and operation. It was first introduced in Moscow and also serves to provide information on the energy efficiency and energy costs of a building to residents and potential buyers, similar to the energy certificates and labels in the European Union (see chapter 4). Energy efficiency ratings were developed for both new and existing buildings. Regional and municipal agencies can provide incentives for buildings with energy performance beyond code.

The new Energy Efficiency Law of November 2009 requires the following:

- All buildings must comply with federal energy efficiency regulations.
- All buildings must have an energy certificate/passport.
- Buildings must be upgraded to follow modern energy efficiency requirements when undergoing major renovation.
- New apartment blocks and renovated buildings should be equipped with water, heat, gas, and electric meters.
- If a building is found not to comply with the regulations, the building developer or owner must undertake remediation measures.
- Federal Building Energy Efficiency regulations are to be revised every five years.

There are some indications that compliance is becoming mainstream in most parts of the country now. Until a couple of years ago, buildings were reviewed systematically only at the design stage, and during construction, only spot checks were conducted. Federal government officials claim that inspections now also take place during construction through Rostekhnadzor, the federal enforcement agency, responsible also for building supervision. Experts doing energy audits and analysis of building construction confirm that compliance with BEECs is reasonable. Also, the building materials industry in Russia has changed and is supplying energy-efficient windows, insulation, and so on, throughout Russia.[13]

Track Record of BEEC Compliance and Enforcement

There can be a big gap between the development of a BEEC and its actual implementation and enforcement, even in many developed countries. This conclusion holds even more for the situation in developing countries.

Quantitative comparisons cannot be made, since no country has completed statistically representative nationwide surveys of the extent to which BEECs are actually complied with. China is carrying out annual inspections in many of the country's largest cities; see figure A1.5, in Appendix 1. In the United States, efforts are currently underway to survey the compliance with BEECs in every state, based on a common methodology, as part of the requirements under the American Recovery and Reinvestment Act (ARRA; see Chapter 4).

Partial data and anecdotes suggest that compliance and enforcement are less than perfect in most countries that enforce their BEECs, as shown by the examples in table 3.2. The experiences with compliance and enforcement in Europe and the United States are covered in more detail in Chapter 4.

Despite the less-than-perfect compliance record, progress can be observed in terms of actual energy performance of buildings. New residential buildings today in certain countries consume much less energy than older buildings from before the 1970s energy crisis (see figure 1.6 with data from Denmark). However, the trend for commercial buildings is showing substantially less improvement; see the evidence from surveys in the United States in Chapter 4.

Table 3.2. Experience with BEEC Compliance around the World

Country	BEEC Compliance
Japan	Less than one third of the new residential buildings and less than three quarters of the new commercial buildings in 2004 conformed to the 1999 Energy Conservation Standard (Matsuo 2006)
Netherlands	Between 2003 and 2005 only 12 to 16% of municipalities carried out control of building permit applications (generally—not just for energy issues) and only 7 to 11% carried out control of construction work adequately. Nevertheless, the Dutch experience of compliance with BEECs is quite positive (see box 4.2).
Denmark	A study from 2000 showed that in 43% of surveyed buildings insulation of pipes and water tanks had been forgotten. Today every building is checked by an independent consultant and the use is denied if insulation is missing. Energy performance certification is—in principle—mandatory for dwellings, but in practice only about 50% of houses and 25% of flats had certificates five years after begin of implementation (see Laustsen 2006)
Sweden	After local authorities stopped control of construction and approval of drawings and calculations in 1993, compliance with calculated values was not very good, with between 50% and 100% higher energy consumption than calculated. Since 2009 compliance is checked locally through the building certificate procedure, required by the EU EPBD (Hjorth 2008).
Germany	40% of single-family homes that received subsidies for energy efficiency measures did not fulfill the requirements of the German BEEC (http://www.baulinks.de/webplugin/2008/1frame.htm?0982.php4).
England/Wales	Compliance levels with general building regulations are thought to be quite high, but compliance with Part L (energy requirements) is thought to be one of the weaker areas. A study of new houses passed by building inspectors found that 43% of them did not meet satisfactory energy standards (BRE 2004). Building control officers are unlikely to take steps to ensure enforcement or withhold the completion certificate; see, for example, Future Energy Solutions (2006).
United States	Compliance rates in U.S. states range from close to zero to almost 100% (table 4.7). For lighting code requirements in commercial buildings, a survey suggests an average 80% compliance rate (DiLouie 2007). Washington state: Overall compliance is close to code (~95%), but actual energy consumption is higher than modeled (Hogan 2008). In New York, audits in 2006 found that 57% of self-certified new building plans failed to comply with the building code, including with BEEC requirements (Hogan 2008).
Canada	Anecdotally, the efficacy of BEEC in the city of Vancouver is over 80%, based on the limited number of blatant violations and execution of details on the job sites (Liu 2006).
China	A reported 80% of construction compliance in 30 of the largest cities across all climate zones, but believed to be much lower in medium and small cities (Chapter 4).

Source: Compiled by authors.

Due to the compliance gap, energy savings and emission reductions are much smaller than they could be if BEECs were universally complied with. The extent of the lost opportunities is not even known, since there is very little measuring of actual energy performance of buildings after construction is completed. Some experts also point out that BEECs are not as stringent as they should be according to cost-effectiveness or cost-optimality criteria.[14] Accordingly, the gap between potential savings and actual savings becomes even greater.

Notes

[1] The plan has to show how much of the standard has been incorporated in the building design, and a point total estimated based on the energy-saving plan. All buildings must submit an energy-savings plan with a point total of at least 60 in order to comply. For more details on South Korea's BEEC development and issues see PNNL (2009 Korea).
[2]ABC (2007).
[3] Based on personal communication with Dr. Seung-eon Lee, Korea Institute of Construction Technology, February 27, 2009.
[4] Based on ABC (2007).
[5] Designated buildings consume more than 20 million MJ electrical energy or have a capacity of more than 1000 kW. This translates to air-conditioned floor area greater than 10,000m^2.
[6] usaid.eco-asia.org/programs/cdcp/reports/Ideas-to-Action/annexes/Annex%205_Thailand.pdf.
[7] Based on UNDP (2008). Compare also Keskin (2008).
[8] "Turkey adopted the Energy Performance in Buildings (BEP) regulation last year … Experts predict the new regulation could create more than $30 billion in investment for energy efficiency solutions in homes. Turkey consumes 36 percent of all its energy through household utilities. Experts predict that with good housing insulation, the nation can save close to $10 billion annually. Turkey has 18.4 million homes according to 2008 statistics, and 10 million of these homes are located in big cities." http://www.todayszaman.com/tz-web/news-209782-danish-energy-minister-targets-multibillion-dollar-markets-in-turkey.html.
[9] Based on information at http://www.ppee.cl/576/channel.html and Campos (2010).
[10] The maximum admissible U-factor for walls in Santiago is 1.9 W/m^{2}K. Santiago has degree days similar to Portugal where the mid-1990 BEEC specified a U-factor of 1.2. All other EU countries had significantly lower values; see Eichhammer/Schlottmann (without year).
[11] Encinas Pino et al. (2009). The authors carried out thermal simulations showing "that the Thermal Regulation has a positive impact in the thermal behavior of … [buildings} during the heating season. However, at the same time, there is an important risk of overheating in summer." This indicates the need to incorporate better ventilation techniques into building designs, as well as other passive cooling techniques, such as solar protection and thermal inertia, that would avoid the need for air conditioning.
[12] Matrosov/Chao/Majersik (2006).
[13] Personal communication with Meredydd Evans (PNNL), May 2010. See also Matrosov/Chao/Majersik (2007).
[14] Bowie/Hamans (2008).

CHAPTER 4

European and U.S. Experiences in Development and Implementation of BEECs

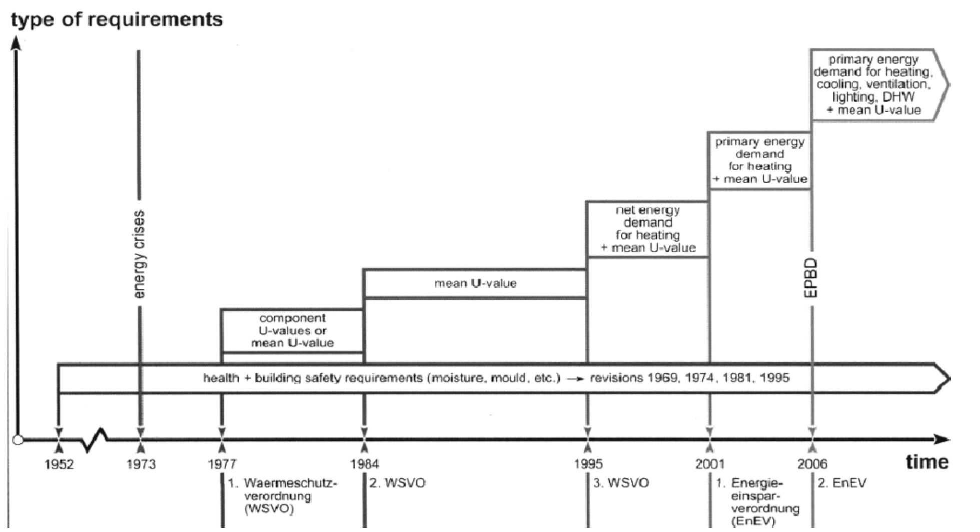
European Union: Early Efforts and Enforcement Approaches in Selected Countries

BEEC Development in EU Countries

Most EU-15[1] countries introduced BEECs in the 1970s and have since updated and tightened them many times. The staged introduction of BEECs for new buildings had a strong influence on energy consumption. New residential buildings in the European Union today are estimated to consume about 60 percent less energy on average than those buildings constructed before the mid-1970s. However, actual savings are usually below those predicted by models due to the combined effect of behavioral factors (such as higher heating temperatures, more rooms heated, or longer heating period over the year) and a certain degree of noncompliance with BEECs. For example, a survey in Germany reported that, while the thermal standards indicate that new dwellings would consume 70 percent less energy than the dwellings built before the first building regulations, the actual savings were only about 35 percent.[2]

Most countries started with simple prescriptive standards for building envelope components and later added performance compliance paths, requiring certain minimum values for net and primary energy demand for heating, respectively. Requirements for other end uses (space cooling, ventilation, lighting, and service water heating) were also added. Not only were BEEC requirements tightened; they also changed in quality (or rather increased complexity). Figure 4.1 illustrates this for the case of Germany. Here, an integrated methodology for building energy performance requirements replaced one that focused on energy demand for heating as a result of having to comply with the EU Energy Performance in Buildings Directive (discussed below). It also triggered the development of software tools to facilitate compliance.[3]

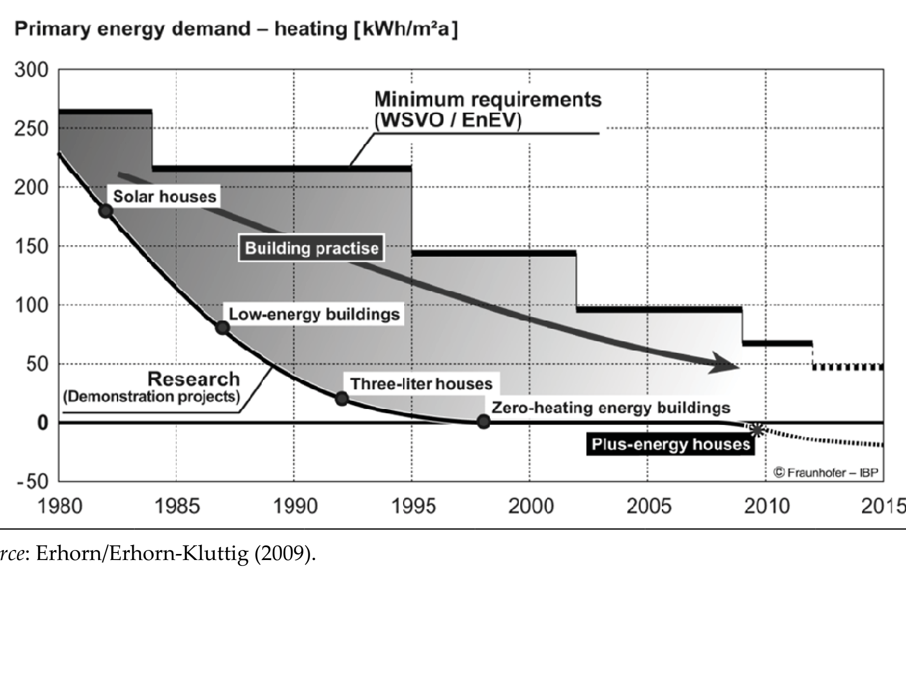
Figure 4.1. Raising the Quality of BEEC Requirements in Germany



Source: Erhorn 2006.

Research and development of improved technologies and introduction of voluntary labels and standards such as low- or zero-energy buildings can push both actual building practice and the tightening of standards. Figure 4.2 shows the resulting decline in heat energy requirements and actual annual specific fuel consumption in Germany.

Figure 4.2. Evolution of Building Energy Efficiency Regulation in Germany



Source: Erhorn/Erhorn-Kluttig (2009).

Enforcement of BEECs in Selected Countries

The ways in which BEECs are enforced in Europe vary significantly and depend largely on the procedures applicable for the building sector in general. All countries require building permits before construction can begin. There is, however, a tendency to extend the category of permit-free construction works (for example, for minor alterations). Most countries have exemptions from the full procedure ("light" procedure) where local building control authorities must be notified but no inspection or permit is required. Most countries also require some kind of inspection during construction, even though often only for a sample, and either approval for use or a completion certificate (table 4.1).

Table 4.1. Main Features of Building Permit Procedures in Selected European Countries

Stage→ Country	Approval, Technical Requirement of Design	Start Building Construction	Inspection during Construction	Completion
Denmark	Yes	After permit is granted	Sample checks	Approval for use
England/Wales	Yes	After permit is granted	Yes	Completion certificate
France*	voluntary	After permit is granted	Yes	Completion certificate
Germany	Yes	After permit is granted	Yes	Approval for use
Netherlands	Yes	After permit is granted	Yes, with regular inspection points	No
Sweden	Inspection plans	3 weeks after notice	Supervision of inspection plan	Completion certificate

Source: Based on Visscher/Meijer 2007.
Note: *See also http://france.angloinfo.com/countries/france/planningforms.asp.

The enforcement of BEECs follows largely the models established by building control in general; see table 2.1. Responsibilities for building quality control and inspection are changing. Almost all European countries initially had "traditional" control systems, in which local authorities exercised control over the building process. More recently, the role of private organizations in the permit procedure has expanded. The extent of the involvement of the private sector in building control varies from being mere contractors to local authorities to assuming full responsibility and even being able to issue permits (table 4.2). In England and Wales, private organizations can even issue building permits. The trend toward more responsibility of the private sector is supported by the development of methods for quality assurance through certification and accreditation. The control process often allows the use of different models. A similar development can be observed also for the enforcement of BEECs.

Table 4.2. Public- and Private-Sector Roles in Building Control in Selected European Countries

Public Responsibility for Control	Private Responsibility for Control (Contracting Model)
Local authority: *Netherlands, Denmark, England/Wales*	Local authority contracts out, private organization is responsible: *Germany* (Pruefingenieur=certified engineer to review and inspect construction plans and sites, generally only for structural requirements in case of special buildings)
Local authority contracts out but remains responsible: *Netherlands, Denmark*	Legal liability for private control based on building regulations: *France* (Inspection during construction by private inspection bodies (bureaux de controle—supervising engineers) hired by the builder; spot checks by public-sector inspectors (CETE=Centre Technique de l'Equipement))
	Private inspection because of liability and insurance requirements: *Belgium, France*
	Full private responsibility: *Norway, Sweden, Germany* (designer/architect has to certify compliance to building owner and is fully liable)

Source: Based on Visscher/Meijer (2007), van der Heijden (2009), and private communication with Marc Bellanger, October 2008.

Enforcement of BEECs generally takes place at the local level, except for Austria and Switzerland, where centralized or centralized/mixed models can be observed (table 4.3). In Denmark and Germany, enforcement is left to the private sector, but with very different arrangements. In Denmark an energy audit has to be carried out by a certified private sector auditor and an energy performance certificate (EPC) issued in order to obtain an occupancy permit (see box 4.1). In Germany, BEEC enforcement is based on self-certification of the builder/architect to the owner. In some states, municipalities will carry out spot checks. The Energy Saving Law specifies penalties in case its requirements are not met.[4] Austria and Switzerland use public control (with a private-sector option in the case of housing with publicly subsidized financing in Austria), and the Netherlands have a mixed model (box 4.2). Given the large number and relatively small size of municipalities, local public enforcement can be a challenge, if not accompanied by supporting measures such as advice or active involvement in enforcement by higher-level public administrations.

Table 4.3. Enforcement Models for BEEC Control in Selected European Countries

	Enforcement Model(s)	Enforcement Philosophy	Enforcement Actors (Number of Municipalities)	Average Size of Municipalities (Population)
Austria	2 (local, centralized for WBF*)	BEEC: local public construction department WBF: both public and private	2,359	3,414
Denmark	1, enforced locally	Private control, based on EPCs	275	19,300
Germany	1, enforced locally	Private control—self-certification to buyer)	14,368	5,744
Netherlands	1, enforced locally	Public and private control	506	31,300
Switzerland	3 (central, decentral, mixed)	Information of builders/ developers, public control of planning and compliance	2,880	2,544

Source: based on Rieder et al. 2005.
Note: * WBF=Wohnbauförderung (public concessionary financing scheme for residential buildings).

Box 4.1. Control of BEEC Compliance in Denmark

In practice, control of new buildings is performed by energy consultants who also issue the energy performance certificates. Before the official permit to use a new building is given, an energy audit has to be performed by the certified or approved energy consultant, who checks that the energy calculation is correct, and performs quality and compliance checks.

Proof of compliance with the energy requirements for new buildings must be given after the completion of the building in order to get the permit to use the building.

If a building does not comply with the energy performance requirements, remedial measures must be undertaken.

Source: Engelund Thomsen (2009).

Box 4.2. BEECs and Their Enforcement in Netherlands

National BEECs have existed in the Netherlands since 1978. A substantive change took place in 1995 when prescriptive standards were replaced with energy performance standards for new buildings and major renovations of existing buildings (EPN), allowing flexibility in the choice of energy saving options for building fabric, space heating, sanitary water, ventilation and use of solar energy. The performance standards have the goal of generating energy savings of 15 to 20 percent, compared with the previous prescriptive standards. To abide by the standard, a maximum energy performance coefficient (EPC) has to be complied with, with separate EPCs for residential (set at 1.4) and different types of commercial buildings (ranging from 3.6 to 1.5). The 1995 standard was closely related to the building practice at the time and was relatively easy to comply with. Since 1995, the standards have been tightened several times, going down to an EPC of 0.8 for residential buildings in 2006.

The Dutch energy agency SenterNovem provides a range of supporting instruments, such as guidebooks, workshops, and demonstration projects. Standard packages of energy saving measures that fulfill requirements of the tightened standards are developed and are used by many architects and installers. Together with the national government SenterNovem had an estimated budget of euro 10-30 million for the implementation of the EPN.

Preparation of the market for introduction/tightening of standards: Inform and educate the market (guide books and workshops), provide financial support for buildings that go beyond the standard, and show that building according to the standard is feasible and has only minor cost implications. Investigations in 1997 show that the market participants were indeed well informed about the introduction of the EPN.

Compliance: Under the current national building regulations, proof of compliance must be provided at every step of the building process (design, calculations, realization). Control of this legal provision is the responsibility of the local authority where the building is located. De facto building permit requirements were in general not checked and verified until about 2000–2001. After that time, municipalities received more support in checking requirements, such as help with the correct use of software, and most municipalities checked EPC calculations. Experience with enforcement during the construction phase was unsatisfactory also. Even though it improved during the past few years, it is still not adequate.

Impact: Targeted energy savings of 15 to 20 percent were more or less achieved by 2004 (if ignoring the fact that there is usually a 2- to 3-year delay between introducing/tightening the BEEC and constructing buildings according to the standard).

Side effects: The EPN contributed to growing market shares for condensing boilers and high-performance glazing such that they have become standard techniques.

Rotterdam: 70 staff are in charge of about 500 applications of building construction permits per year, six of which handle energy and sanitation. They check applications and give recommendations on whether to issue a permit. If an application is deemed insufficient, the applicant has eight weeks to improve it. Only about 20 percent of applications are correct, 10 percent are completely wrong, the rest have some errors. Almost all applications are corrected within the allotted time frame. Controls of building energy efficiency aspects on site or after completion of a building are rare; they occur in only 1 to 2 percent of all building permits.

Sources: Joosen (2007) and Rieder et al. (2005).

Three types of instruments are regularly used to improve compliance with BEECs: controls, incentives, and information. Actual controls of BEE aspects are carried out only "sometimes" or "rarely" in the countries studied by Rieder et al. (table 4.4). This is true for checking calculations in the documentation required in construction permit applications and for controlling actual application of building energy efficiency measures on construction sites or the results post-construction. Exceptions to this rule are buildings receiving various kinds of subsidies, either for low-income families and/or for achieving better energy performance than required by BEECs. In most countries, those buildings undergo stricter controls, both at the construction permit stage and on site. Of the countries studied by Rieder et al. (2005), Austria and Germany seem to provide the least amount of support to actors involved in construction and to local authorities in charge of enforcement. Denmark, the Netherlands, and Switzerland are more active in this respect.

Table 4.4. Instruments for BEEC Enforcement

	Information/ Advice	Financial Incentives/ Penalties	Controls (Calculatory Checks) at Construction Permit Stage	Controls on-site	Support to Local Authorities
Austria	+ +++ (WBF)	Incentives (WBF)	Rarely	+ ++ (WBF)	+
Denmark	++	Subsidized audits in 1981–1995, fines related to scale of energy wastage	Some (in large cities)	None (up to municipalities), except for subsidized buildings; since 2007 permit of use granted only after energy performance certificate states compliance; remediation if violation	Advice and training for staff in municipalities
Germany	+ to ++	KfW subsidy program; fines between €5,000 and €50,000	Rarely	None	+ to ++
Netherlands	++	No	Some (large cities)	+ or none; remediation if violation	Advice to small municipalities (checklists)
Switzerland	+++	No	Some	+ to ++	++ to +++

Source: Based on Rieder et al. 2005.
Note: +++: a lot ++: some +: little.
KfW: Kreditanstalt fuer Wiederaufbau.

In many countries there is little follow-up and evaluation of the overall effectiveness of BEECs, which is influenced by the extent of compliance. Limited surveys of compliance with BEECs suggest that compliance is far from perfect (table 4.5). The reasons for the observed lack of compliance, especially in smaller municipalities, are very similar in most countries:

- insufficient resources, knowledge and motivation at the level of local enforcement officials and therefore few controls of BEEC aspects

- inadequate training of construction personnel, especially in dealing with more complicated aspects of energy efficient construction such as thermal bridges
- lack of information at all levels of the building supply chain.

Table 4.5. Extent of Compliance with BEECs and Underlying Problems

	Quality of Compliance	Problems of Compliance/Enforcement
Austria	For WBF much better, especially for multiunit residential buildings, than for BEEC in general; compliance lags behind standard (about 20% for WBF buildings); BEEC requirements are fairly low and can easily be achieved with existing construction materials.	Insufficient resources in local authorities; pressure on local authorities not to act when compliance is lacking; lack of knowledge; BEECs are not considered very relevant.
Denmark	In design documents energy performance indicators are rarely correctly calculated; actual construction is somewhat worse than necessary to comply with BEEC. Requirement to get an energy certificate is 40–60% complied with, but its effectiveness is low.	Insufficient resources in local authorities; experts lack technical know-how; competition between local authorities for construction; certificates lack information and aren't well known and lack acceptance.
Germany	Calculation of energy performance indicators in design documents is usually correct; actual compliance lags behind BEEC (estimated deviation of 20% between documentation and actual implementation); faulty technical construction.	Insufficient resources in local authorities; private control doesn't work; BEEC and related norms are too complicated; weak knowledge.
Netherlands	Up to 50% of energy performance indicators in permit applications with incorrect calculations; good compliance post construction with 8–25% noncompliance rate for residential buildings and about 40% for commercial buildings (but relatively small deviations).	Insufficient resources and know-how, especially small municipalities; low priority of energy issues in building permit process.
Switzerland	In building permit applications 50% of energy performance indicators are incorrectly calculated; about 5% of buildings don't comply with standard.	Insufficient resources, partial lack of competencies in local authorities, varying commitment of enforcement agencies.

Source: Based on Rieder et al. 2005.

Summary of Enforcement Experience in Europe

It is not surprising that enforcement approaches vary in European countries, reflecting different traditions and roles of the public sector. Almost all European countries once had a traditional control system based on local authority building control. The importance of private organizations in checking and controlling building regulations, both at the planning and construction level, is increasing across the board.[5] This change is driven by increasing complexity of buildings and regulations, particularly for building energy efficiency aspects. The cost of maintaining sufficient and properly educated staff at the municipal level is prohibitive in most cases and has been hard to justify until recently for building energy efficiency-related purposes.

It seems easier to rely on accredited private-sector experts working for builders to ensure that designs and actual construction comply with regulations. The public sector has several ways of ensuring that this system leads to the desired outcomes. One is spot checks with subsequent broad dissemination of the results; the other is sanctioning in case of fraudulent approval by revoking accreditation or by imposing significant penalties for designers, builders, and others.

Many practitioners in municipalities with private-sector controls emphasize the value of informal discussions with and education of all participants in the building chain—developers, architects, designers, construction companies, and building owners. Together with some spot checks by municipal authorities this is deemed a rather successful compliance route.

Self-certification has been tried in several countries and has been shown to fail particularly in areas of regulation not seen by industry as direct safety areas such as access and carbon emissions.[6] Self-certification relies on honest builders and informed buyers. Third-party enforcement or letters of assurance have the advantage of providing legal recourse to the building owner in case the builder makes errors or doesn't comply with regulations.

Toward Regional Harmonization: the EU Energy Performance in Buildings Directive

Since the late 1990s, EU policies and regulations have been driving the development of BEECs in EU member countries. The European Union committed in 2007 to the 20-20-20 target to be achieved by 2020: Reduction of GHG emissions by 20 percent below 1990 levels, a 20 percent share of renewables in the energy mix, and reduction of primary energy use by 20 percent compared with projected levels through improved energy efficiency.[7]

Buildings in EU member states are responsible for 40 percent of energy consumption and 36 percent of CO_2 emissions. The building sector offers a large potential of cost-effective energy efficiency measures. By cutting the energy use in buildings by about 30 percent, Europe's energy consumption would fall by 11 percent, more than half of the 20-20-20 target.[8] Realizing this potential would have environmental and competitiveness benefits for the EU and also substantially improve the security of energy supply.

The 2002 Energy Performance of Buildings Directive (EPBD, 2002/91/EC) is the major regulatory measure targeting energy efficiency improvements in the building sector and imposing a harmonization of methodologies for BEECs and related measures within the European Union. The EPBD requires that all member states should adopt by January 2006:

- methodologies for integrated building energy performance standards (Article 3)
- minimum energy performance requirements on the basis of those methodologies for all new buildings and those >1000 m^2 with major refurbishment (Articles 4–6)
- certification schemes for all buildings (Article 7)
- inspection and assessment of boilers and air conditioning installations (Articles 8, 9).

Details are provided in table 4.6.

Table 4.6. EPBD Requirements to Be Implemented in Each EU Member State

A common methodology for integrated minimum standards to • Integrate insulation, heating, cooling, ventilation, lighting, renewable energy installations, passive systems, CHP, District Heating/Cooling, orientation of the building • Give flexibility to designers to meet energy reduction standards in the most cost-effective way • Be expressed in simple energy indicators • Be adopted by member states for different categories of buildings taking into account climatic differences and CEN standards • To be reviewed regularly (<5 years) to reflect technical progress
The certification schemes: • Member states to ensure that an energy performance certificate is made available to building occupiers when a building is constructed, sold or rented out • Certificates to be valid for no more than 10 years • Certificates to be accompanied by information on how to improve the energy performance of the building in a cost-effective way • Certificates to be displayed in public buildings of over 1000 m2 • Possible extension or phasing-in of certification schemes for a maximum of three years if there is a lack of qualified and/or accredited experts
Inspection of boilers, heating systems, and AC installations: • Member states to introduce requirements for regular inspections of boilers (option A) • Member states to ensure provision of advice to users that gives the same results as regular inspections (Option B; to be proven by member states) • Member states to establish regular inspections of air conditioning systems with output of more than 12 kW • Possible extension or phasing in of inspection schemes for a maximum of three years if there is a lack of qualified and/or accredited experts

Source: Summary of http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF.

By 2008, 22 member states declared that they were fully compliant with all EPBD requirements.

Some member states delayed full implementation until 2009, citing the lack of accredited experts to produce energy certificates or carry out the inspection of boilers and air conditioning systems. In addition to the lack of technical skills and expertise, other issues that slowed down the implementation of the EPBD were low public acceptance and awareness, and perceived high costs.[9] There is also "a lack of proper national administration, and it has taken more time than anticipated to revise national building regulations, set up the certification schemes and train experts…. Governments want to keep costs down, supporting systems were not in place, experts need guidance and there are not enough incentives to spur stakeholders to act. Last but not least, there is no monitoring of the impact of the EPBD on actual energy savings."[10]

Revision of the EPBD

Experts and policy makers realized soon that the EU goal of reducing energy use in buildings by 30 percent by 2020 could not be reached with the 2002 EPBD. For achieving energy savings, existing buildings in the EU are far more important than new buildings. The original EPBD requirements extended only to existing buildings > 1000 m^2, which account for 29 percent of the EU building sector.[11] The technical potential to reduce CO_2 emissions in those larger buildings in EU-15 countries amounts to 82 million tons per year, whereas for all existing buildings the potential would be 398 million tons annually.[12] In addition, more aggressive targets for energy performance of new buildings were deemed necessary.

A revision of the EPBD ("recast") was proposed by the EU Commission in 2008, approved by the European Parliament with substantial changes and a compromise recast approved by the European Parliament in May 2010. With its publication in the Official Journal of the EU on June 19, 2010,[13] it has become effective. Member states should implement the recast directive within two years. An evaluation of the directive would take place in 2017.

The recast (see major features in box 4.3) requires that all new buildings constructed after 2020 consume "nearly" zero-energy, meaning that they achieve very high energy performance and cover any remaining energy use to a very significant extent with renewables. Most importantly, the scope of the original EPBD is extended by abolishing the previous limitation of the energy efficient renovation requirement to large buildings.

Box 4.3. Major Features of the EPBD Recast

- Requirement for "nearly" zero energy new buildings in 2020 (2018 for public buildings)
- Requirement to upgrade energy performance when buildings undergo *major renovations*
- Removal of the previous threshold that limited renovation requirements to buildings larger than 1000 m^2
- Energy performance standards have to be set at "cost-optimal"[a] levels by each member state
- Mandatory requirements that refurbishment *must* result in the installation of components meeting national minimum performance requirements, with a view to achieving cost-optimal standards
- Energy Performance Certificates must be presented to prospective tenants and buyers, reflected in commercial advertising and permanently displayed in all buildings, commercial as well as public, over 500 m^2 visited by the public (250 m^2 for public buildings in 2015)
- Stricter enforcement and compliance oversight
  - Inspections to cover entire systems, not just components of a system
  - Mandatory requirement to inform building tenants of the refurbishment improvements options
  - Independent control mechanisms to be established for certification and inspection, including a random selection of statistically significant percentage of EPCs and inspection reports to be checked
- Financial incentives are acknowledged as being crucial for the implementation of the directive, especially for the energy-efficient retrofit of existing buildings. Member states will have to present proposals.[b]

Source: Borg (2010), Hitchin (2010), and Elsberger (2010).
Notes: a. "Cost-optimal level" means the level where the cost-benefit analysis calculated over the life-cycle of a building is positive, taking into account at least the net present value of investment and operating costs (including energy costs), maintenance, earnings from energy produced and disposal costs, where applicable; European Parliament's amended EPBD proposal (2009); cited in Hermelink, Andreas H. (2009) "How Deep to Go: Remarks on How to Find the Cost-Optimal Level for Building Renovation," report for ECEEE;
b. Various EU funds such as the European Regional Development Fund can be used for the energy efficient renovation of housings in EU member states; http://www.euractiv.com/en/climate-change/eu-regions-get-105-green-projects/article-180104. See for example the Estonian revolving fund scheme; http://urbenergy.net/105.0.html?&L=5.

United States: State-Level Adoption of BEECs

BEECs in the United States

The United States does not have a national BEEC. Two national model codes exist, the International Code Council's (ICC) International Energy Conservation Code (IECC) and the American Society of Heating, Refrigerating, and Air-conditioning Engineers

(ASHRAE) and Illuminating Engineering Society of North America's (IESNA) Standard 90.1 (box 4.4). They have been adopted by many states and local authorities.[14]

Box 4.4. U.S. National Building Energy Model Codes

Code development and revision is carried out by certified private-sector agencies, the International Code Council (ICC), which develops several building codes) and ASHRAE and IESNA, respectively. The IECC is applicable to all residential and commercial buildings and provides the minimum energy efficiency provisions for residential and commercial buildings. The code contains building envelope requirements for thermal performance and air leakage while making allowances for different climate zones. Because it is written in mandatory, enforceable language, state and local jurisdictions can easily adopt the model as their energy code. The first IECC was released in 1998. The most current version is IECC 2009.[a] The IECC is used in over 40 states. It is referenced in federal regulations, LEED, and many other state and federal programs. It is the relevant model energy code for federal tax credits, energy efficiency standards for federal residential buildings and manufactured housing, state energy code determinations, and qualification for Federal Housing Administration (FHA) and other government-backed mortgages.

ASHRAE/IESNA Standard 90.1 applies to all buildings except residential buildings with three or fewer stories (that is, commercial buildings including high-rise multifamily residential buildings) and provides minimum requirements for the design of energy efficient buildings. The first edition of ASHRAE Standard 90 was published in 1975; the most current version is ASHRAE/IESNA Standard 90.1-2007.[b] Many countries worldwide have based their commercial BEECs on a version of ASHRAE/IESNA Standard 90.1.

Both codes take into account eight climate zones and have two **compliance paths**, prescriptive/component performance for the individual building systems and performance-based for the total building including all of its systems. For ASHRAE/IESNA 90.1, the building has to comply with the mandatory provisions for the individual systems and either the prescriptive/component performance method or the Energy Cost Budget Method. IECC requires compliance with either the prescriptive/component performance method or the Total Building Performance Method, which serves the same purpose as the Energy Cost Budget Method.

For **commercial buildings**, both codes cover building envelope, HVAC, service water heating systems, electric equipment and systems, lighting, and other (motors). Buildings using the performance-based compliance option for the building including all of its systems are in compliance if their design meets all mandatory requirements and their estimated annual energy use is less than that of a building with standard design that employs the prescriptive/component performance requirements.

For **low-rise residential buildings**, IECC requirements exist for the building envelope, space heating, space cooling, service water heating, and lighting systems:

- Focus is on building envelope (ceilings, walls, windows, floors, foundations)
  - Sets insulation levels, window U-factors (no limit on glazing area, strict limits on U-factor in northern United States, which cannot be traded off) and solar heat gain coefficients
  - Infiltration control—caulk and seal to prevent air leaks
- Ducts—seal and insulate
- Limited space heating, air conditioning, and water heating requirements, since federal law sets most equipment efficiency requirements
- Lighting—a minimum of 50 percent of the lamps shall be high-efficacy (compact fluorescent)
- No plug load requirements

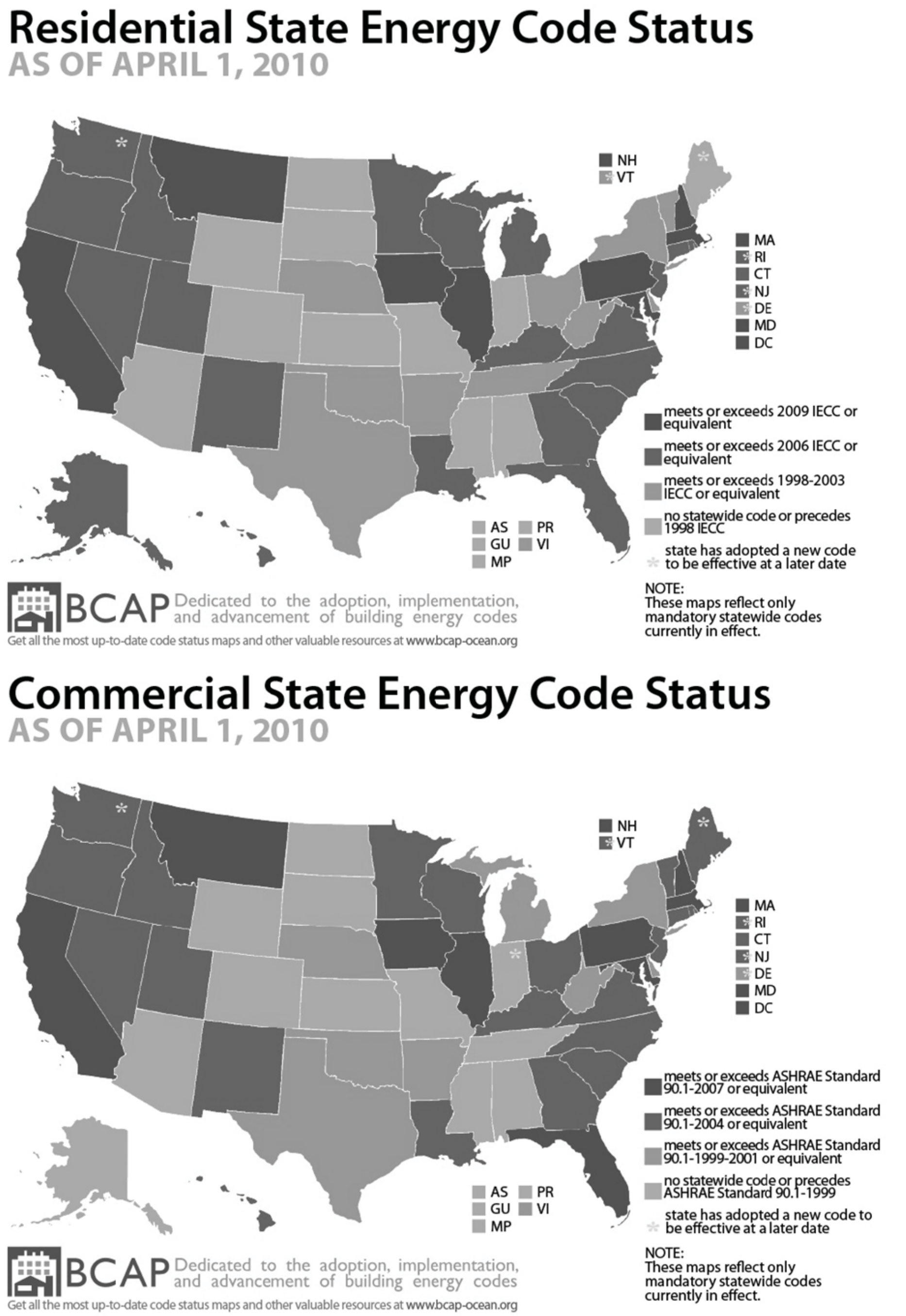
Source: BCAP: http://bcap-energy.org/node/4, and PNNL (2009 US).
a. For more information see www.iccsafe.org.
b. For more information see http://www.ashrae.org. ASHRAE also publishes a companion Standard 90.2 for residential buildings of three and fewer stories, but this document is not cited in the 1992 Energy Policy Act and so has not been adopted by states.

States receiving financial assistance from the federal government are required by the 1975 Energy Policy and Conservation Act to initiate mandatory programs and measures, including energy conservation standards for new buildings. According to the Energy Policy Act of 1992, when updated versions of the IECC and Standard 90.1 are published, the U.S. Department of Energy must determine within one year whether these codes and their revisions would improve energy efficiency for residential and commercial buildings, respectively. If the determination is positive, each state then has two years to certify that it has made revisions to its own energy code or that its existing energy code achieves equivalent energy savings to the updated version of the IECC or Standard 90.1. A state may decline to adopt a residential energy code by submitting a statement to the Department of Energy, detailing its reasons for doing so.

Most states and municipalities periodically update their building energy codes, many of them regularly and as part of an automatic procedure shortly after revision of the national model codes, which are usually updated every three years; see Figure 4-3 for the current status of residential and commercial BEECs. Some states and local authorities have adopted BEECs that are more advanced than the model codes or state codes, respectively, for example, Seattle (see box 4.7). Most of the model national construction codes (building, mechanical, electrical, plumbing, and so on) are also updated every three years. Revising BEECs on the same schedule as the other construction codes establishes them as one of the family of codes that all designers and contractors must comply with, rather than an outlier that doesn't fit into the regular system. This allows BEEC training for designers and contractors to occur on the same schedule as training for the other construction codes. It sets the expectation that the BEEC will be updated and refined in conjunction with all the other construction codes, so that designers and contractors, manufacturers and suppliers, and implementation agencies all know to expect some changes every three years.

In the near future, the BEEC landscape in the United States might become somewhat more homogenous. The January 2009 stimulus package ("American Recovery and Reinvestment Act", ARRA) is requiring states receiving additional federal energy grants to pledge implementation of residential and commercial BEECs that meet or exceed the most recently published IECC and/or ASHRAE/IESNA codes and a plan to achieve at least 90 percent compliance with the code requirements in new and renovated buildings by 2017, including active training and enforcement programs and measurement of the rate of compliance each year.[15] All states have made this pledge.

Figure 4.3. Status of State Residential and Commercial BEECs, April 2010



Source: http://bcap-ocean.org/code-status-maps.

Impact of BEECs

Since the mid-1970s, several generations of U.S. energy codes and standards have resulted in estimated energy efficiency improvements of about 60 percent.[16] This lowers overall energy consumption, generates energy bill savings, and reduces peak energy demand (box 4.5), as well as decreases local and regional air pollution and greenhouse gas emissions.

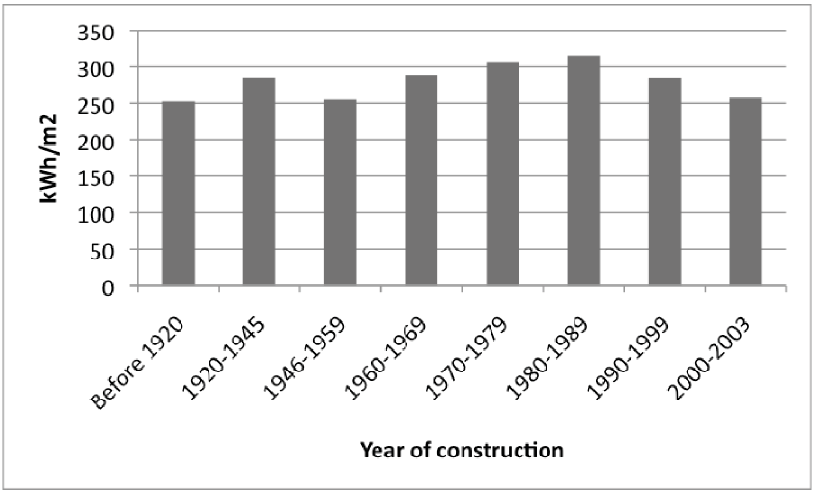
Box 4.5. Impact of Building Energy Efficiency Standards in California

California develops and regularly updates its own Building Energy Efficiency Standards, which are generally more stringent than the national model codes (see figure 4.3). The first of such standards were introduced in 1978 and most recently revised in 2002, 2005, and 2008. Each recent revision cuts energy use by 10 to15 percent compared to the previous iteration. Statewide compliance is estimated at 70 percent, with large variations for different measures (table 4.8). According to the California Energy Commission, the state's building energy efficiency standards (along with those for energy-efficient appliances) were the main reason why per capita electricity consumption has essentially stayed flat in California since the mid-1970s, while it continued to increase in other states. The standards saved more than $56 billion in electricity and natural gas costs between 1978 and 2006 and averted building 15 large power plants. It is estimated the standards will save an additional $23 billion by 2013 (CEC 2007). Those standards reduced peak power demand in 2003 by 5.75 GW, while reducing electric energy use by 11 TWh/yr. The electric energy needed to cool a new home in California has declined by two thirds (about 2,400 kWh/year to 800) from 1970 to 2005 (figure 1.5), despite the fact that today's new home is about 50 percent bigger and is in a warmer climate as new development occurs farther from the coast.

Source: See California case study, Appendix 5.

The Commercial Building Energy Consumption Survey (CBECS) done every three to four years by the U.S. Energy Information Administration (EIA) shows that the category containing the grouping for the oldest buildings in the United States (those constructed before 1920) actually has the lowest levels of energy consumption on a per square meter basis. These older buildings were designed when central mechanical heating or cooling was much less common. Consequently, more attention was often paid to building siting, window orientation, window shading, thermal mass, and so on. Thus, there are lessons to be learned for designers that would be applicable to new buildings. However, older buildings are likely to be less intensively used because they do not have the electrical systems to serve today's higher electrical loads and may not have air conditioning. Figure 4.4 also shows that energy use indices (EUIs) in U.S. commercial buildings were rising quickly through the 1960s and into the 1970s. The adoption of BEECs in the late 1970s and early 1980s by some states and local jurisdictions in the United States may have begun to slow the rate of increasing building EUIs. However, the building EUIs did not really begin to recede until the 1990s. This would appear to indicate that widespread effective implementation of BEECs did not really occur on a national level in the United States until 5 to 10 years after initial action by the early adopters.

Figure 4.4. Energy Use Indices for U.S. Commercial Buildings, since the Early 1900s (kWh per m^2)



Source: Authors, based on Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey, http://www.eia.doe.gov/emeu/cbecs/cbecs2003/overview1.html.

Compliance and Enforcement of BEECs in the United States

Evidence of Compliance with BEECs

Compliance with BEECs in the United States is quite varied. Available data[17] for residential buildings (table 4.7) suggest full compliance only in two northwestern states, while in most other states significant lack of compliance can be observed.

Table 4.7. Code Compliance Rates for Residential Buildings in U.S. States, 2005

State	Compliance Rate, %
OR (Oregon)	100
WA (Washington)	94
MT (Montana)	87
CA (California)	70
LA (Louisiana)	65
VT (Vermont)	58
AR (Arkansas)	55
IA (Indiana)	53
ID (Idaho)	52
MA (Massachusetts)	46
NY (New York	30*
ME (Maine)	16

Source: BCAP (2005).

Note: New York: current "effective" compliance rate, reflecting how much of the maximum potential energy savings are achieved; http://www.dps.state.ny.us/NYSERDA_Codes_and_Standards_Strategy_15_October_2008_FINAL.pdf.

Statewide compliance rates, however, only tell a limited story. Within states compliance with BEECs varies by locality and also by specialty. Compliance is highly dependent on the BEEC measure (table 4.8) and the local building department and design community. In smaller towns and rural areas, compliance tends to be lower. Hogan (2008) observes that compliance with mechanical requirements may be less in smaller jurisdictions, which tend not to have a mechanical inspector; compliance with building envelope requirements depends entirely on the commitment of the local government.

Table 4.8. California—Summary of Building Measure Noncompliance Estimates

Building Measure	Estimated Noncompliance rate
Residential	
Hardwired lighting	28%
Window replacement	68%
Duct improvement	73%
Nonresidential	
Lighting controls under skylights	44%
Cool roofs	50%
Bi-level lighting controls	n/a
Ducts in existing buildings	100%
Duct testing/sealing in new buildings	100%

Source: Quantec 2007.
Note: The study began shortly after the implementation of the updated 2005 building codes. Utility-sponsored training and education programs aimed at improving compliance rates had not been completed yet. It was expected that compliance with the 2005 standards would improve as training efforts continued.

BEEC Enforcement Approaches

BEEC enforcement typically includes the following steps:

- plan review
- product, equipment, and material review
- testing and certification review
- building inspection during construction
- construction substitution review
- building inspection prior to occupancy.

In the United States, four **enforcement approaches**[18] can be observed, presented in order of frequency (for residential buildings):

1. *Local enforcement*: Code enforcement is performed by municipal or county officials. This process relies on an established enforcement administration within the municipality, usually the building department, and typically calls for modest increases in staff. Within this model, local governments collect a fee to support code enforcement services. These fees and charges either are retained by the building department to cover all the costs or provide income to

the general treasury to offset a percentage of the costs for performing this function. The fees for code enforcement (for example, plan reviews, inspections, and permit issuance) vary by the construction value of the project but are intended to correlate with the amount of time and resources expended on typical projects each project. However, some jurisdictions reserve the right to charge additional fees if extra plan review or extra inspections are necessary, so the balance of any unusual costs could be charged to a particular user. Advantages of local enforcement agencies include their close proximity to the construction site and their one-on-one interactions with the design and construction community, providing opportunities for greater direct enforcement during design and construction; see Seattle example in box 4.7.

2. *State agency enforcement*: State inspectors enforce the state-adopted code. In this model, state inspectors supplement local code officials by conducting additional inspections. Traveling and coordination by state code officials to conduct inspections statewide involves greater costs that vary with the size of the state. Although this process may strengthen enforcement by shifting it to the state, it might also result in weak enforcement if an insufficient number of inspectors are responsible for monitoring activities in a large geographic area. This model is particularly common in smaller states, in rural jurisdictions with no code officials, and for state-owned or financed construction.
3. *Third-party enforcement*: An independent entity, trained in energy efficiency and approved by the local building department or the relevant state agency, performs code enforcement tasks. The builder hires the third-party individual or entity to perform plan review and/or inspection services. This process requires less infrastructure and cost on the part of the state and local government and passes the costs of enforcement directly onto the builder. Often affiliated with professional organizations, most third-party reviewers are experienced in solving and working with the complexities and subtleties of BEECs, have access to better sources, references, and contacts, and are more prepared to alleviate heavy workloads. This type of enforcement is therefore gaining interest in the market, but it is not yet widely used. Box 4.6 provides details on third-party BEEC enforcement in several U.S. states.
4. *Self-certification*: Requires the builder to provide certification of compliance to a local or state agency. This process requires minimal staffing or financing to support a code enforcement administration. However, without plan reviews and onsite inspections, the legitimacy of compliance depends solely on the individual's expertise and ethics. For example, New York permitted the use of licensed design professionals completing an official form attesting to code compliance. In 2006, audits found that 57 percent of self-certified new building plans failed to comply with the building code, including with BEEC requirements.[19]

Box 4.6. Examples of Third-Party BEEC Enforcement in U.S. States

Washington State. The **special plans examiners and inspectors** (SPE/I) program was developed in Washington State, after a 1991 study of compliance in Oregon and Washington revealed that compliance with the commercial energy code was roughly 50 percent in both states. To increase compliance, the non-residential energy code (NREC) was restructured. Among the changes is the option to use SPE/Is for required inspections as an alternative to the use of local government inspectors. Once the special inspectors were trained and certified, permit holders could contract them directly to perform the proper reviews. At the end of the process, the special inspector must provide a report(s) to the building official in charge who remains responsible for the ultimate approval. Funding for the training and certification functions of the SPE/I program was provided by the utilities in Washington for a period of three years. When the utilities ended their funding, the program ceased to exist. Even though only about 10 percent of permitted buildings used the SPE/I approach, the results of the program were satisfactory, partially because many local building jurisdiction staff that enforced the energy code were certified. A 1997 compliance study concluded that "most buildings (83 percent) reviewed by a SPE/I complied with all aspects of the energy code…"[a] "The program helped market the energy code, provided a professional development opportunity, raised professional standards, helped ensure a minimum competency level, provided local jurisdictions with options for enforcing the energy code, and was a mechanism for helping the building industry become more familiar with the … code."[b]

Maine. In Maine, the law specifically exempts municipalities that are enforcing the Maine Uniform Building and Energy Code through third-party inspections from the provision of law requiring the inspector of buildings to inspect construction for compliance with the Maine Uniform Building and Energy Code. It specifies that the inspector of buildings may issue a certificate of occupancy upon receipt of an inspection report by a certified third-party inspector and that the municipality is not obligated to review such a report for accuracy; see http://www.mainelegislature.org/legis/bills/bills_124th/billpdfs/HP046601.pdf.

Several states/jurisdictions use HERS (or other home energy rating system) raters for some inspections required for their BEEC enforcement. The **HERS Index** is a scoring system established by the Residential Energy Services Network (RESNET), which is a not-for-profit membership corporation that acts as a national standards making body for building energy efficiency rating systems. A home built to the specifications of the HERS Reference Home (based on the 2006 IECC) scores a HERS Index of 100, while a net zero energy home scores a HERS Index of 0. Each 1-point decrease in the HERS Index corresponds to a 1 percent reduction in energy consumption compared to the HERS Reference Home. The **ENERGY STAR** program (see Appendix 7) uses the HERS index based on plan reviews and on-site inspections by HERS raters (typically including a blower door test to test the leakiness of the house and a duct test to test the leakiness of the ducts) to ensure that the building will meet ENERGY STAR performance guidelines; http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS and http://resnet.us/home-energy-ratings.

A training and certification program already exists for the development of HERS raters, turning out a growing pool of qualified raters. Many states and municipalities have or are in the process of adopting energy codes tied to the federal ENERGY STAR program that employs HERS raters to assure compliance. Those raters have detailed knowledge of how to inspect critical items such as duct leakage along with generalized knowledge of the energy code and above code energy standards. A total of ten states have incorporated or merged home energy ratings or have specifically approved use of home energy rating software into their energy code compliance process: **Alaska, Arkansas, California,**[c] **Connecticut, Florida, Indiana, Iowa, New York, Massachusetts, Vermont**.[d]

(Box continues on next page)

Box 4.6 (continued)

New York State: Numerous jurisdictions around New York State have adopted the US-EPA Energy Star Home criteria as their residential energy code. The HERS-As-Codes model uses Home Energy Rating System (HERS) certified raters with additional training in local or state codes as third-party enforcement agents. The Town of Brookhaven, the first to adopt the Energy Star Code example, has run it successfully since 2007. HERS raters conduct their usual plan review, assuring the plans "as-designed" reach the Energy Star level of compliance, and assuming a minimum air leakage that they will verify later with a blower door test. Raters then work with the prospective builder of the home to assure that all the details of the as- designed plans are followed in the field and during construction. They test whole-house air sealing and duct tightness requirements near the end of the project construction, and finally, they run the as-built home measurements through the REMRate software for determination of the Energy Star Score that will be affixed to a label permanently attached to the home. During this time, raters also check certain additional, mandatory code requirements that are not required by Energy Star or reflected in the Rating Score. Several Mid-Hudson municipalities in New York use HERS raters perform a code compliance function. In addition to their normal HERS training and testing, they are required to take New York-specific energy code training. The New York code serves as the baseline for review and inspections for Energy Star compliance. The REMRate software used by the HERS raters includes special reports for code compliance, including inspection checklists and the certificate of compliance required by the IECC, and in this case, reports modified by the software providers, AEC, for New York-specific code requirements as well; http://www.scribd.com/doc/31735100/Task-4c-3-Third-Party-Compliance-for-Implementation-in-Maine.[e]

Notes:
a. Baylon et al. (1997).
b. See http://www.energycodes.gov/implement/case_studies/case_certify.stm with more details about the SPE/I program.
c. See California case study, Appendix 5, for details. RESNET software and HERS cannot be used in California which has developed their own third party home energy rating system for which three providers have been approved by the CEC; see http://www.energy.ca.gov/HERS/ and California case study in Appendix 5.
d. The HERS infrastructure is also used for the provision of energy-efficient mortgages where a home's projected energy savings – documented by the HERS provider - are added to the borrower's income in the mortgage qualification process; see Residential Energy Services Network (RESNET) 2001.
e. See Building Codes Assistance Project (BCAP) (2009).

For commercial construction, local enforcement is the most frequent enforcement model (74 percent), followed by self-certification (14 percent) and third-party inspectors (12 percent).[20] State enforcement seems to be very rare. However, note that there can be a mixture of models within one state for the same BEEC. For example, in Washington state, the local enforcement model is generally used for the building envelope requirements. The largest municipalities use the local enforcement model for the mechanical system requirements, but many smaller municipalities do not have a mechanical system expert on staff and so may rely on third-party enforcement or self-certification for the mechanical system requirements. The largest municipalities also use the local enforcement model for the lighting system requirements, but most municipalities rely on the state agency enforcement model for those requirements.

Box 4.7. Mandatory Enforcement of BEECs in Seattle

Washington state has, together with Oregon, the best compliance with BEECs in the United States (see table 4.7). Seattle's BEEC is 20 percent more stringent than the state BEEC, but also here compliance with the BEEC is practically universal. It should be noted that, as almost everywhere, actual energy savings are on average less than modeled. Reasons are that construction in practice is less than perfect, plug loads are underestimated, HVAC ratings are assumed for standard conditions, tenants (especially in larger, commercial buildings) are different from those assumed.

In 2005, 7,000 applications for plan review were received with a total construction value of slightly above US$2 billion. 80 percent of the applications were for alterations of existing buildings. A total of about 80,000 inspections were carried out for building, mechanical, and electrical installations.

The city department of planning and development has a staff of 27 code officials who carry out all preliminary screening of plans, plan reviews and inspections to assure compliance with the building code in general and with the BEEC in particular. For multifamily and commercial projects, the plan review for BEEC compliance is handled by specialized energy personnel who check for compliance solely with the BEEC and mechanical code requirements. These specialized energy personnel also serve as a resource to other staff and answer technical questions from designers and the general public. For the plan review of small residential projects and for all construction inspections, the various energy aspects are handled not by specialized energy staff but by staff with similar specialties. For example, structural specialists review building envelope plans, electrical specialists lighting plans, and so on. If information is missing from plans or if drawings are incorrect, written corrections have to be sent in before a permit to begin construction is issued. The building, mechanical, and electrical inspectors then inspect the pertinent features at the construction site, if necessary several times, to verify that construction is consistent with approved plans and thus in compliance with codes. If corrections are necessary, construction must be revised before an occupancy permit is issued.

Staff is usually trained on the job; after code revisions, staff training takes place in small groups according to their specialties. Public workshops are held for architects, designers, and trade associations, usually by an experienced staff member who is considered the energy champion within the department.

Funding for staff to review BEEC aspects of plans and inspect construction was initially provided by a separate fee, amounting to 20 percent of the building permit fee. This enabled the department to build up capacities and expertise to deal with the new requirements. Now there is no separate allocation for BEEC enforcement within the overall building permit fee of 0.5 percent of construction value (total of US$10 million in 2005). There are, however, funds for additional BEEC compliance staff from the publicly owned electric utility (Seattle City Light) due to the fact that Seattle's code is 20 percent more stringent than the Washington State Energy Code.

Seattle officials believe that compliance is more likely and energy savings can be more or less guaranteed when the same rules apply to everybody and requirements are enforced for everybody. In this case, local public enforcement delivers good results.

Source: Authors, based on Hogan (2008).

Issues in BEEC Compliance/Enforcement

Practitioners generally agree that the level of compliance with and enforcement of BEECs tend to be relatively low because energy is not considered a life and safety issue such as structural and fire safety. In addition, BEEC enforcement is often near the bottom on the list of enforcement actions because of limited funding for plan review and building inspection and for training of staff, limited time to fulfill needs of the plan review and building inspection, and limited staffing for the review and inspection of each building. Consumers and building owners often do not appreciate more energy-efficient homes and therefore do not put any pressure on builders to comply with BEECs. Many designers, builders, and building officials continue to have little knowledge about energy fundamentals, and this leads to poor compliance. Complexity of code requirements that prevent uniform interpretation of BEECs and perceived lack of cost-effective products that conform to BEECs are other reasons why compliance is low.

Improving BEEC Compliance/Enforcement

Methods and strategies for improving BEEC compliance include:

1. Better training and certification of code officials, building professionals and building operations and maintenance staff through the state building energy code administrator; more use of hands-on, on-site training.
2. Increase local and state capacities and expertise to enforce code through the use of certified independent third-party inspectors.
3. Adopt commissioning requirements as part of the BEEC to ensure that all building systems perform as designed.
4. Track and report energy code compliance to inform progress; measuring and reporting energy performance, including benchmarking.
5. Maintain adequate and dedicated funding (for example, through a fee for service structure) so that code agencies can administrate (that is, plan review and inspect), train local officials, provide technical support, and enforce the code.
6. Simplification of BEECs, both for the ASHRAE/IESNA Standard 90.1 (2004 version) and the IEEC (2006 version), has taken place during the past few years. For example, in the residential sector, prescriptive codes written in straightforward language seem to work best.[21]
7. Strategic coordination with energy efficiency program administrators to train the building design community in best practices to meet and exceed minimum energy code requirements.[22] In addition to education and training, successful implementation of BEECs is improved by positive interaction of building code officials with the building industry, for example, by exchanging information about code updates, code compliance options, and innovative construction techniques.
8. Not surprisingly, having a committed and dedicated energy champion in the local building or planning department will improve the likelihood of a high degree of compliance with BEECs. This also increases the likelihood of improved compliance in surrounding jurisdictions, at the state and eventually at the national level.[23]
9. Financial incentives to builders, consumers, and building owners for tested and verified energy efficient and green buildings would lead to better compliance with BEECs. Some utilities provide incentives, for example, for Energy Star homes. Alternatively, penalties could be imposed; California is considering those as part of its long-term BEEC compliance plan.[24]
10. Increase public awareness of the multiple benefits of building energy efficiency.

Funding for Compliance Improvements

Stable sources of funding for training and certification, technical support for the regulated community for code adoption, for code development and for compliance reviews are important. Possible sources include:

- Fee for service structure that sets aside dedicated funding for plan review and inspections of BEECs or for training and certification. For example, in Connecticut a surcharge of $0.16 per $1,000 value of permit work raises over $1 million per year for education programs for all aspects of building code work.[25]
- Utility programs or similar stable sources of funding; see examples in box 4.7 and box 4.8.

Box 4.8. Utility Funding for Compliance Improvement

Example 1: PGE's 2005–2008 Residential New Construction program offers extensive training courses on emerging new technologies for the building industry, including courses on Title 24 code changes, quality of insulation installation credits for contractors, and pilot programs relevant to building energy efficiency in new homes. Other activities include attendance at building industry trade conferences/ outreach events and contractor/builder field visits as necessary. The target audience consists of builders, developers, energy consultants, HERS* raters, architects and other industry professionals.

Source: http://www.californiaenergyefficiency.com/ calenergy_old/pge/2009.pdf.
Note: *See, for example, http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_HERS.

Example 2: Funding for the training and certification functions of Washington state's special plans examiners and inspectors (SPE/I) program that established third-party review and inspection for nonresidential construction was provided by the utilities in Washington state; see details in Box 4-6. Ultimately, this funding model proved unsustainable, as the program ceased to exist once the utilities ended their funding, which amounted to about $5 million over the three-year life of the program. Although using utility funding to start up such a program, especially for the development of a training and certification program, may make sense, alternative funding sources for its continuation should have been identified.

Source: NEEP (2009) and http://www.energycodes.gov/publications/research/documents/caseStudies/case_certify.doc.

Example 3: The Northwest Power Planning Council and the Bonneville Power Administration worked to encourage the four Northwest states to adopt aggressive new BEECs in the 1980s and 1990s. The utilities first offered incentives for buildings that met the new model code before it was adopted as mandatory. In a political deal, the utility agreed, in return, for the state of Washington adopting a new code at the recommended levels, to pay for compliance efforts for the first 18 months. Savings continued as the code was enforced subsequently without incentives.

Source: Goldstein 2006.

Example 4: California's BEECs in the early 1990s required a U-factor of 3.75 W/(m2-K) for windows. However, test procedures for measuring U-factors were inadequate. Products with actual U-factors as high as 5.5 W/(m2-K) could be considered to comply. Solving this problem required establishment of test procedures and test laboratories. Utilities paid incentives for products that complied with new testing requirements and funded the startup of labs with sufficient capacity to test all windows. This resulted in a significant upgrade to the code in 1995, requiring that windows had to be tested to meet the 3.75 W/(m2-K)) U-factor.

Source: Goldstein 2006.

Example 5: Most American homes transfer heat from the furnace and air conditioner to the space through air ducts. These ducts typically lose 20 percent or more of the energy in their heated or cooled air before reaching the room. Duct leakage can be reduced to below 6 percent with on-site pressure testing. California offered tested "leak-free" ducts as an efficiency measure available through the performance compliance path in 1998. The state noted that "leak-free" ducts would be required in the prescriptive packages in the near future. In response to the energy crisis of 2000, California required "leak-free" ducts beginning in 2002. Utilities encouraged this process by funding an infrastructure of independent, third-party testing, and rating experts who were recognized by the state for being able to offer certification of leak-free ducts.

Source: Goldstein 2006.

Summary of U.S. Enforcement Experience

BEECs have been in place in the United States for more than 30 years. They vary by state—with California having the strictest BEEC and some states not having any. In most states, commercial codes also apply to larger multiresidential buildings. Compliance shows large discrepancies, ranging from almost full compliance in the Pacific Northwest to about 70 percent in California to lows in the one-digit range in some states.

BEECs are generally enforced together with the general building code, usually at the local level by public officials. Less frequent is enforcement at the state level (typically in smaller states and in mostly rural jurisdictions). Some jurisdictions allow for third-party enforcement (especially at the plan review stage) or self-certification, with or without spot checks. It seems that self-certification has not really worked out in the United States. Third-party review and inspection, by contrast, is employed more frequently, especially with the advent of voluntary rating schemes such as Energy Star that require post-construction inspection and have contributed to training and certifying a substantial number of raters.

Few municipalities have been able to achieve complete compliance. Those that have—for example, Seattle—had the following factors working to their advantage:

- Political support, expressed in adopting strict local BEECs and providing incentives for going beyond code
- Popular support for building energy efficiency due to environmental consciousness in the community
- Extra funding in the beginning of BEEC enforcement, allowing building up enforcement capacity, hiring extra staff, and training code officials and building professionals
- Existence of a building energy efficiency champion in the local administration

Building on those factors, the introduction of the following enforcement principles, processes, and tools led to successful compliance:

- Streamlined process of review and inspection with correction lists and written change orders that need to be incorporated and executed before permits for construction and occupancy are issued
- Resources for inspectors to make them more efficient—for examples, cars and laptops
- Mandatory enforcement with strict reviews that set expectations and inspections of every construction site

Compliance improves if enforcement is considered firm and fair.

Additional measures that have been shown to help with compliance are:

- Central help desk or similar (circuit riders) at the federal or state level can provide support with developing, implementing and enforcing BEECs at the local level. In the United States, DOE is funding a nationwide central help desk that is staffed by the Pacific Northwest National Laboratory (PNNL).[26] The Building Codes Assistance Project (BCAP) is providing additional support for BEEC compliance and enforcement to states and municipalities and has recently developed a Best-Practice network and website.[27]

- Joint training of code officials, designers, and building industry improves understanding of codes and their application, but also makes code officials more aware of technical issues.

In the near future, BEEC compliance activities in the United States will see an upsurge, triggered by requirements in the 2009 stimulus bill that states adopt BEECs and improve compliance very substantially. The federal government provides some support for some of the necessary measures. In particular, methodology guidelines have been developed to measure compliance rates[28] and to evaluate actual performance of buildings and energy savings.

Lessons Learned from the Pioneers

New buildings in the European Union and the United States today, in general, consume much less energy per square meter than buildings constructed 20 to 50 years ago, before the adoption and more-complete implementation of BEECs (other things being equal), in large part due to the implementation of increasingly stringent BEECs. But actual energy savings and emission reductions due to BEECs and related appliance standards in general are less than what the codes or standards would indicate due to significant noncompliance. Note that buildings constructed more than a century ago do not necessarily use more energy than those constructed recently, especially commercial buildings. The real extent of the lost opportunities is not known, since there has been little emphasis on measuring the energy performance of buildings after construction.

The substantial compliance gap observed in many countries in the EU and at the U.S. states level is caused mainly by the lack and inconsistency of enforcement and inadequate knowledge and skills of involved parties. The countries, states, and municipalities that have done well in compliance are often those that have involved key stakeholders in the development of the BEEC, have devoted sufficient resources to support enforcement, made strong efforts to train and educate the key stakeholders in BEEC compliance, and adopted systematic approaches/procedures for enforcement. Compliance begets compliance, as designers and contractors are more likely to comply with a BEEC if they know that their competition also must comply with the same standards and that all are being treated equally. Conversely, even if well-trained and aware of the requirements in a BEEC, where designers and contractors do not think that a BEEC is being enforced, they will be reluctant to fully comply with it. For example, these designers and contractors may fear losing contracts if their bid is higher because they have included all the features necessary to comply with the BEEC, while their competition has a lower price because they do not include all of these features.

There are multiple ways through which BEECs can be enforced. Some work better in certain situations than others. The increasing use of the third-party enforcement approach is seen as a meaningful way to address the resource constraint of government enforcement agencies. The public sector retains responsibility in most countries for enforcement of building codes in general and BEECs in particular. Faced with increasingly complex BEECs and insufficient resources for code enforcement at the local level, many countries have allowed contracting out some of the review and inspection duties that require substantial expertise to certified/accredited third parties. The cost of maintaining sufficient and properly educated staff is high in most cases in smaller cities and has been hard to justify since construction volume is much more modest there. Since they are frequently hired by builders, mechanisms need to be put in place to ensure that third parties have incentives to carry out their work properly. These include spot checks by public sector enforcement officials, loss of certification/licensing, penalties and legal liability for mistakes.

Having a range of compliance options is important for most effectively addressing the varying needs of different building projects and preferences of different users. BEECs have become more complex and demanding since they were first introduced more broadly in the mid-1970s. A movement from a fixed menu of options to flexible approaches that achieve the same overall energy savings can be observed over time. BEECs now generally provide multiple compliance options that serve needs ranging from designers and contractors working on small projects and alterations to those working on large projects with sophisticated consultants. BEECs also now provide better direction to the manufacturers for product development.

Regularly updating the BEEC provides for incremental improvements and allows adjustments to improve implementation. The EPBD requires that BEECs in EU member states are updated at least every seven years. Most member states have a shorter updating schedule of three to five years. The national model BEECs and most state BEECs in the United States are updated every three years. Such regular and frequent updating of BEECs provides a means to incrementally improve the stringency of the requirements and to incrementally expand the scope of the requirements, so the changes are not so challenging to implement. In the United States, not only the BEEC but also most of the model national construction codes (building, mechanical, electrical, plumbing, and so on) are updated every three years. Revising BEECs on the same schedule as the other construction codes establishes them as one of the family of codes that all designers and contractors must comply with, rather than an outlier that doesn't fit into the regular system. This allows BEEC training for designers and contractors to occur on the same schedule as training for the other construction codes.

There is a trend toward making BEECs have a more-uniform format and structure across various countries in an economically integrated region (EU) or within a large country (United States) so as to improve performance evaluation and to improve compliance. Although there will always be local differences in stringency based on climate, enforcement capacity, availability of materials and equipment, and construction practices, having a more-uniform code format and structure allows designers, contractors, manufacturers, and suppliers, to more easily identify the BEEC requirements for a particular locale regardless of which country or state it is in. It also has the benefit of spurring greater intraregional flow of technologies and innovations by leveling the playing field across previously segregated markets. This is indicated in the European Union's effort to implement the EPBD and the U.S. government's new initiative to encourage all states to adopt the newest model codes.

It is important to engage all participants in the building supply chain in a constructive way. This requires a good balance of public authority enforcement through spot checks and informal discussions with and education of all participants in the building chain—developers, architects, designers, construction companies, manufacturers, suppliers, and building owners.

Having a champion in the local enforcement agency will increase the likelihood that the BEEC is implemented. Having a champion city will increase the likelihood that the BEEC is implemented in the county/state. Having a champion state will increase the likelihood that the BEEC is implemented in the country.

Notes

[1] EU-15: The original 15 member countries Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom. EU-10: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia joined on May 1, 2004. Bulgaria and Romania became EU members on 1st January, 2007.Together these countries form the EU-27.
[2] WEC 2004, p. 70.
[3] For the software tool, see Erhorn et al. (2007).
[4] See Erhorn/Erhorn-Kluttig (2009) and table 4.4.
[5] BRE (2008), p. 30.
[6] www.rics.org/NR/rdonlyres/D22F5E37-6EA7-46CB-923F-20D21B361C65/0/018JRFutureofBuildingControl.pdf.
[7] Cp., for example, http://www.energy.eu/directives/com2008_0030en01.pdf.
[8] By cutting the energy use in buildings by about 30%, Europe's energy consumption would fall by 11%, more than half of the 20-20-20 target, http://www.eeb-blog.org/2008/02/epbd-the-eus-bu.html.
[9] See RICS (2008) and (2009) and http://www.buildingsplatform.eu/cms/index.php?id=237.
[10] http://www.eeb-blog.org/2008/02/epbd-the-eus-bu.html.
[11] Commission of the European Communities (2008). However, in Germany, for example, smaller buildings which make up about 80% of the building stock were never exempted from energy-efficient renovation requirements.
[12] Ecofys (2004).
[13] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF
[14] The following section is based on http://bcap-energy.org/node/4 unless otherwise noted.
[15] See Section 410 of the American Recovery and Reinvestment Act of 2009.
[16] Deringer/Iyer/ Huang (2004), p. 1.
[17] Compliance rates cited in table 4.7 are from various reports and are based on different metrics. They are thus not entirely comparable. Definite national level studies of compliance do not exist. As part of the BEEC related provisions of the stimulus bill, DOE's Building Energy Codes Program has developed procedures and tools to help states and jurisdictions measure and report compliance with BEEC's, based on a uniform definition of compliance. (http://www/energycodes.gov/arra/compliance_evaluation.stim).
[18] Based on BCAP (2008a and 2008b) and Bartlett et al. (2003).
[19] Hogan (2008).
[20] BCAP (2008b).
[21] See evidence from Oregon in Ecotope (2001).
[22] NEEP (2009).
[23] The energy champion in the local building or planning department can advocate within the agency for effective implementation. This champion can start out by writing procedures for implementation of the BEEC within the agency, and then be an internal resource to staff by providing training to plan reviewers and inspectors, assisting plan reviewers with information on design drawings and review of compliance forms, assisting inspectors with questions that come

up in the field at the construction site, conducting weekly meetings where staff discuss project-specific questions related to the BEEC, and writing publications to explain particular BEEC requirements that questions commonly come up about. This champion can provide outreach through training on particular aspects of the BEEC that is tailored to the specific needs of design professionals, contractors, manufacturers, suppliers, and the general public. As a result of having an internal champion, this local enforcement agency is likely to become a champion city. The impact of a champion city spills over to the nearby region. Designers who work within the greater metropolitan area and nearby counties are likely to use the same energy efficiency measures in all their designs. It is easiest for designers to have one set of specifications that they use in many projects, rather than varying the specifications for each project. In turn, manufacturers and suppliers will stock energy-efficient products that comply with the BEEC because designers are specifying these products for the buildings that they design. Thus, while a champion city may be in the lead, it will bring along the surrounding jurisdictions and it will also demonstrate to others in the state that the BEEC is here to stay and being implemented. Then, as statewide implementation improves, this state is likely to become a champion state. As such, the impact of the state spills over and begins to influence the national discussion. This increases the likelihood of more-widespread implementation at the national level.

[24] CPUC (2008).

[25] NEEP (2009), p. 28, based on http://www.cga.ct.gov/2007/pub/Chap541.htm#Sec29-252a.htm.

[26] http://www.energycodes.gov/help/helpdesk.php.

[27] http://bcap-ocean.org/.

[28] http://www.energycodes.gov/arra/compliance_evaluation.stm.

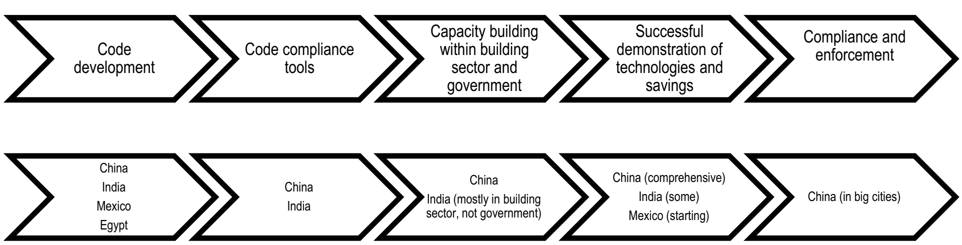
CHAPTER 5

Experiences from Early Adopters of BEECs in Developing Countries

Summary of Case Studies: China, Egypt, India, and Mexico

Many developing countries have adopted either mandatory or voluntary BEECs at the national level. But, as shown in chapter 3, there are great disparities in implementation and compliance. Very few countries have achieved a significant rate of compliance. In many countries, BEECs are still voluntary, while efforts are made to develop technical and enforcement capacity necessary for a successful implementation of the BEEC. In even more countries, voluntary BEECs have been introduced, but the BEECs or even the basic building codes may have little impact because of weak government oversight of building construction. Some countries try other approaches to push the construction sector toward more sustainable practices by requiring that developers abide by minimum EE standards for government-financed low-income housing. China, India, Egypt, and Mexico each represents an interesting case for the aforementioned situations, respectively. Figure 5.1 represents the usual phases of implementing BEECs and visualizes the progress each of the four countries has made so far. Their experiences are summarized and emerging lessons and effective approaches are presented in this chapter. Details about the underlying conditions and the BEEC programs of the four countries can be found in Appendix 1.

Figure 5.1. From Code Development to Compliance—Country Examples



Source: Authors.

Urbanization and Energy Use in Buildings in the Four Countries

Among the four case study countries, China and India are the two most populous nations and have a large impact on global energy consumption and GHG emissions due to their sheer population size, their dependence on coal for electricity generation, and their rapid economic growth. They have in common with Egypt and Mexico that per capita energy demand is still quite low compared to industrialized countries such as Japan or the United States (see figures 1.1 and 1.2). Except for Mexico, the majority of the population in these countries still lives in rural areas. But urbanization is proceeding fast, triggering high growth of urban building construction. Much of this construction in India and Egypt, where informal construction activities are widespread, seems to be escaping the government oversight system. Energy consumption in the building sector, particularly electricity for lighting and cooling, is fast growing and contributing to the growing gap between supply and demand. Among the four countries, China is the only one with substantial heating requirements, which explains its much higher per capita fuel use in residential and commercial buildings (see table 5.1).

Table 5.1. Basic Country Data—China, Egypt, India, and Mexico

	China	Egypt	India	Mexico
Gross National Income per capita (2008) *	US$2,940	US$1,800	US$1,070	US$9,980
Annual GDP per capita growth (1998-2008)	9.2%	2.7%	5.6%	1.7%
Total population (million) 2005 actual/2030 forecast	1,313/1,458	73/104	1,134/1,506	104/128
Urban population (million) 2005/2030	531/880	31/52	326/611	80/107
Estimated stock of urban residential and commercial buildings in 2005 (million m^2)	14,744	Not available	About 8,000 (incl. rural)	1,700
Estimated growth of urban building stock from 2005 to 2030 (million m^2)**	9,690	Not available	16,000 to 32,000 (incl. rural)	574
Per capita residential and commercial energy use (2005)	Electricity: 306kWh Fuel: 242 kgoe	681 kWh 82 kgoe	124 kWh 143 kgoe	648 kWh 157 kgoe
Residential and commercial energy use as % of total final energy use (2007)	29%	23%	45%	20%

Sources: UN World Urbanization Prospects (http://esa.un.org/unup/index.asp), IEA Energy Statistics (http://www.iea.org/stats/index.asp), and country case studies (Annex 1).

Notes: * World Bank Atlas method.

** Based on urban population growth and current residential and commercial floor area per capita in urban areas.

Development and Implementation of BEECs

China

Systematic government efforts on energy conservation began in the early 1980s. There was high-level political consensus in the national leadership that improving energy efficiency was important to national energy security and would enhance public health by reducing wasteful coal consumption. The latter point was especially prominent in northern Chinese cities where coal-fired winter heating was a major cause of ambient air pollution. The Ministry of Housing and Urban-Rural Development (MoHURD), formerly known as the Ministry of Construction, is responsible for developing and updating national BEECs. The first set of official minimum energy-efficiency requirements for centrally heated new apartment buildings and associated heat-supply systems was issued in 1986 and the implementation took place mostly in Beijing and Tianjin cities while pilots and demonstrations were carried out in a few more northern cities. The first mandatory national BEEC for new residential buildings in cold and severe cold climate zones was issued in 1995. Two additional mandatory national BEECs for new residential buildings were issued in 2001 and 2003, covering temperate and subtropical/tropical climate zones, respectively. With the mandatory national BEEC for new public and commercial buildings, issued in 2005,[1] China had in force a full set of mandatory BEECs for new residential, commercial, and public-service buildings in urban areas.[2] Some of the key characteristics of the Chinese BEECs are described in table 5.2. To help strengthen the consistency in compliance enforcement and standardize enforcement procedures the national *Code for Acceptance of Energy Efficient Building Construction* was issued in 2007.

Each of the current set of national BEECs in China is expected (as calculated by the theoretical formula defined by the code) to achieve 50 percent energy savings for the applicable new buildings and end uses compared to their corresponding baseline buildings (based on standard designs in the 1980s) under the same operation conditions. Measurements of actual energy savings are scarce. But available survey data indicate that actual energy savings are significant lower than the calculated savings (China case study, Appendix 1). For example, for apartment buildings with coal-fired district heating systems in Beijing, those compliant with the 1995 BEEC use about 37 percent less coal than the pre-BEEC buildings, instead of 50 percent. Nonetheless, this theoretical threshold does provide simple and clear targets for building designs.

China has achieved marked progress in compliance enforcement in the last five years. The results of annual government inspections indicate that in a few dozen large cities about 80 percent of new residential buildings completed in 2008 complied with the applicable BEECs, compared with about 20 percent in 2005 and an abysmal 6 percent in 2000.[3] This is due to a convergence of several key factors: the *governance of urban building construction* has become more streamlined and transparent, the *system of BEEC compliance enforcement and procedures* has been improved and standardized, the *capacity of the construction industry* to meet the technical requirements of BEEC has become broad-based, *quality building materials and components* for BEEC compliance have become widely available—even though they still vary widely in quality and energy efficiency, the *ability to afford and willingness to pay* for the incremental costs of

BEEC compliance have increased significantly, and the *capacity and motivation of local governments to enforce BEECs* have been strengthened. The national campaign to achieve the 20 percent energy intensity reduction goal of the 11th Five-Year Plan (2006–2010) has put real pressure on local governments to step up compliance enforcement.

MoHURD is set to promulgate a revised national residential BEEC for cold climate regions (65 percent theoretical energy savings compared to building designs of the early 1980s) in 2010. As a sign of growing local confidence in compliance, Beijing and Tianjin, the two largest urban building construction markets in northern China, already adopted similarly stringent local BEECs in 2004.[4] Several provinces followed the steps of Beijing and Tianjin since 2007. Such subnational initiatives could become the driver for more advanced BEECs in the future. This perhaps is the most significant and rewarding outcome of China's national intervention in building energy efficiency.

Egypt

Various multilateral and bilateral assistances in the last two decades have helped launch important government energy efficiency initiatives, including the development of BEECs. The Ministry of Housing, Utilities, and Urban Development is responsible for developing and updating the national BEECs. The residential BEEC was introduced by a ministerial decree in 2005 and the commercial BEEC in 2009. Both codes are comprehensive (table 5.2) and were developed with international assistance provided through the United Nations Development Program and the Global Environment Facility. The residential BEEC is expected to cut electricity for cooling in air-conditioned new homes by 20 percent while improving comfort in non–air-conditioned new homes. Both codes and a third BEEC for public buildings are mandatory. But the process of BEEC enforcement is still in a very early stage, and compliance is negligible. A comprehensive implementation program was designed but has not been implemented. Thus, basic compliance tools are still lacking and capacity building has not taken place.

India

The Energy Conservation Act was enacted in 2001, ushering in systematic government efforts to promote energy efficiency and conservation. Energy conservation buildings codes (ECBCs) were clearly identified by the Act as a key policy intervention. The Bureau of Energy Efficiency (BEE, under the Ministry of Power) was created in 2002 to lead national energy efficiency efforts. The ECBC was developed under the guidance of the Bureau of Energy Efficiency with technical assistance from the U.S. Agency for International Development. It was officially introduced in 2007 as a standalone voluntary code for large commercial buildings (with connected load of 500kW or more). States will have to adopt the ECBC for it to eventually become applicable. The government has indicated that the ECBC will become mandatory after gaining compliance capacity and implementation experience. An ECBC compliant building is expected to use about 39 percent less energy than the national benchmark (110 kWh/m^2/year compared with 180 kWh/m^2/year).

A detailed ECBC User Guide has been developed and published to facilitate compliance. U.S. AID provided the funding for compliance capacity development, including (1) training of professionals, (2) establishment of a panel of ECBC expert architects to provide advice to design professionals, (3) development of technical reference materials for envelope design, energy simulation, and so forth, and (4) support for development of curricula in architectural/engineering colleges. The government also established an ECBC Program Committee to facilitate development of ECBC compliant building designs, implement demonstration projects, and set up compliance and evaluation procedures. A benchmarking survey of commercial buildings has just been carried out and a star-rating system for office buildings established. The Ministry of Power and several other agencies have created Energy Efficiency Services Limited (EESL) as a vehicle to support states and municipalities in code implementation,[5] since BEE itself cannot carry out any support to the states (this is the realm of the Ministry of Urban Development). New Delhi has adopted the ECBC in 2009, making it mandatory for government buildings.

Mexico

Mexico has had a mandatory standard for commercial buildings since 2001, developed by CONUEE, the national energy conservation agency, with support from experts of the Lawrence Berkeley National Laboratory (LBNL). In order to become effective, the national code needs to be incorporated into the construction regulations of states and municipalities. This has not occurred yet. Energy efficiency standards for lighting and air conditioning units that have been mandatory for more than 10 years have been fairly successful in terms of energy and capacity savings and widely applied (see Mexico case study in Appendix 4). More recently, the National Housing Agency (CONAVI) has developed guidelines for sustainable housing, including requirements for thermal insulation and water saving equipment, as part of the voluntary national housing regulation (CEV—Codigo de Edificacion de Vivienda). Developers that want to participate in the government-subsidized low-income housing development program will have to satisfy those requirements. To facilitate the incorporation of energy efficiency and other sustainability features into low-income housing construction, the Mexican government submitted a methodology under the Clean Development Mechanism (CDM). It was approved in 2009 and is expected to provide some incremental cost financing to developers, as well as support for monitoring and evaluation and capacity building.

Table 5.2. BEECs in China, Egypt, India, and Mexico

	China	Egypt	India	Mexico
BEEC status (time introduced)	Three mandatory national residential BEECs for separate climate zones (1995, 2001, and 2003, respectively) One mandatory national commercial BEEC for all climate zones (2005)	Mandatory national residential BEEC (2006) Mandatory national commercial BEEC (2009) Mandatory national BEEC for public buildings (2009)	Voluntary national commercial BEEC (2007)	Mandatory national (federal) commercial BEEC (2001) Energy efficiency design requirements in low-income housing developments receiving federal funding (2009)
Other relevant mandatory EE standards	Air conditioners, commercial lighting	Air conditioners, electric water heaters (CFL program)	Air conditioners, tubular fluorescent lamps, domestic water heaters, fans	Window and central air conditioners, water heaters, nonresidential lighting systems, thermal insulation materials
Climatic zones for BEEC application purpose	Five climate zones: severe cold, cold, hot-summer/cold-winter, hot-summer/- warm-winter, and temperate	Eight climate zones: north coast/shores, delta and Cairo, north upper Egypt, south upper Egypt, eastern shores, highland hills, desert, and southern Egypt	Five climate zones: composite, hot and dry, warm and humid, moderate, and cold	Four climate zones: mild, hot and humid, hot and dry, extremely hot and dry
Key BEEC requirements	Residential BEECs Building envelope District heating (in cold and severe cold zones) Commercial BEEC Building envelope HVAC	Residential BEEC and Commercial BEEC Building envelope HVAC Service hot water Lighting Electric power	Building envelope HVAC Service hot water Lighting Electrical power	Building envelope
Expected energy savings	50% calculated energy savings against bench-mark pre-BEEC building designs	20% calculated energy savings against benchmark building	39% calculated energy savings against national benchmark building	25-35% reduction of total electricity consumption estimated for low-income housing
Compliance path	Largely prescriptive but allowing Tradeoff between envelope components in residential codes Energy budget option for commercial buildings	Prescriptive path Equivalent alternating path (tradeoff) and Whole building performance (energy budget) path	Prescriptive path Equivalent alternating path (tradeoff) and Whole building performance (energy budget) path	Performance-based (prescriptive requirements for comparator building)
Stage of adoption	Have been adopted by all provinces subjected to BEECs.	Municipalities are responsible for implementation and enforcement of building codes. A formal enforcement mechanism has not been established due to lack of resources.	Needs to be adopted by states. New Delhi has adopted it and made it mandatory for government buildings.	Needs to be incorporated into local construction regulations by municipalities that have authority to develop and enforce local building codes and define the specific requirements for the construction of new buildings.
Compliance status	Mainstreamed in large construction markets (large cities)	De facto no compliance	Pilots and demonstrations; large construction projects required to carry out environmental impact analysis need to follow ECBC requirements	De facto no compliance with commercial BEEC Compliance with CEV is starting for low-income housing developments

Source: Case studies.
Note: BEECs for China (at least for the heating zone) and Mexico are fairly homegrown. BEECs in Egypt and India are based on U.S. ASHRAE standards (see Chapter 4), taking into account climatic differences and, in the case of Egypt, also the need for natural ventilation.

The results after developing a BEEC are quite different in the four countries:

- *China* has essentially mainstreamed BEECs in new building construction in urban areas, thanks to an early start and persistent government efforts. Even though compliance enforcement is still inconsistent and enforcement in medium and small cities is believed to be much more problematic than in large cities, implementation of BEECs is now commonly accepted practice in the construction sector and the incremental costs have been essentially internalized. It has, however, taken more than two decades after starting with the first trial BEEC in the late 1980s.
- *Egypt* appears to face daunting challenges to implement fairly sophisticated BEECs in an environment where even basic building code requirements are not effectively enforced. A new simplified general building law and the interest of the green building community that is just now forming in Egypt may provide a better environment for and interest in constructing more energy-efficient buildings (see box 5.1). There is an urgent need for national government leadership to establish a supporting policy and institutional framework for BEEC implementation and orchestrate the necessary capacity building in local enforcement and in the supply chain.
- *India* is making a big effort, putting in place the measures and procedures and developing compliance capacity necessary to successfully implement the ECBC locally. By focusing on large commercial buildings first, the efforts are likely to yield relatively quick progress in compliance if local governments adopt the ECBC and pursue enforcement seriously. However, the rapid pace of construction of large residential buildings suggests that those residential buildings should sooner rather than later be required to incorporate energy efficiency measures. Providing some incentives for the developers of high-end large residential building complexes to apply the requirements of the ECBC might establish precedents for eventual adoption of a BEEC for residential buildings, effectively curbing the enormous growth in residential electricity consumption.
- *Mexico* developed a national BEEC for commercial buildings early on, but has not been able to develop a federal government-led BEEC program. States and municipalities have so far not seen any compelling reason to include energy efficiency requirements in their building regulations. The National Housing Agency has developed guidelines for sustainable housing, including basic energy-saving features. Requiring developers participating in government-

supported low-income housing developments to incorporate such features represents an attractive approach to leverage market uptake of more energy efficient buildings through federal low-income housing subsidies. This could effectively demonstrate to both the supply chain and consumers the real benefits of applying and acquiring energy and water saving technologies, and paving the way for the states to begin requiring BEEC compliance.

Challenges to Mainstreaming BEECs

Why have the four countries that started from the common fact of having developed a BEEC experienced such different results? Although China has the advantage of starting the earliest, its relative success also came from overcoming rather similar challenges faced by other countries, such as supply chain capacity, local enforcement capacity, and incremental cost financing. Some of the explanation is offered in table 5.3. One of the main drivers for successful BEEC implementation is a political commitment at the national and the subnational level to energy efficiency or sustainable energy sector development. In the best case, this will include removing impediments to energy efficiency such as subsidized energy prices.

Box 5.1. Appliance Standards, BEECs, and Green Building Standards—Seeking Synergy

Appliance standards are easier to effectively implement than BEECs and can have substantial impact in terms of energy and capacity savings as shown in the case studies for India, Mexico, and California. They should, however, not be recommended as substitutes for BEECs. In hot climates, even in low-income countries, wherever mechanical cooling begins to be used, it is important that the building envelope be designed to minimize the cooling load (such as through light-colored roofs and walls to reflect heat, massive construction to moderate temperature swings, recessed windows to reduce solar gain, exterior shades and blinds to control solar gain). Simply establishing appliance standards for cooling equipment will not take care of strains on the electrical grid in low-income countries due to increasing energy consumption for cooling.

Voluntary green building standards and guidelines or rating schemes, such as those in China, India and Mexico (and under consideration in Egypt), provide initial examples of sustainable building practices that demonstrate that energy efficient and other sustainable building practices can be realized and provide a large number of benefits that outweigh their costs.

From a tactical point of view, and when resources are limited, it might initially be worthwhile in warm climate regions to focus limited resources on regulations that may seem easier to implement, such as performance standards for AC and requirements for sun shading, light reflective roofs, and roof insulation.

Source: Authors.

Table 5.3. Conditions for Implementation of BEECs

	China	Egypt	India	Mexico
Political commitment to energy efficiency	Strong at national level, and the political and governance system is relatively effective in orchestrating national and local efforts. National Energy Conservation Law Energy intensity reduction targets for all sectors in current national five-year economic and social development plan	Limited but increasing	Strong at national level, but the decentralized political and governance system may reduce the effectiveness of programs that require local enforcement. National Energy Conservation Act (2002) National Action Plan on Climate Change (2008)	Strong at federal level, but the decentralized political and governance system has prevented the adoption of the national commercial BEEC.
Proper incentives	Fairly high and cost-recovery electricity tariffs Heat metering and consumption-based billing for heat only on a demonstration basis	Heavily subsidized electricity tariffs for majority of households and for smaller commercial customers	Fairly high electricity tariffs for commercial sector Heavily subsidized tariffs for most households	Heavily subsidized electricity tariffs for most households; fairly high tariffs for commercial sector
Government oversight of building construction sector	Complicated system, but inclusive and generally enforced Compliance enforcement relies heavily on third parties.	Fairly complex and expensive permit system that is poorly enforced Large informal sector is not covered	Large informal sector is not covered Some third-party involvement (fire safety code enforcement)	Local system for enforcement of general building codes in place, with some third-party involvement through auxiliary, nongovernmental entities that have responsibility to confirm compliance with building codes
Compliance capacity of supply chain	Fairly good in big cities and at design stage (usually large developers) Limited in small cities (usually small developers) Wide availability, if varying quality of code-compliant materials and components	Very limited availability of materials and components required by compliance	Increasing availability of materials and components required for compliance, but still with fairly high incremental costs	Significant availability of materials and components required for compliance Training/capacity building of enforcement agents and of construction trades needed
Incremental cost financing	Largely internalized and reflected in building prices	Would be an issue with more consumers	Would be an issue with most consumers	Should not be an issue with most consumers

Source: Compiled by authors.

One of the biggest challenges for successful BEEC implementation is the governance of the construction sector in terms of the inclusiveness and effectiveness of the government oversight system. Although the Chinese permit system may appear to be most time consuming and cumbersome (table 5.4), it seems to have been relatively effectively enforced, as indicative from its relative success in BEEC compliance (box 5.2). On the other extreme, the building permit system in Mexico appears to be simple, efficient, and well established (if very diverse) at the local level. Discretion is, however, commonly practiced in building inspection, raising doubts on the effectiveness of compliance enforcement.

Simplifying procedures and reducing red tape are clearly needed, but having a system that is able to deliver the needed supervision also is critical. Partially triggered by the inability of governments to respond to the need for building permits amidst a surge in new construction, many countries have allowed accredited private-sector agents to carry out some compliance checks and enforcement tasks. This is similar to the developments that are taking place in OECD countries also.

Table 5.4. Dealing with Construction Permits: Warehouse Construction from Initiation to Completion

Country or region	Number of Procedures	Total Days Required	Cost as % of per Capita Income
China (Shanghai)	37	336	579
Egypt (Cairo)	25	218	332
India (Mumbai/Range of other cities)	37/15-37	195/80-258	2395/204-2718
Mexico (Mexico City)	12	138	113
OECD countries	15.1	157	56
East Asia and Pacific	18.6	169	140
South Asia	18.4	241	2311
Mideast and North Africa	18.9	159	358

Source: The World Bank Group: http://www.doingbusiness.org/ExploreTopics/DealingLicenses/.

Since the four countries are at rather different stages of implementing BEECs and their political and economic conditions also are quite different, the nature and the extent of the constraints to mainstreaming BEECs in each country vary significantly. Table 5.5 summarizes the main barriers and constraints in BEEC implementation and actions needed for the four countries.

Box 5.2. Spotlight on Tianjin/China—Compliance Enforcement Using Third Parties

China's third-party-based BEEC compliance approach is intricately linked to the established system of building code enforcement. The responsibilities of government oversight agencies for BEEC compliance are now well defined and in general are followed by concerned agencies through the construction cycle.

Stakeholders in Compliance Enforcement

1. The Compliers
   - Developer (Linchpin)
     - Design Firms (contracted by developer)
     - Building Contractors (contracted by developer)
     - Material and Components Suppliers
2. The Review and Inspection Entities (Third Party)
   - Construction Drawing Review Entities (fee for service, certified by Gov.)
   - Construction Supervision Firms (contracted by developer, certified by Gov.)
   - Testing Laboratories (fee for service, certified by Gov.)
3. The Government Oversight Units
   - Municipal Planning Bureau (site plan approval)
   - Municipal Construction Commission (Gov. Principal)
     - Construction Quality Control and Inspection General Station
     - Concerned Administrative Units (Energy Conservation Office, QiangGaiBan, others)
4. Building Owners and Investors (very little engagement so far)

The BEEC compliance process now relies heavily on the due diligence of the developer through third-party services: the architects have to design according to BEEC requirements, a qualified review entity has to certify the construction drawings as BEEC compliant, a qualified testing facility will conduct tests of samples of materials and components to verify BEEC compliance, the construction supervision entity has to perform required checks and inspections, and an independent technical entity will perform sample testing of building envelope thermal properties and evaluate overall BEEC compliance as part of the completion acceptance inspection.

The roles of the government agencies are to make sure that these procedures are properly followed and penalties are enforced if violations are found. For example, if improper installation of wall insulation is identified by a random site inspection, reports will be filed with the General Station for Building Construction Quality Supervision, which will suspend the construction and require completion of remediation measures by the developer before such sanction is lifted.

China's third-party-based BEEC compliance approach still is a work in progress, but it has proven to be viable. For such a distributed-responsibility system to work effectively, the third-party entities must be proficient about their specialty areas and keenly aware of their due-diligence responsibilities in the BEEC compliance chain. The government also needs to have a clear sense of responsibility and adequate human resources to monitor these entities so as to maintain credible threats to potential violators.

Potential negligence or abuse of power of involved parties notwithstanding, establishing this system of accountability is a critical step toward broad-based BEEC compliance and continuous improvement. The third-party compliance approach has its advantage in alleviating government resources constraints in view of the huge scale of China's urban construction. It also effectively internalizes the cost of compliance enforcement, an aspect that the government could explore to improve compliance through greater consumer awareness of developers' obligations in delivering BEEC compliance.

Source: China case study, Appendix 1.

Table 5.5. Barriers and Constraints in BEEC Implementation and Actions Needed

	Barriers and Constraints	Actions Needed
China	• Metering and consumption-based billing for district heating consumers remain very limited. • Inconsistence in compliance due to abuse of professional code of conduct by third parties. • Wide variability of quality of materials and components required for compliance. • Although testing of materials is certified, sub-par products can still easily enter the market, since accreditation of testing laboratories is lax and manufacturers can shop around for best test lab results. • Lack of information to and awareness of consumers regarding the obligatory BEEC requirements for developers. • Compliance enforcement in medium and small cities is constrained by reluctance and weaker technical capacity of local governments, weaker supply chain capacity and weaker willingness to pay (lower incomes) than in large cities.	• The government initiated reforms for heat tariff, metering and billing in early 2000s. Progress has been slow due to resistance by district heating companies and concerns about resistance from residents in pre-BEEC buildings that have no thermal insulation. The government should quickly expand the mandate for metering new buildings to all heated buildings. • Increase the transparency of compliance enforcement by requiring building labels to disclose basic obligatory requirements and parties responsible. • Standardize and require labels for key insulation and fenestration products, based on certified national testing. • Central and provincial governments need to keep the pressure on BEEC compliance enforcement and strengthen capacity in medium and small cities.
Egypt	• Subsidized residential electricity prices. • Lack of enforcement of the basic building code. • Municipal officials and the supply chain participants have little necessary information, knowledge and skills to embrace, enforce, or comply with BEECS and have little confidence in new materials and technologies that have no track record of local applications. • Limited ability to internalize incremental cost of EE technologies because of low income level. • Underdeveloped materials and components market for compliance, including related testing and certification capabilities. • Large informal building construction outside of government oversight.	• Firmly anchor BEEC implementation as an essential part of broad national energy efficiency strategy and establish supporting policy and institutional framework, including gradual rationalization of energy prices. • Streamline government oversight procedures for building construction and provide resources for enforcement and expansion of coverage. • Scale up pilots and demonstrations of BEEC compliance technologies and inspection procedures and dissemination of results. • Develop compliance infrastructure, including basic compliance manuals, training and education of users, and testing and certification capabilities.

(Table continues on next page)

Table 5.5 (continued)

	Barriers and Constraints	Actions Needed
India	• Lack of information about energy use and efficiency in commercial buildings. • Risk perception due to lack of confidence in performance of new technologies. • Underdeveloped materials and components market for compliance, including related testing and certification capabilities. • Limited ability to internalize incremental cost of EE technologies is because of low income level. • Large informal building construction outside of government oversight.	• Start large-scale pilots and demonstration by working with proactive states and municipalities so as to track-test and improve the preconceived compliance procedures and requirements and setting the stage for transition to mandatory ECBC. • Maximize market-driven actions by disseminating actual cost and benefit information of ECBC compliant buildings or projects and the use of noncash incentives such as fast-tracked permit approval and high profile media exposure. • Accelerate the schedule for mandatory ECBC to help spur the market for materials and components and support the development of testing and certification capabilities.
Mexico	• Lack of information of the importance of building energy use by local authorities and lack of knowledge of BEECs at the appropriate political level. This, combined with local autonomy over construction regulations, is a significant barrier to adoption of BEECs. • Discretion is commonly practiced in building inspection, raising doubts on the effectiveness of compliance enforcement if energy efficiency requirements are added to the permit process. • Developer resistance due to cost of compliance caused by (1) sunk investment in very specific technologies that have costs at a competitive level, (2) new investment in the equipment and training in the new processes and in new supply lines for the new materials, and (3) limited ability of low-income households to increase borrowing for higher construction costs. • High levels of subsidy in electricity rates, reducing the interest of both the financing agencies and the end user in acquiring higher first-cost technologies.	• Strengthen the capacity to adopt and/or develop and mandate the codes and standards under the sustainable housing program of the National Housing Commission (CONAVI) and the Green Mortgage program by the federal Institute for worker's housing INFONAVIT. Make the low-income housing project a successful large-scale demonstration of building energy efficiency and persuade municipalities to incorporate energy efficiency requirements in their building regulations. • Significantly increase and strengthen the capacity of the private-sector stakeholders accredited under the national standards and accreditation system to respond to the larger certification demand. • Implement an integrated and coordinated effort of data gathering to have a better idea of the main characteristics (such as built area, energy use, installed equipment, patterns of occupancy, materials, basic architectural elements) of the building stock by region. • Design and implement a nationwide information program directed to municipal authorities to help them learn of the importance and potential of energy conservation in buildings and the instruments and about the mechanisms in place (national standards and codes).

Source: Compiled by authors.

Lessons Learned from the Early Adopters

Making a Political Commitment to Energy Efficiency

For developing countries faced with a general lack of financial resources, institutional and human capacities, as well as underdeveloped markets and technical capabilities, the strength of the political commitment, especially that of the national government, is critical to planning and mobilizing efforts and rallying broad-based support to eventually overcome those constraints to improving energy efficiency. This has been well demonstrated in China and is emerging strongly in India. The uniqueness of the Chinese political and governing systems notwithstanding, the universal virtues of the Chinese approach in the market reform era are persistence and progressiveness with a practical sense to solve problems in development.

Making Compliance with Building Codes More User-Friendly and Strengthening Government Oversight of Building Construction

The inclusiveness and effectiveness of the government oversight system for building construction is vital for the success of implementing BEECs and achieving compliance since enforcement of BEECs is almost always added to the existing system of enforcement for basic safety- and health-related building codes. In many developing countries, the regulations to secure construction and occupation permits are so time consuming and costly that many applicants are driven into the informal sector or resort to bribery, defeating the purpose of having such a system. Simplifying building permit procedures, making them more predictable and reducing bureaucratic hurdles are clearly needed for most developing countries.

Developing the Enforcement and Compliance Infrastructure

Even with a good building-permit system in operation, moving from development of BEECs to actual implementation is an elaborate process that requires thoughtful and coordinated efforts, usually taking years to achieve significant results. The three basic constraints that must be addressed in any developing countries whose BEEC implementation is nascent are: training and education of reviewers and inspectors who are responsible for enforcing BEECs, training and education of designers, engineers, and other construction trades who are responsible for delivering compliance, and developing markets and necessary testing and certification capacity for materials and equipment required by compliance. The involvement of these parties in the development of the BEEC, particularly at the local or regional level, is likely to lead to greater support for implementation. The aim is to build a mutually reinforcing dynamic among these three elements. Although much inconsistency still exists, a particular strength of China is its ability to produce quality materials and equipment at highly competitive costs. This has been deliberately nurtured and supported by government policies. To ensure the consistency of quality materials, the testing and certification infrastructure needs to be strengthened and expanded to cover all relevant products in a reliable manner.

Starting with What Can Be Complied with and Enforced Effectively Now, and Incrementally Expand the Scope Over Time

It is very important for developing countries to start with realistic goals and be highly conscious about the compliance cost implications when BEECs are developed. It is more desirable to start with a simple and practical BEEC that is effectively enforced and strengthen it over time than to take on a complicated and stringent one that cannot be complied with. However, note that mandatory enforcement is ultimately the key; simply relying on pilot projects will never yield full implementation. The first BEEC China introduced in 1986 was undemanding measured by what is commonly practiced today. But it launched the effort, and the ensuing pilots and demonstrations made it possible for the government to significantly tighten it in 1995 while still managing to keep the incremental cost low. As confidence grows and capacity is improving, many provinces now are actually implementing their own BEECs that are much more stringent than required by the current national mandatory codes.

Notes

[1]This general BEEC for commercial buildings superseded a BEEC that targeted only tourist hotels since 1993.

[2] The rural housing markets, which include small towns and rural villages, are not officially subjected to the mandatory BEECs.

[3] Estimates of the Ministry of Housing and Urban-Rural Development (formerly Ministry of Construction) based on its annual national inspections on BEEC compliance. China has 35 or so cities with urban population of 2 million or more, which are classified as large (2 to 4 million) or super large (over 4 million) cities.

[4] Chinese legislation allows provinces to adopt standards which are more stringent than the national ones.

[5] In addition to functioning as a resource centre for capacity building of State Designated Agencies, utilities, and financial institutions, EESL will function as a Super-ESCO and as a Consultancy Organization for CDM, energy efficiency, and so forth. (http://www.powermin.nic.in/JSP_ SERVLETS/jsp/newsdis.jsp?id=618).

CHAPTER 6

Mainstreaming BEECs in Developing Countries and International Assistance Strategies

Urbanization and growing wealth in developing countries portend a large increase of demand for modern energy services in residential, commercial- and public-service buildings in the next two decades. With about one third of global final energy used for serving people's energy needs in buildings, increasing the efficiency of building energy services is and will remain fundamental to national energy security and climate change mitigation.

The plugged-in energy loads of buildings and related energy use and efficiency, such as those of appliances and office equipment, can be addressed overtime and with flexibility and well-targeted policies and programs. But the built-in energy loads, such as those for space heating, space cooling and lighting, are intrinsically related to building design and construction and are best or must be addressed during the design and construction process. Energy efficiency measures related to the built-in energy loads are also much more difficult to implement because of the complexity of the building business and the deep-seated misalignment of incentives among involved parties.

Global experiences in the past 30 years or so indicate that mandatory BEECs, when practically formulated, continuously updated, and actually enforced, are both effective and economic in overcoming the market barriers and delivering energy savings. The global experiences also teach us that successful implementation of BEECs is a multifaceted, complex, resource-intensive process that can take many years to achieve, and that government interventions and persistency are critical to making energy efficiency a pillar of building construction.

There is an urgent need to assist middle-income and fast-growing developing countries where active space heating and/or space cooling are normal practices and where the formal building construction sector plays a large role in urban development. The following recommendations on country-driven actions and international assistance are primarily concerned with this category of countries. Several conditions are particularly important to foster in order to address the four key challenges summarized in Chapter 1 of this report.

Expand and Strengthen the Political Support for Energy Efficiency

Many developing countries have developed mandatory or voluntary BEECs, but most have failed or are currently unable to enforce or implement them in meaningful ways. Such failures may be easily attributed to the lack of indigenous technical, institutional, and market capacities. But often, the fundamental issue is the lack of necessary government support and commitment to enable the development of those capacities. Such political and organizational mobilization has to come within and often through the efforts of champions of energy efficiency at local, regional, and national levels.

The multilateral development institutions (MDIs) or bilateral assistance could help expand and strengthen the political support for energy efficiency by increasing the in-country knowledge and awareness of the critical issues, practical solutions, and cost-benefit implications of promoting energy efficiency in general and BEECs in particular. Considering the importance given to energy efficiency by the international community, it is useful to conduct more in-depth and actionable sector-level energy efficiency assessments for developing countries. Engaging countries in substantive discussions of their energy efficiency strategies and actions requires convincing evidence and analysis of the costs and benefits of pursing those activities.

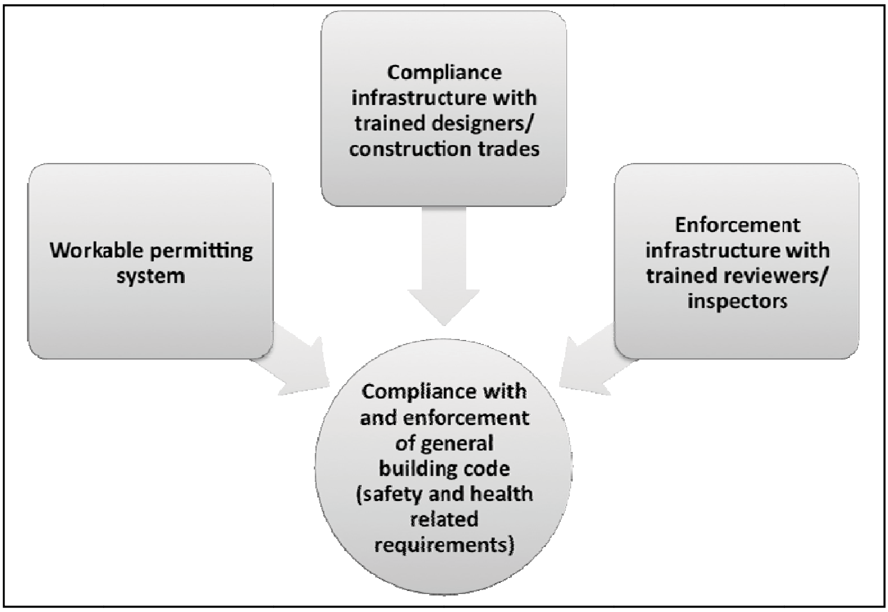
Improve the Effectiveness of Government Supervision of the Building Construction Sector

BEECs are a new dimension of government oversight of the building construction sector. But the elements of successful implementation are similar to those for implementing the general building codes (figure 6.1). It is difficult to imagine good compliance enforcement of BEECs if the building construction in general is poorly managed and governed. In many developing countries government oversight of the construction sector for traditional safety requirements is ineffective due to the combination of overly complicated and costly permit application and review process and a lack of resources to handle the required due diligence. As a result, a large portion of the building construction business is conducted informally, without any necessary inspections for basic building safety compliance.

The World Bank Group has tracked the building construction sector and observed some progress in reforming the process of obtaining construction permits.[1] Improving the effectiveness of government supervision of the building construction sector can be addressed by:

- Simplify the building laws and streamline the permit process and make it more user-friendly and predictable. Many countries (for example, Egypt) have simplified their building laws, reducing the number of procedures to be complied with and the time it takes to clear each procedure. However, many countries still show wide divergence locally (for example, states in India).
- Strengthen the compliance and enforcement infrastructure by committing requisite government resources and through involvement of nongovernment entities for regulatory due diligence. China has developed a government construction oversight system that depends heavily on third-party services for building codes, including BEECs, compliance, and enforcement. Mexico's building code compliance involves the private sector, as well.

Figure 6.1. Elements of Strengthening General Building Code Compliance



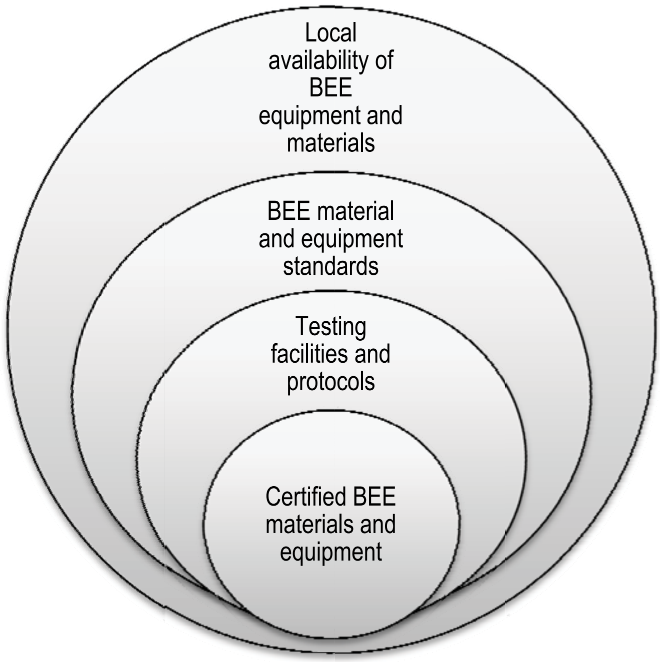
Source: Authors.

Develop Technical and Engineering Capacity of the Supply Chain

The local availability of materials and equipment that can reliably fulfill the requirements of the BEEC is frequently an issue that can slow down the progress of BEEC implementation. Construction materials such as insulation products or energy-efficient windows are usually produced locally and traded, at best, regionally. The local construction industry can be a strong opponent of BEEC implementation if it perceives BEECs as upsetting its manufacturing practices. Mexico is a case in point. However, strong and persistent push for BEEC compliance also sends unambiguous signals to local manufacturers about the type of products in demand. With increasing experience and more frequent application of BEECs, local manufacturing usually picks up. In China, for example, two-pane energy-efficient windows are now ubiquitous, low-emissivity coatings are becoming common, and various kinds of insulation materials are widely available. The remaining issue is one of reliability of the materials. The next steps would involve the development of standards for materials and equipment, the setup of testing facilities and protocols, and the development of a certification system (figure 6.2).

It is advisable that international assistance involved in the building energy efficiency demonstration projects during the first years after BEEC adoption pay special attention to the potential and viability for domestically producing the materials and components for BEEC compliance, as well as market development strategies to increase the supply and assure the quality of such products domestically or at regional level (involving multiple countries).

Figure 6.2. From BEEC Development to Implementation—Local Supply of Compliant Equipment and Materials



Source: Authors.

In parallel, different trades in the building supply chain need to be trained and updated about compliance requirements and good practices in every phase of building construction. National-level commitment and involvement is important in resource-constrained developing countries for establishing and sustaining systematic programs to educate new generation of architects and engineers, train professionals, inform the public, disseminate good practices, and standardize procedures. International assistance programmed into such nationally orchestrate efforts is likely to have greater systemic impact and value. China has taken this approach and achieved good results under the leadership of the Ministry of Housing and Urban-Rural Development. Although currently focusing on large commercial buildings, India is embarking on a similar approach under the leadership of the Bureau of Energy Efficiency to help its building construction sector to adapt to the compliance requirements of ECBC.

Capacity building for the building supply chain needs to extend to those tasked with enforcement of the building code, such as site plan and building design reviewers, construction and equipment inspectors, whether they are government employees or third parties. Although China relies heavily on certified third parties for compliance enforcement, all city governments maintain a division in their construction department with responsibility of overseeing and supporting BEEC implementation. These similarly tasked government administrative units form a national network for the capacity building and market development assistance supporting the implementation of BEECs.

For developing countries that have made significant inroads in achieving compliance of their first BEEC's, additional efforts should be made to support advanced energy efficiency programs. For BEECs to incrementally improve over time, it is desirable to have examples of greater energy efficiency. Utility incentive programs and green building programs can provide encouragement for progressive designers to go beyond the minimum requirements in the current BEEC. Their experiences will then provide examples that can be pointed to as support for the next increment in the subsequent update to the BEEC.

The same group of developing countries should also begin to regularly update their BEEC so as to provide a structure for incremental improvements in energy efficiency and allow adjustments to improve implementation. BEECs should be revised on a routine basis, such as every three years. In addition, it is desirable for this updating to be done on the same schedule as the national construction codes (building, mechanical, electrical, plumbing, and so forth.). This establishes the BEEC as an integral part of the family of codes, facilitates BEEC training, and provides an opportunity to refine the code language in the BEEC to improve implementation of existing requirements.

Bridge the Gap in Incremental Cost Financing

Despite their life-cycle cost advantages, more energy-efficient buildings in general will cost more to build than their less-efficient counterparts. Incremental costs in the range of 2 to 10 percent are frequently cited, depending on the stringency of BEEC requirements. Mandatory BEECs essentially require homeowners and building owners to pay for the incremental costs of energy-efficient buildings. But this creates tension in developing countries, where most of the population still is poor by developed country standards. For low-income countries, there are indeed hard tradeoffs between the current desire of having adequate housing and the long-term benefit of having energy-efficient housing. This constraint or dilemma can only be resolved with broad economic development and will take a long time for low-income countries. There is a larger development issue in the pursuit of more energy-efficient buildings. This has been amply demonstrated in the case of China.

In working toward the long-term goal of internalizing the incremental cost of more energy-efficient buildings, developing countries will need to rely on internal policy reforms to set their economies on a sustained growth path. Directly relevant to energy efficiency promotion, it is essential that the policy reforms should lead to rationalization of energy pricing and billing. Scarcity is the most powerful incentive to conservation and finding solutions to reduce waste. The most effective means of signaling scarcity is through proper pricing and charging for consumption. The economic benefits of BEECs do not transpire if building occupants underpay their energy services.

For middle-income developing countries, the incremental cost financing for compliance with their BEECs can and should be largely borne by the building/homeowners. China has essentially made that transition in its large cities. The main issue for many middle-income developing countries is to finance the resource needs to enforcement broad-based BEEC compliance. User fees included in permit fees or payments of developers to third parties (as is the case in China) would be the usual sources. Utility DSM programs funded by EE surcharges could be useful in paying for capacity building, incentives and monitoring, and evaluation.

For developing countries that have made significant inroads in achieving compliance of their first BEECs, additional efforts should be made to support advanced energy efficiency programs. For BEECs to incrementally improve over time, it is desirable to have examples of greater energy efficiency. Utility incentive programs and green building programs can provide encouragement for progressive designers and developers to go beyond the minimum requirements in the current BEEC. Their experiences will then provide examples that can be pointed to as support for the next increment in the subsequent update to the BEEC.

For low- and lower-middle-income countries, the incremental costs of development and implementing BEECs will be a major issue. It is thus important that these countries do what they can afford, targeting the market segment where economic benefits are greatest and enforcement is most likely to succeed. India's initial focus on large commercial buildings is a good example. However, while smaller buildings may not be regulated until a later phase, it is important to begin addressing at least some of the energy consumption in all buildings in some manner. Initiatives may include supporting architecture designs (such as appropriate building orientation, shading, natural ventilation and so on), which improve comfort without additional active energy services and energy efficiency measures that rely on locally available materials and benefit local manufacturing. Valuable companion programs with substantial benefits in the short- to medium-term would be to introduce energy efficiency standards for lighting and the most prevalent electrical appliances.

The Global Environment Facility (GEF) has been a principal source of international financing for development and implementation of BEECs, focusing primarily on supporting national code development, pilots, and demonstrations. While carbon financing and other clean technology investment financing mechanisms are not likely to be able to cover a significant portion of the incremental cost in adoption and enforcement of BEECs (see Mexico case study in Appendix 4), they could provide additional support to strengthening and broadening BEEC enforcement, and in particular encourage market-driven energy efficiency innovations from the private sector, such as the voluntary rating systems for green buildings.

Because of the complexity and high transaction cost of meeting the eligibility, monitoring and verification requirements of the Clean Development Mechanism (CDM)[2], component based carbon-financing schemes focusing on the use of certified products, such as a special type of windows, insulation materials of certain defined physical properties, and/or more efficient air conditioners, could help spur the broader adoption of components of higher energy efficiency performance. Such an approach would be especially useful in new residential constructions where benefits of energy savings are highly disaggregated and building-level verification is much more difficult than large commercial buildings.

Notes

[1] http://www.doingbusiness.org/ExploreTopics/DealingLicenses/.

[2] Cheng et al. (2008).

Appendixes

Appendix 1. Case Study: Implementing Building Energy Efficiency Codes in China[1]

Introduction

China is among the first in developing countries to introduce mandatory BEECs and has achieved significant success in compliance enforcement. Government inspections indicate that in a few dozen large cities, about 80 percent of residential buildings completed in 2008 complied with the applicable BEECs, compared with about 20 percent in 2005 and an abysmal 6 percent in 2000.[2] Much of the progress in compliance has been obtained only in the past five years or so, benefiting from the convergence of several factors due to government reform efforts and economic growth:

- *Governance of the urban building construction* has become more streamlined and transparent.
- The *system of BEEC compliance enforcement and procedures* has been improved and standardized.
- *Capacity of the construction industry* to meet the technical requirements of BEECs has become broad-based.
- *Quality building materials and components* for BEEC compliance have become widely available.
- The *ability to afford and willingness to pay* for the incremental costs of BEEC compliance have increased significantly.
- The *capacity and motivation of local governments to enforce BEECs* have been strengthened.

The national campaign to achieve the 20 percent energy intensity reduction goal of the 11th Five-Year Plan (2006–2010) has been critical to stepping up city-level compliance enforcement.

China's attempt to mandate energy efficiency for buildings began in 1986, when the first set of official minimum energy-efficiency requirements for centrally heated new apartment buildings and associated heat supply systems was issued for trial implementation. That effort led to the issuance of the first mandatory national BEEC for new residential buildings in cold climate regions in 1995. Two additional mandatory national BEECs for new residential buildings were issued in 2001 and 2003, respectively, covering different climate zones. The mandatory national BEEC for new public and commercial buildings was issued in 2005.[3] By then, China had in force a full set of mandatory BEECs for new residential, public, and commercial buildings.[4] To help strengthen consistency in compliance enforcement and standardize procedures, the national *Code for Acceptance of Energy Efficient Building Construction* was promulgated in 2007.

Each of the current set of national BEECs is, in theory, expected to achieve 50 percent energy savings for the applicable new buildings and end uses compared to their corresponding baseline buildings (based on standard designs in the 1980s) under the same operation conditions. Although actual measured energy savings are generally much lower, these theoretical thresholds do provide simple and clear targets for building designs. The Ministry of Housing and Urban-Rural Development (MoHURD) is set to promulgate a revised national residential BEEC for cold climate regions, with expected theoretical energy savings of 65 percent in 2010. As a sign of growing local confidence in compliance, Beijing and Tianjin, the two largest urban building construction markets in northern China, adopted similarly stringent local BEECs in 2004.[5] Several provinces have followed the steps of Beijing and Tianjin since 2007. Such subnational initiatives could become the driver for more advanced BEECs in the future. This perhaps is the most significant and rewarding outcome of China's national intervention in building energy efficiency.

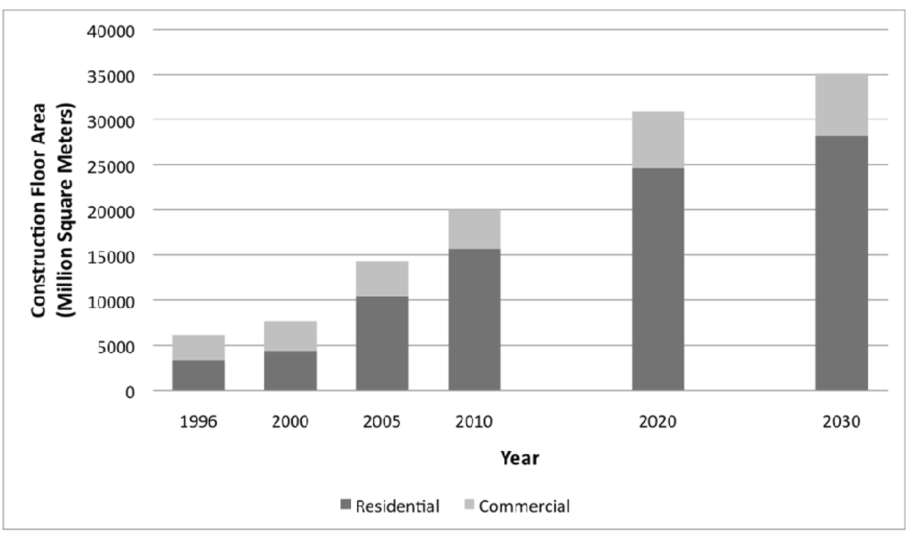
Sector Background and Energy Implications

Urban Construction Patterns and Trends

China's official urban population has tripled since 1980 and is currently about 600 million. [6] The share of registered urban population grew from 20 percent of the total population in 1980 to 45 percent in 2007. In absolute terms, urban population increased by about 11 million per year from 1980 to 1990, 16 million per year from 1990 to 2000, and over 19 million per year since 2000.[7] A recent study projected that China's urban population would exceed 1 billion by 2030.[8]

The urban housing reform started in the late 1980s. It introduced private home ownership and "commodified" urban housing supply. Commodification signifies a reform/transformation that changes the allocative mechanism from one of government control and central planning to one of commercial practices and market forces. This, coupled with strong economy growth, unleashed an unprecedented urban construction boom that has not yet shown signs of abating. From 1995 to 2005, the urban building stock almost tripled. It is projected to almost triple again by 2030 (figure A1.1).

Figure A1.1. Construction Floor Areas of Residential and Commercial Buildings in Chinese Cities, Actual and Projected in Million Square Meters



Sources: National Bureau of Statistics of China (http://www.stats.gov.cn) and Lang et al. (2008).

Urban construction in China is very organized compared to most other developing countries, an advantage for implementing BEECs. Efforts have been made to restrict large, informal settlements and unregulated constructions common in many large developing-country cities. This organized urban development has delivered staggering results in terms of the sheer quantities of modern urban buildings and infrastructures built in a short period of time, as is evident in figure A1.1. As the end of 2006, 65 percent of the urban building stock had been constructed within a span of 10 years. As of 2005, of the overall urban building stock, residential buildings accounted for 65 percent, public and commercial buildings for 24 percent, and industrial buildings for 11 percent of the total construction floor areas.[9]

Residential buildings in Chinese cities are multistories or high-rises of predominantly heavy-mass structures with solid brick or concrete walls. Commercial buildings also are predominantly heavy-mass structures and are increasingly equipped with central HVAC systems. Glazing areas in both residential and commercial buildings have increased dramatically.

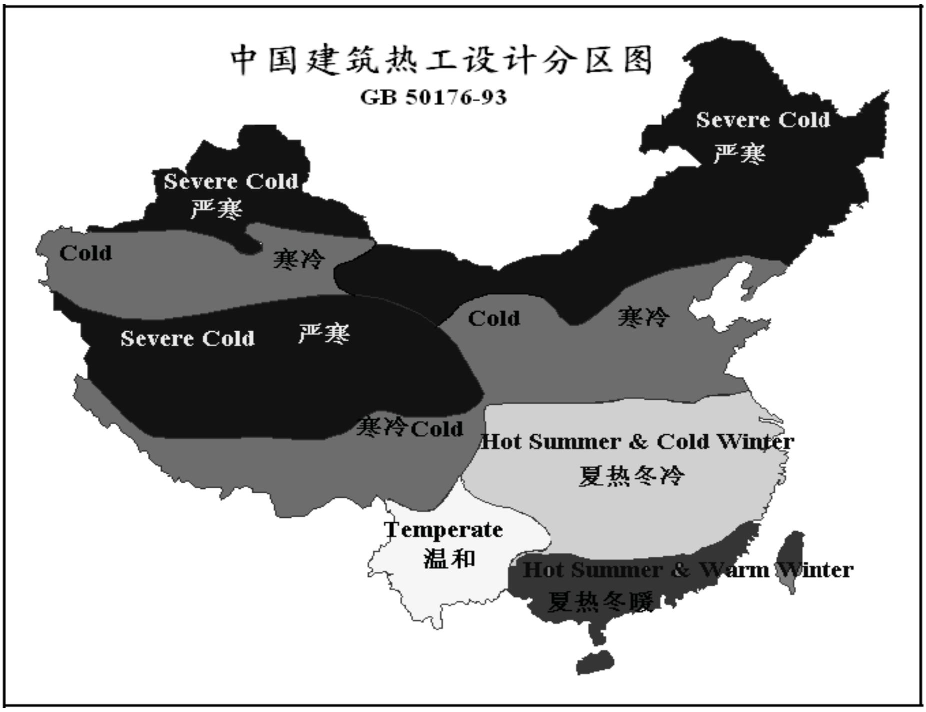
Climate Impact on Heating and Cooling Demand

Climatic conditions greatly affect the demands for space heating and air conditioning. For thermal design purpose China is divided into five climate zones (figure A1.2):

1. Severe cold zone—average temperature in the coldest month ≤ –10°C
2. Cold zone—average temperature in the coldest month 0 ~ –10°C
3. Hot-summer/cold-winter zone—average temperature in the coldest month 0 ~10°C and average temperature in the hottest month 25 ~ 30°C
4. Hot-summer/warm-winter zone—average temperature in the coldest month > 10°C and average temperature in the hottest month 25 ~ 29°C
5. Temperate zone—average temperature in the coldest month 0 ~ 13°C and average temperature in the hottest month 18 ~ 25°C

The three existing residential BEECs cover urban large residential construction in cold and severely cold zones, hot-summer and cold-winter zone, and hot-summer and warm-winter zone, which respectively account for about 42, 43, and 12 percent of urban residential, public and commercial building stock. Urban buildings in the temperate zone, about 3 percent of the total urban building stock, are not subjected to a mandatory residential BEEC. The BEEC for public and commercial buildings covers all climate zones. Compared with other parts of the world at the same latitude, the climate conditions are generally more severe in China: winter is colder and summer is hotter. Humidity levels are also high in eastern and southeastern regions. As such, identical buildings and consumption behavior would lead to higher heating and air-conditioning requirements in China than in many other countries at the same latitude.

Figure A1.2. Climatic Zoning for Building Thermal Design Purpose in China

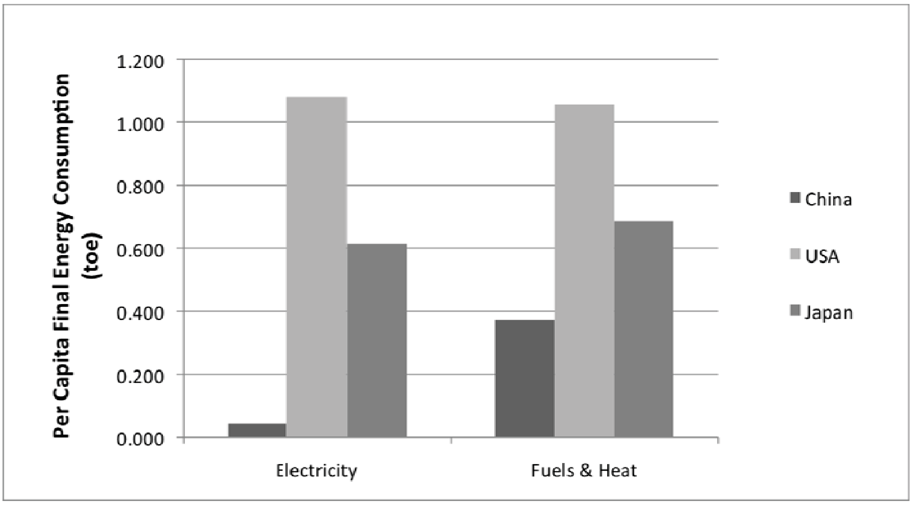


Source: GB 50176-93 Thermal Design Code for Civil Building, Ministry of Construction, China, 1993.

Energy Use and Efficiency in Residential, Public, and Commercial Building

According to International Energy Agency (IEA) statistics,[10] residential, public, and commercial buildings in China consumed about 455 TWh of electricity and 493 million tons of coal equivalent (Mtce) of fuels (including biomass) and heat in 2006, compared to about 2,651 TWh and 223 Mtce, respectively, in the United States. The differences in per capita consumption between the United States and China are large, spectacularly so in electricity use. The comparison provides an indication of what continued urbanization, income growth, and lifestyle change could result in end-use energy consumption in buildings (figure A1.3). This accentuates the importance of focusing on the drivers of future energy uses in residential, public, and commercial buildings in China.

Figure A1.3. Per Capita Energy Use (toe) in Residential, Public, and Commercial Buildings, 2006



Source: IEA Energy Statistics, 2006
Note: Excludes biomass. Electricity is converted into coal equivalent using a heating value of 0.123 gram of coal equivalent per kWh.

Statistics of specific energy uses in buildings are lacking. Among urban residential, public, and commercial buildings expert estimates put residential space heating as the largest energy end use at 41 percent in 2004. Other residential energy uses accounted for 24 percent, and public and commercial buildings for 35 percent.[11] With the rapid increases of household income and new apartment ownership, the demand for space heating and air conditioning has increased dramatically. From 1995 to 2007, district heating supply by floor area quadrupled and the air conditioning saturation rate in urban area shot up from 8 to 95 percent.

Measurement of the impact of BEECs is confounded by the absence of heat metering and consumption-based billing, the presence of fuel switching, and the rebound effect (increased comfort demand) induced by increased income levels. Recent surveys in Beijing indicate that actual energy savings of BEEC compliant buildings, while measurable, are much less than what is (theoretically) expected of BEEC. They also present interesting contrasts between coal-fired and gas-fired central heating systems. The latter is apparently much more fuel efficient in terms of net energy requirement (table A1.1). One must not read too much into these figures because of a lack of information on how the data were collected and what factors were controlled.

Even with large improvements and good compliance of technical energy efficiency standards in buildings, including building envelope and energy-consuming systems and equipment, overall energy use in Chinese buildings is likely to grow significantly in the next 20 years. This is, in part, because China, with continued income growth, is still moving up the energy consumption ladder with prevailing technologies (figure A1.3).

Table A1.1. Survey of Space Heating Energy Use in Beijing's Residential Buildings, Winter of 2007–08

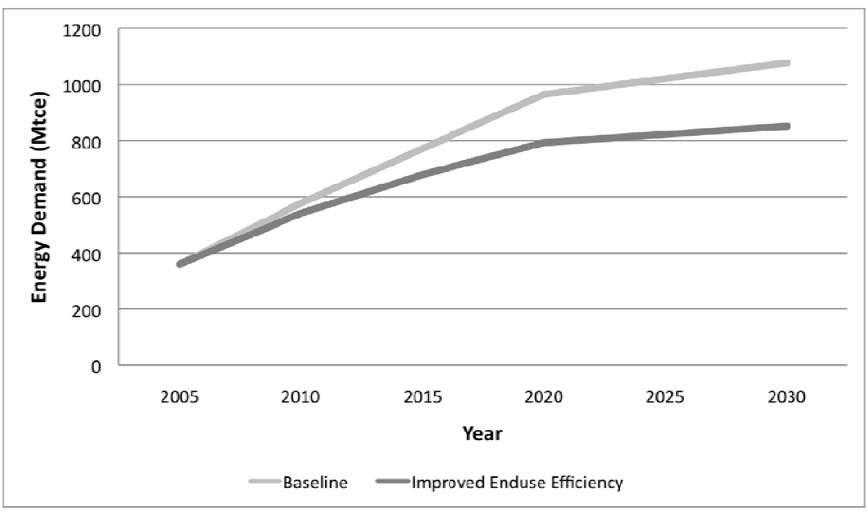
	Actual Coal Consumption (MJ/m^2-gross floor area)	Actual Natural Gas Consumption (MJ/m^2-gross floor area)
Pre-BEEC buildings (baseline)	708	345
Buildings compliant with BEEC-95 (50% theoretical reduction in fuel use)	448	281
Buildings compliant with current Beijing BEEC (65% theoretical reduction in fuel use)	**	260

Source: Lang/Tu (2009).

Note: Apartment buildings built after the promulgation of the current Beijing BEEC (2005) are, in general, served by gas-fired heating systems.

About 40 percent of China's urban building stock by 2030 will be built after 2010. Making sure that those buildings attain increasingly higher energy efficiency performance will have a large impact on energy consumption of the building sector. Recent scenario analysis indicates that increased stringency of BEECs and applicable minimum energy efficiency standards for appliances, as well as increased compliance, together with retrofit efforts, would lead to a large reduction in energy requirements from residential, and commercial buildings in Chinese cities, up to 225 Mtce/yr by 2030, compared with a baseline where BEECs and other end-use efficiency are less aggressively pursued (figure A1.4). Large-scale application of advanced designs and technologies (such as passive buildings with ultra-low heating and cooling

Figure A1.4. Scenarios of Energy Demand (Mtce) in Residential, Public, and Commercial Buildings in Chinese Cities, 2005–30



Source: Lang (2008).

Note: Electricity consumption represented in this figure is converted into coal equivalent by the heating value of average fuel requirement for thermal electricity generation per kWh, which changes over time.

requirements) and sea changes in lifestyle (proactive conservation behaviors) could further flatten the lower energy curve and even start to push it downward in the outer years of the next two decades.

Development of Building Energy Efficiency Codes

Systematic government efforts on energy conservation in China started in the 6th Five-Year Plan period (1981–1985), thanks to the advocacy of a group of prominent intellectuals and similarly minded government officials. Although energy efficiency renovations in industrial sectors were the focus at the time, government policy advisors also sensed the importance of the building sector, especially for new buildings. Starting from scratch, the initial approach to introducing BEEC was realistically cautious and gradual to ensure that the new energy efficiency requirements were technically feasible and financially viable. The key characteristics of the process in developing China's first mandatory BEEC are summarized next.

Garnering Broad-Based Political Support

Promoting building energy efficiency started as part of a broad national energy conservation strategy endorsed by the central government. This ensured robust and broad-based political support, even though the work was spearheaded by the then Ministry of Construction.[12] The initial research and development activities were also supported by the then State Economic Commission and State Planning Commission, two key agencies in charge of economic planning and execution. In the Chinese governance system, consensus at the national level enabled the alignment of the local-level political support.

Focusing on High-Impact Buildings First

The initial efforts of BEEC development targeted large residential buildings in cold-climate cities only. This decision was made because such buildings (1) accounted for about half of all residential buildings in urban China and far outweighed public and commercial buildings in terms of total floor area, (2) consumed substantially more energy than buildings in other climate regions because of space heating,[13] and (3) were the main contributor of serious winter air pollution in northern cities because space heating was exclusively based on coal. Centralized space heating, which would supply all new residential developments in cold climate cities, was extremely wasteful due to poor thermal performance of building envelope and inefficient heat supply systems.

Setting a Clear and Realistic Energy Efficiency Target Based on Robust Empirical Evidence

In the early 1980s, the Chinese economy was still operating at basic substance level (between 1980 and 2007, real GDP increased by 13 times). The incremental construction cost of building energy efficiency requirements was of great concern to policy makers, and serious efforts were made to understand how much efficiency gain was achievable at affordable cost. The trial edition of the BEEC issued in 1986 was very conservative. But it ushered in large-scale demonstrations. About 30 million m^2 apartment buildings were built across major cities in cold-climate regions in the next nine years to test various compliance approaches, technologies, and materials. This large-scale experiment gave policy makers confidence to eventually promulgate a more stringent and mandatory national BEEC in late 1995 (referred to as BEEC-95 thereafter), which still is in force. Information from demonstration and pilot projects suggested that for cities across the cold-climate regions, the incremental construction cost for compliant buildings would not exceed 10 percent of the baseline construction cost of the building, an implicit threshold for affordability.

Keeping the Requirements Simple and Prescriptive

The high homogeneity of Chinese apartment buildings in terms of basic design and construction materials is a big advantage to introducing simple and prescriptive energy efficient design requirements. The BEEC-95 is a substantive model regulation that establishes the methodologies, criteria, restrictions, and reference (target) values for determining specific regulated energy efficiency parameters in specific subclimate zones across a vast geographical area of China. It establishes minimum thermal performance requirements for the whole building envelope and its components while also setting key design parameters for boiler house and heat supply network. The minimum thermal performance requirements for the building envelope in the BEEC-95 centers around a key indicator called *building heat consumption index* (BHCI),[14] which is the *calculated average heat demand* per m^2 floor area of a given building during the heating season (equivalent of maximum allowed heat losses through building envelope). The maximum BHCI allowed for a subclimate zone is considered the most important compliance parameter that every building design has to demonstrate according to the methodology defined by the BEEC-95, in addition to meeting the U-factor requirements for different building envelope components.

Key Characteristics of Chinese BEECs

In summary, the following can be said of the current Chinese practice in regulating energy efficiency performance of buildings:

- National model codes need provincial-level adoption.
- Practices apply to new building construction as well as to additions and retrofits of existing buildings.
- They contain mandatory requirements (U-factors for windows, for example) plus voluntary elements (for example, for natural ventilation).
- Emphasize requirements for building envelope thermal performance, although
  - Residential code for cold climate regions also covers central heating system energy efficiency; the two hot summer region codes include HVAC system requirements.
  - Commercial building code also addresses HVAC system efficiency.
  - Separate national standards for lighting, room air conditioners, and commercial HVAC equipment are referred to by BEECs.
- Practices are largely prescriptive but use flexibility in
  - Allowing tradeoff between envelope components in residential codes.
  - Allowing energy budget option for commercial buildings.

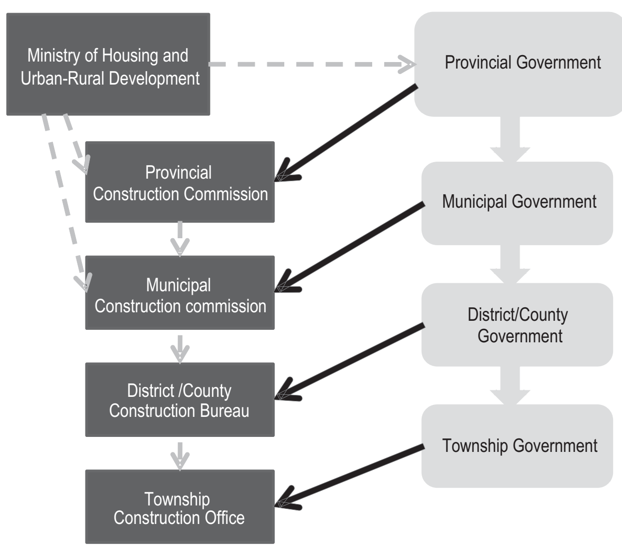
Implementation of Building Energy Efficiency Codes

It took China about 20 years to finally achieve a relatively broad level of success in BEEC compliance. This, in view of the tradition of strong government intervention in China, is a testimony to the difficulties of implementing BEECs in developing countries, where the broad enabling environment is often weak. It should be noted that at the time of starting with BEEC implementation, a functional government oversight system for building construction under a more market-based system did not exist yet. Rather, the national government had to put in a completely new system for managing urban construction into which BEEC compliance and enforcement was integrated gradually.

Urban Construction Management

Urban construction is regulated nationally but managed locally. Provincial governments are responsible for adapting national regulations and codes to regional conditions (for example, seismic or climatic) and municipal (and lower-level) governments are responsible for actual enforcement. Figure A1.5 illustrates the administrative structure of urban construction management. MoHURD develops and oversees sector policies but is not administratively linked to its corresponding agencies in provincial, municipal, and lower-level governments. MoHURD obtains its coercion power from the State Council as exemplified in the recent nationwide push for BEEC compliance as part of the overall drive to achieve the energy-savings targets set by the State Council in the 11th Five-Year Plan.

Figure A1.5. Government Oversight of Urban Construction Management



Source: Authors.

The Housing Construction Cycle and Institutional Arrangements for BEEC Compliance

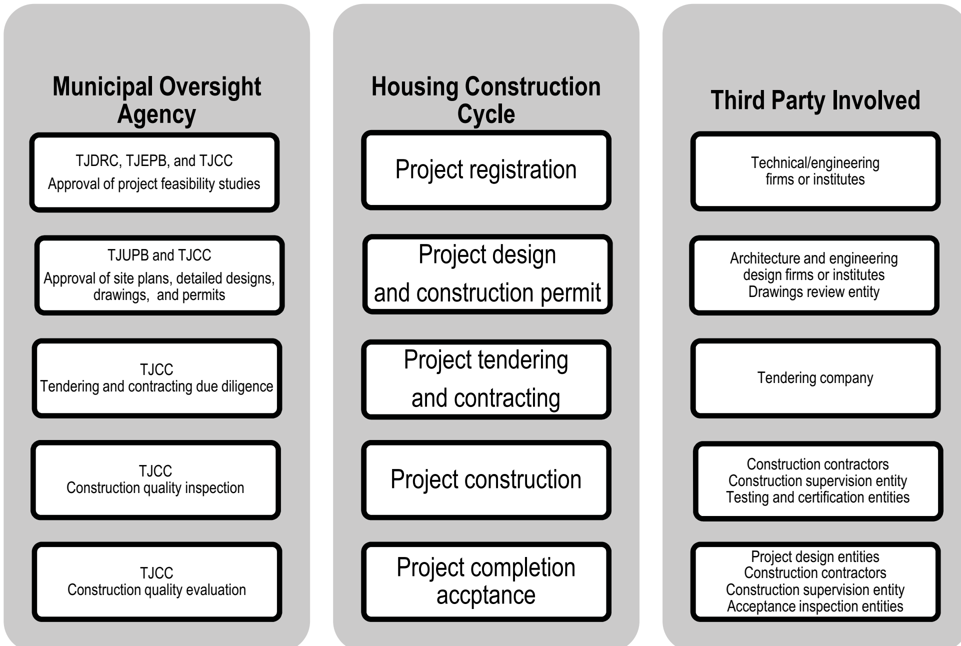
The commodification of housing supply in the late 1980s brought drastic changes to the way the government managed the urban housing construction sector. Over a period of ten years or so, housing supply (and supply of other urban building types as well) was transformed from a predominantly government planned and sponsored activity to one that relies on commercial entities who are subjected to government regulations and oversight. Real estate developers need to comply with various government regulations during the different phases of the construction cycle.

Tianjin Municipality was a pioneer in integrating BEEC compliance into the regular housing construction cycle. Tianjin's practice is used to illustrate the typical process for achieving BEEC compliance in China.

A housing development project in Tianjin (and typically so in other cities as well) goes through a five-phase cycle before the keys are turned over to apartment owners. The developer needs to interact with government oversight agencies, including mainly various departments of Tianjin Construction Commission (TJCC), Tianjin Development and Reform Commission (TJDRC), Tianjin Environmental Protection Bureau (TJEPB), and Tianjin Urban Planning Bureau (TJUPB), to obtain necessary government approvals. The developer has to rely on the services of multiple third-party entities to comply with basic requirements needed for those approvals (figure A1.6). Such structured and regulated construction transaction arrangements took shape only in the last 20 years or so.

The responsibilities of government oversight agencies for BEEC compliance are now well defined and in general are followed by concerned agencies through the construction cycle. TJCC, through its functional divisions, is the designated line agency involved in the entire construction cycle. This includes the overall supervision and coordination provided through the Building Energy Conservation Office, due diligence in design review through the Construction Design Management Department, due diligence in the tendering and contracting process through the Tender and Contract Management Office, and compliance enforcement during construction through the General Station for Building Construction Quality Supervision, and overall technical and administrative support provided by Tianjin Building Wall Reform and Energy Conservation Management Center, a quasi-government agency reporting to TJCC. The role of this Center has been critical historically and still is important to ensure BEEC compliance because it has been the main repository of local BEEC technical competence. It also acts as the municipal government's BEEC inspector (although the enforcement authority lies with the General Station for Building Construction Quality Supervision). This is generally the case in many northern cities where such an organization exists.[15]

Figure A1.6. Tianjin: Housing Construction Cycle and Stakeholder Involvement



Source: Authors.

Although oversight of the government agencies remains critical, the BEEC compliance process now relies heavily on due diligence of the developer through third-party services: The architects have to design according to BEEC requirements, a qualified review entity has to certify the construction drawings as BEEC compliant, a qualified testing facility will conduct tests of samples of materials and components to verify BEEC compliance, the construction supervision entity has to perform required checks and inspections, and an independent technical entity will perform sample testing of building envelop thermal properties and evaluate overall BEEC compliance as part of the completion acceptance inspection. The roles of the government agencies are to make sure that these procedures are properly followed and penalties are enforced if violations are found. For example, licenses of third-party entities can be suspended or revoked if they are found to be negligent. If improper installation of wall insulation is identified by a random site inspection of the Building Wall Reform and Energy Conservation Management Center, reports will be filed with the General Station for Building Construction Quality Supervision, which will suspend the construction and require completion of remediation measures by the developer before such sanction is lifted.[16]

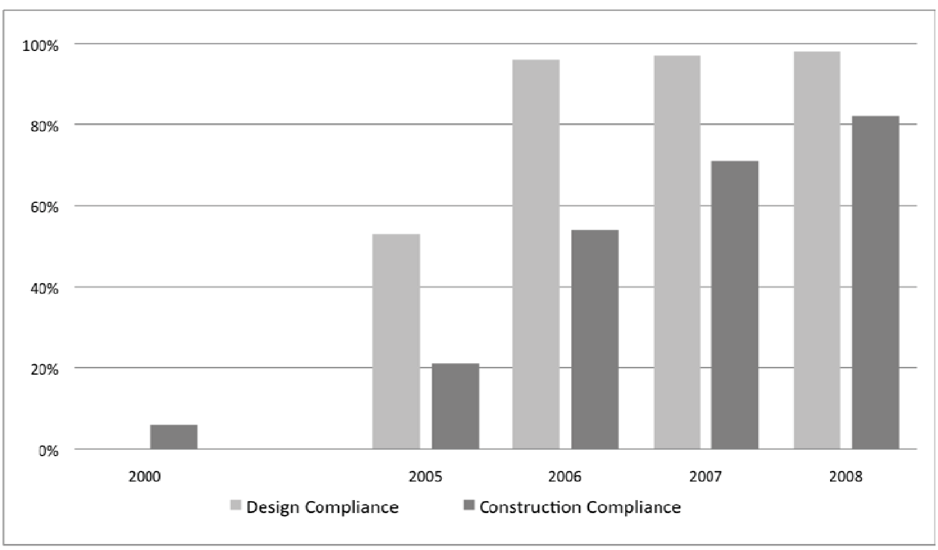
For such a distributed-responsibility system to work effectively, the third-party entities must be proficient about their specialty areas and keenly aware of their due-diligence responsibilities in the BEEC compliance chain. In fact, they have to take training courses and pass fairly stringent national licensing exams. The government also needs to have a clear sense of responsibility and adequate human resources to monitor these entities so as to maintain credible threats to potential violators. Potential negligence or abuse of power of involved parties notwithstanding, establishing this system of accountability is a critical step toward broad-based BEEC compliance and continuous improvement.

The third-party compliance approach has its advantage in alleviating government resources constraints in view of the huge scale of China's urban construction. It also effectively internalizes the cost of compliance enforcement, since the developer is paying for the third-party reviewers, inspectors, and supervisors. In the future, compliance could be improved further by targeting consumers with an awareness campaign to educate them about the developers' obligations in delivering BEEC compliance and the benefits of energy-efficient housing. This would create more market demand for BEEC-compliant residential buildings.

Achieving BEEC Compliance and Lessons Learned

National inspections conducted by MoHURD since 2005 indicate that in a few dozen of largest cities BEEC compliance has gone mainstream, not only at the design stage, but also in actual construction (figure A1.7). This annual survey follows a consistent methodology. Local construction commissions are scored based on the inspection results, providing some incentive to carry out good enforcement. The quality of compliance is, however, hard to gauge and there have been many documented cases where BEEC requirements were poorly executed. But by and large, BEEC compliance has become broad-based practice in new building construction. Compliance at the construction level does not necessarily mean, however, that compliant buildings

Figure A1.7. Results of National Inspection on BEEC Compliance in Large Chinese Cities



Source: Press Releases, Ministry of Housing and Urban-Rural Development.

actually achieve the energy-savings stipulated in the BEECs. When actual building energy consumption is measured, which is not systematically done, more often than not it falls short of the savings target. But as mentioned in chapter 3, this is a common occurrence also in mature markets.

Four aspects of the Chinese efforts to mainstream BEEC compliance are particularly noteworthy.

1. *Establishment of a streamlined urban construction management system.* Internationally, integration of BEEC enforcement into the regular building construction management system is often cited as a key to success in scaling up BEEC compliance. But this experience comes from industrialized countries where the construction sector is mature and rules and regulations are relatively well established and followed. In that respect, the Chinese efforts in developing a functional government-regulated but commercially operated urban construction market have been fundamental to BEEC compliance. The current reliance on third-party services for BEEC compliance is a direct product of mapping BEEC requirements into the new urban construction management system.
2. *Development of capacity and concrete compliance methods at the local level.* The Chinese regulatory process normally requires a national regulation to be formally adopted by provincial governments (or provincial-status municipalities such as Beijing and Tianjin) to become locally effective. This is an important provision to get regional government organized and prepared for implementation, as they are required to issue a provincial version of the same regulation of equal or greater stringency. This adoption and adaptation process also includes development of locally suitable compliance methods, which include specific technical designs for building envelope components, for example, the drawings of insulated exterior wall, roof, and thermal bridges using alternative materials. Consequently, trainings are conducted for local architects, and pilots are carried out to get local developers and builders familiarized with the compliance techniques and materials before the provincial BEEC becomes effective. This usually takes place first in the provincial capital, which almost always is the largest city of a Chinese province. The truth is that even for a leading city like Tianjin, developing initial BEEC compliance capacity takes a long time. In the case of BEEC-95, it took Tianjin about two years to issue its own version (1997) and still a few more years to reach a significant level of compliance. MoHURD provided technical assistance to local capacity building in compliance enforcement, studied and monitored the progress, and facilitated cross-sharing of good experiences. These efforts eventually led to the standardization of compliance enforcement procedures in the national *Code for Acceptance of Energy Efficient Building Construction*, complete with standard BEEC inspection forms and checklists.[17] Such standard procedures may not solve all compliance issues, but they are valuable for dealing with the most common problems and provide a good foundation to further improve compliance locally and to develop more stringent BEECs, as Tianjin and Beijing, for example, have done.

3. *Development of markets for materials and components for BEEC compliance.* The availability of materials and components for BEEC compliance and the lack of experience in using them were major constraints to scaling up BEEC compliance in the 1990s. MoHURD encouraged experiments with different insulation materials and techniques. In the cold-climate region, the exterior cladding system using expanded polystyrene (EPS) panels became the dominant exterior wall insulation method in the early 2000s because it is easy to manufacture, quick to install, and relatively cheap, while also providing good thermal insulation.[18] Double-glazed vinyl windows were introduced initially for BEEC compliance, but quickly became popular because they also provide good sound insulation. In recent years, as the housing market continues to move up the amenity ladder, casement windows, more expensive but more durable and more airtight than sliding windows, have become increasingly popular. In the last ten years or so, a booming housing market and a fast-expanding transport network have contributed to making the materials and components for BEEC compliance widely available throughout China. But the market remains very fragmented in terms of the large number of manufacturers and suppliers and highly variable quality of products. Moving the market toward providing consistent quality products will require increased BEEC compliance enforcement for testing and certification of insulation materials and fenestration products. The construction industry is still prone to corner cutting by using substandard materials and components. It is aided by some testing laboratories that, while certified, do not employ very rigorous testing protocols and allow manufacturers to shop around for the best results. But the lack of quality materials and components is no longer a major constraint to BEEC compliance.
4. *Leadership and stewardship of the national government.* To include BEEC into the national energy policy agenda in the mid-1980s when most Chinese families lived in cramped quarters was considerable farsightedness of national leaders. The former Ministry of Construction (now MoHURD) played a pivotal role in initiating, keeping alive, and strengthening the BEEC agenda in China over a period of time that was characterized by other much bigger reform agendas of the central government. MoHURD's broad sector responsibilities, including strategic policies and sector regulations in urban infrastructure, municipal services, urban housing market, building construction, and the construction supply chain have at times overwhelmed and marginalized its activities in promoting BEEC. The incubating role of MoHURD was critical at the beginning when the knowledge base of BEEC was small and concentrated in just a few academic/research institutions, there was little domestic experience on designing and construction of thermal-performance-enhanced buildings, and there was no commercial scale production of insulation materials and double-glazed windows. However, MoHURD's ability to influence BEEC implementation has been constrained by its limited coercion power since provincial governments are its political equals. It has become more successful since 2006, when the State Council pressured provinces to act upon the energy intensity reduction target.

Improvements Needed and Future Directions of BEEC Compliance in China[19]

Although official reports indicate much progress in BEEC compliance of buildings, the system of enforcement still needs improvements, especially in the following areas:

- The current BEECs focus on specific energy efficiency requirements for building level designs and their implementation. Some low- or zero-cost energy efficiency gains can be achieved by providing some clear and specific requirements or guidance for real estate development master plans—for example, by improving the building form, orientation, and sun shading. These parameters need to be set in the *Control Site Plan* stage when the development's master plan is approved. After that stage, there is very little flexibility in the planning parameters, and this can adversely affect building-level energy efficiency.
- Address some gaps in design requirements arising from changes in building features due to market demand. For example, balconies are often sealed up with windows and used as additional internal floor area. But treating them as part of the formal apartment would change the formal shape of the building and violate regulations for shading, distance between buildings, and other ratios. Discretion on design review of this aspect often fails to adequately address excessive heat losses or gains because of the large glazing area of the enclosed balconies.
- Due to a lack of resources and human capacity the frequency of inspection for buildings under construction are not sufficient or done superficially. Some cities like Tianjin have formally included checklists in routine inspection procedures for BEEC enforcement, but this is not ubiquitous.

Practical experiences of demonstration projects in the GEF and World Bank supported *Heat Reform and Building Energy Efficiency Project* (HRBEE) implemented by MoHURD identified several other measures that would fill perceived gaps:

- A review of the *technical offer* by the construction company to the developer could help ensure that it complies with the technical specifications and construction drawings.
- Workshops should be held to communicate BEEC requirements in a user-friendly and practical manner to the quality inspection station, the construction supervisor, and the developer's project manager to strengthen understanding of requirements.
- Checklists as part of acceptance procedures, prepared during key stages of the project construction cycle, should be adopted.
- Training of the construction workers and construction supervisors by quality inspection stations (training could focus on one building element for one month, then another in a step-by -step capacity-building effort).
- Verification of the technical documentation: certification of products and installation standards could be done with spot checks.

Large disparities in climate conditions, technical capacities, and the level of economic development lead to significant variations in compliance efforts and results among different provinces or cities. Although compliance in large cities is improving, as indicated by recent national inspections, the lack of resources, knowledge, and capacities prevents implementation of BEEC requirements in medium and small cities, which account for about two thirds of the new building construction in urban areas. Anecdotal evidence indicates that BEEC compliance rates in medium and small cities are generally much lower than in large cities. In the near term, the big challenge for China is to replicate the recent success in BEEC compliance in a few dozen large cities in hundreds of medium and small cities, a good target group for the national compliance enforcement campaign during the 12th Five-Year Plan period (2011–2015). This will require continued political pressure and technical assistance from the central and provincial governments to local governments.

The government is tapping into the market forces for improved BEEC compliance, especially in the area of increasing consumer awareness and rights about the basic BEEC obligations of developers. MoHURD has been promoting labeling and certification for insulation materials and fenestration products, and more recently initiated piloting of whole building energy efficiency labeling. Such efforts will further broaden the geographical coverage of BEEC compliance and enhance quality and transparency of compliance.

Building labeling is now recognized as a valuable tool to influence real estate buyers and thus create incentives for developers to pay closer attention to BEECs. Under MoHURD's pilot building labeling system, developers pay for participation (two part charges of RMB 1/m^2 for prelabel design compliance and generally between RMB 30,000—RMB 100,000 for monitoring and verification depending on the size of the building.) This labeling goes from one to five stars, according to energy efficiency performance and utilization of renewable energies. There are two stages of labeling: (1) a prelabeling after the commissioning stage based on actual (revised) construction drawings submitted to the relevant municipal authorities and (2) final labeling attributed after testing and appraisal by certified laboratories that is implemented from one to five years after the commissioning.

The fact that quite a few large cities and a couple of provinces are now able and willing to go beyond the requirements of national BEECs indicates that the driving force for market transformation has begun to shift toward regions. This new dynamism will serve China well. The larger and more advanced markets will lead in innovations and provide the rest of the country with ideas and experiences.

MoHURD will have an increasing role as a facilitator even as it retains its responsibility of developing national BEECs. With the increasing sophistication of building markets, MoHURD should consider to update BEECs on a regular schedule and include all aspects of building energy efficiency in one code document to enable that the separate energy aspects of buildings are better integrated, leading to better energy performance of buildings.

Notes

[1] This summary note was written by Feng Liu, Energy Sector Management Assistance Program of the World Bank, based on inputs from Siwei Lang of China Academy of Building Research and Fengxiang Tu of China Construction Industry Association.
[2] Estimates of the Ministry of Housing and Urban-Rural Development (MoHURD, formerly Ministry of Construction) based on its annual national inspections on BEEC compliance. China has 35 or so cities with urban population of 2 million or more, which are classified as large (2 to 4 million) or super large (over 4 million) cities.
[3] This general BEEC for commercial buildings superseded a BEEC that targeted only tourist hotels since 1993.
[4] The rural housing markets, which include small towns and rural villages, are not officially subjected to the mandatory BEECs.
[5] Chinese legislation allows provinces to adopt standards which are more stringent than the national ones.
[6] Tens of millions of migrants from rural areas are not included in the official urban population count.
[7] National Bureau of Statistics of China, http://www.stats.gov.cn/tjsj/.
[8] McKinsey Global Institute (2008).
[9] Public and commercial buildings include all building types which are not identified as residential or industrial buildings. Typically they include office buildings, schools, hospitals, hotels, shopping malls, transport terminals, and so forth.
[10] IEA Energy Statistics, http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Balances.
[11] Tsinghua University Research Center for Energy Efficiency in Buildings (2008).
[12] Chinese political decision making is largely based on consensus among the top leadership. The term of "broad-based" here is related to that consensus building.
[13] Note that in the early 1980s air conditioning was basically nonexistent in China.
[14] Defined as the net heat consumed in unit time by unit construction floor area (W/m^2) at outdoor mean air temperature during the official heating season to maintain the indoor design air temperature. In disaggregate terms, BHCI equals to the sum of net heat losses through all building envelope components via conduction, plus heat losses through infiltration, and minus internal heat gains, all on a seasonal average basis. The solar heat gains are factored into the calculation of the net heat losses through each building envelope component by applying a set of predetermined coefficients.
[15] In their early existence, they were generally called Building Wall Reform Office (BWRO) and were part of local government construction authority. They were set up in the 1980s to promote alternative wall materials to clay bricks whose manufacturing was destroying prime farm land near cities. Later, the BWROs were conveniently tasked to help promote BEEC-95. They became an official affiliate of local governments as a result of government downsizing. In Beijing and Tianjin where they were particularly strong, BWROs became the champions for BEEC. Although the role and the name of the former WMROs have changed as BEEC compliance was gradually integrated into the regular construction quality supervision, the moral of the WMRO story is that dedicated institutional and human resources support at city government level has to be in place to meaningfully implement BEECs.
[16] This peculiar informant and enforcer setup in BEEC compliance is a practical solution to the institutional legacy of BEEC in northern China. It also allows the government to enforce regulations more effectively without adding to the ranks of civil servants.
[17] The acceptance code also includes some aspects of commissioning, for example, it requires testing runs of HVAC equipment.

[18] EPS panels are flammable and banned, for example, in the United States and Russia. An alternative, but more expensive insulation material is rockwool.
[19] This section draws upon the presentations by Gailius Draugelis, Task Team Leader for the HRBEE project, and Marc Bellanger, Consultant, at a seminar on building energy efficiency at the World Bank, Beijing, October 12, 2009.

Appendix 2. Case Study: Building Energy Efficiency Codes in Egypt[1]

Introduction and Conclusions

BEECs were introduced in Egypt between 2005 and 2009. They impose mandatory energy performance requirements for residential, commercial, and public buildings in three different code documents. A proposed implementation plan based on best practices of international experience has, not been carried out. Consequently, training and capacity building of actors in the building chain has not been accomplished and compliance and enforcement procedures required at the local level are not available to municipalities responsible for enforcement of building codes. BEECs are thus not enforced. This is not a surprise in a country with a very complex, lengthy, and expensive system of procedures to apply for and receive construction permits. As a result, the majority of construction takes place in the informal sector.

The government supports residential developments for low-income housing, especially in new cities. As the Mexican national housing program (see Mexico case study, Appendix 4) has shown, such construction projects can serve as a large-scale demonstration of the application of BEECs and provide valuable information of costs and benefits of energy efficient construction and appliances. They could also give a boost to local industry in the manufacturing of energy efficient building materials such as insulation and windows. The earlier failure in Egypt of requirements to incorporate solar water heating equipment into public housing programs shows that strict quality control and enforcement of the requirement is a necessary condition for success.

Equipment standards and labeling of appliances that are responsible for a large share of electricity consumption, such as air conditioners, have been introduced. Since most of the energy consumption in the building sector (that is, the residential, commercial and public sector) is for appliances, it may be more beneficial in the short to medium term to design standards and labels for a wider variety of popular appliances, provided they are enforced and retailers and consumers educated about their benefits. A better targeting of subsidies for electricity that limits them to truly low-income households would provide a sound basis for the energy efficient transformation of the appliance market.

Even though power-sector reform has the goal of reducing subsidies for all but low-income households, subsidized electricity tariffs for almost all residential consumers and small commercial users still create substantial disincentives to adopt energy efficiency measures.

This case study illustrates that for many countries that struggle with enforcement of basic building codes and that have, on the other hand, a very significant energy consumption through appliances, it may be beneficial to concentrate first on achieving a good compliance with appliance standards and get consumers accustomed to paying attention to efficiency aspects. In the meantime, government housing programs, voluntary green building standards and incentives to comply with BEECs may be helpful to familiarize the construction industry and suppliers of energy efficient building materials with building energy efficiency technologies, as well as spread the word about the benefits of energy efficient buildings.

Sector Background and Energy Implications

Urban Population and Construction Patterns and Trends

About two thirds of Egypt's total population of 73 million (2005) are living in urban areas (that is, settlements with more than 10,000 inhabitants). Using the official Egyptian definition, which excludes urbanized rural areas, the share would be only 43 percent. By 2030, Egypt's population is expected to reach over 104 million (see table A2.1).[2]

Egypt's population is concentrated in only 5.5 percent of the territory. About 30 percent live in the two biggest cities, Cairo and Alexandria, a total of about 65 percent in Cairo and the Nile delta.

The Egyptian building stock comprises about 11.5 million buildings. 60 percent of building units are in the residential sector. Expenditures in the construction sector is expected to increase by about 3 to 4 percent annually between 2005 and 2015, slightly less than in the immediate past.

Table A2.1. Building Stock in Egypt, 2006 and 2030 Projection

	Buildings (million) 2006/2030	Units (million) 2006/2030
Residential	n.a.	16.5/22.8
Nonresidential	n.a.	11.3/16.0
	11.5/16.0	27.8/38.8

Source: Mosallam/Miraj (2009).

Note: 2006 data are based on Saleh (2008); 2030 Projection is based on population growth between 2006 and 2030 and corresponding linear expansion of each category of housing stock during this period. Data are from "Egyptian Population Per Year Over Selected Years", Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2008 Revision.

Supply and demand of urban housing is mismatched. The number of housing units in urban areas reached about 9.5 million units, whereas the number of urban households is estimated at only about 6.8 million units. A significant number of units are vacant. At the same time, there is a significant shortage of housing units not only for low-income but also for middle-income households. It is estimated that "around 175,000 to 200,000 new housing units[3] are needed annually to keep pace with household formation, but that only the top 10 to 20 percent of the income distribution can afford to acquire a formal sector house."[4] One of the main reasons for the nonaffordability of formal housing is the lack of mortgage lending, which, in turn, is caused by inadequate legal infrastructure; high registration fees, taxes and inefficient property registration procedures; restrictions on bank credit to the housing sector; lack of risk information for lenders; and inconsistent approach to property valuations.[5]

As a result, a large share of residential (and commercial) construction takes place in the informal sector. Of Egypt's urban population, 40 to 50 percent is estimated to live in informal settlements and squatter areas. "The informality label characterizes housing built in violation of existing urban planning legislation and the building code, often by converting (legally owned) agricultural land to urban uses without land subdivision or building permits, and in almost all cases without registered property titles (whether legally owned land and property or squatter)."[6]

More than half of the new housing stock is built informally; the rest is shared by the government and the private sector. The private sector has become increasingly important as a source of housing construction, targeted at upper-income families, supplying at least half of formal housing construction.

Government-built housing is concentrated in several programs targeted at limited-income families; they feature apartment blocks on state land in new towns or city fringes. Units are heavily subsidized, up to 75 percent.

Informal housing usually consists of small apartments (40–80 m^2) in multistory walkups. The structural integrity of buildings, especially those recently built, is fairly good as is the overall quality of construction, since the builder will usually own and "consume" the product.

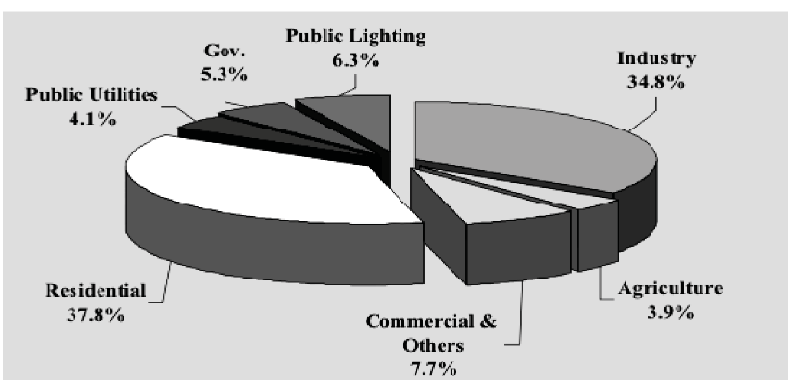
Substantial urban planning reforms are currently taking place in Egypt. The centerpiece is the new Unified Building Law (119/2008). It combines planning, subdivision, and building regulations, and provides new structures for building maintenance. It also allows local authorities to set their own planning and building standards for particular urban areas within a specified range.[7]

Energy Consumption Growing Fast; Electricity Use in the Building Sector Even Faster

Energy consumption in Egypt is increasing fast, at rates of about 5 percent. Projections indicate that energy consumption could more than double from 60 Mtoe to 135 Mtoe in 2030, whereas it could triple in the building sector from 8 Mtoe in 2005 to 25 Mtoe during the same period.[8]

Triggered by increase in urban populations and growing incomes and comfort demands, electricity use in the building sector has grown particularly fast, with annual growth rates of about 7 percent. In 2002, final energy consumption of the residential and commercial sectors amounted to 10 percent of the total; including public buildings, they accounted for about 44 percent of total electricity consumption. In 2007/2008, the residential sector had overtaken the industrial sector in terms of electricity consumption, and more than half of all electricity was consumed in the buildings sector; see figure A2.1.

Figure A2.1. Electricity Consumption by Sector, 2007–08



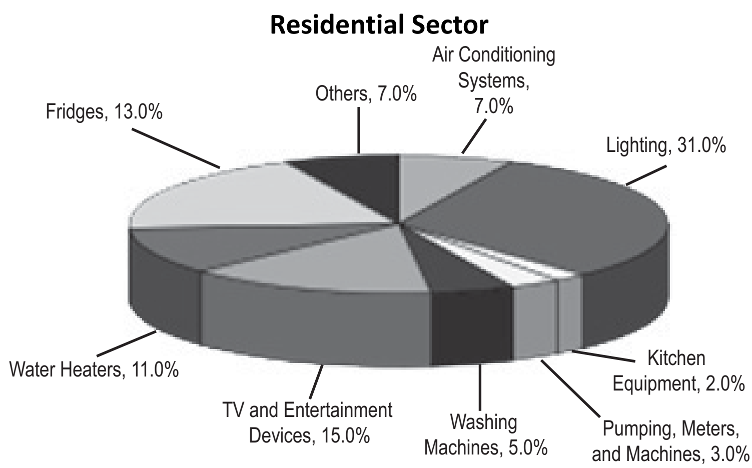
Source: Mahmoud (2009).
Note: Total consumption = 106.6 TWh.

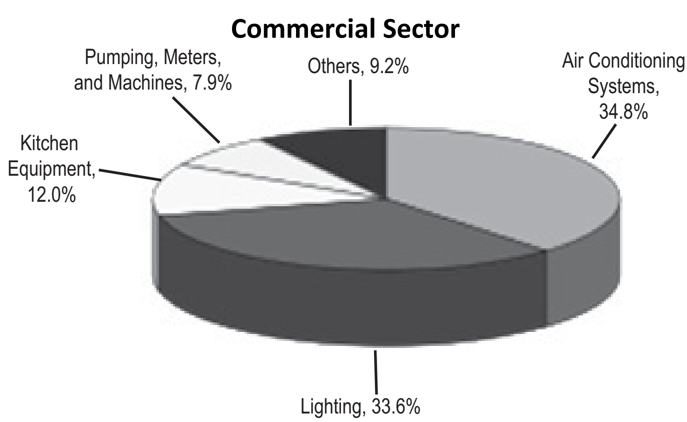
Actual data of electricity consumption patterns are very limited. Surveys indicate that lighting and cooling are the most important end uses of electricity. In the residential sector, lighting, refrigerators, televisions, and other entertainment account for about two thirds of consumption; in the commercial and public sector, air conditioning and lighting account for over two thirds and about half of electricity consumption, respectively.[9] The increasing use of electricity for cooling adds substantially to the peak load during summer,[10] requiring installation of new power capacity.

Egyptians have almost universal access to electricity; but 80 percent of the population uses it only for basic services (excluding air conditioning), contributing only 50 percent to total residential electricity consumption.[11]

The residential sector also consumes a substantial share of LPG and natural gas, mostly for cooking and water heating (figure A2.2).

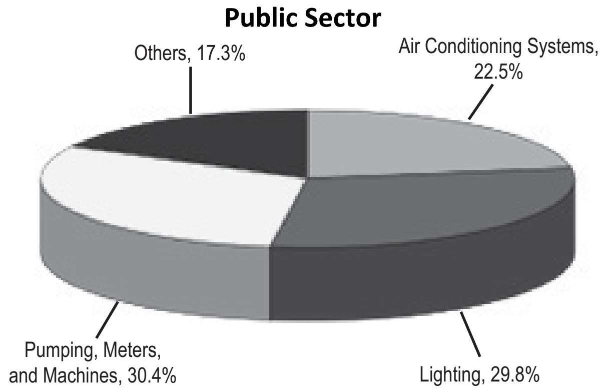
Figure A2.2. Sectoral Electricity Consumption Patterns, 2002





(Figure continues on next page)

Figure A2.2 (continued)



Source: Abdin/Elfarra (2006).
Note: Data are based on a survey of electricity use.

Development of BEECs and Other Relevant Initiatives

Drivers for Developing BEECs

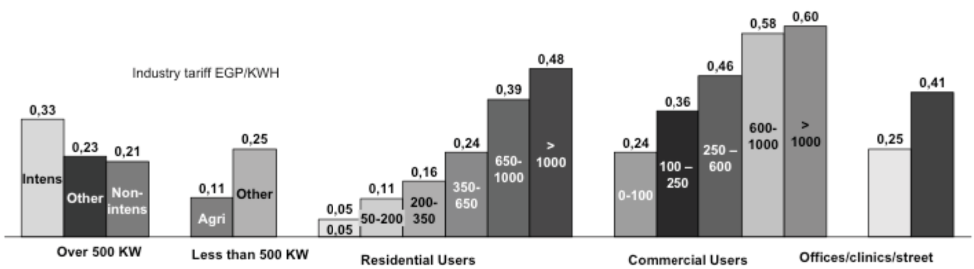
Shortage of power generation capacities. To diversify energy resources and contribute to energy security, the use of renewable energy and the rational use of conventional energy resources are promoted within the framework of the Energy Strategy of Egypt.[12]

This is especially important for the power sector. It is generally recognized that the high growth of electricity consumption, particularly in the building sector, puts a significant strain on power sector capacities. If continued unabated this would require significant additions, especially to peak load generation. Electricity is mostly generated with domestic natural gas and oil; both resources are approaching the limits of what can be supplied internally. The government's strategy favors the addition of renewable sources to the generation mix, particularly wind energy and solar-thermal generation. The strategic long-term objective is to cover 7 percent of electric demand from renewable energy by 2021/2022, not including 7 percent from hydropower plants.[13]

Energy efficiency, which could lead to significant energy savings and reduction in consumption and capacity, receives only occasional attention, for example, by developing standards for appliances and buildings. Scarce attention is, however, paid to implementation of those standards. One reason for this neglect could be that energy efficiency is not championed by any ministry or important agency. There is no relevant national strategy, no quantifiable objectives, proposal to develop tools and legislations, monitor and follow up achievements, and assess impacts and accumulated experiences and lessons learned to modify and improve future plans. As there is no specific organization responsible for setting and/or implementing energy saving plans and objectives in Egypt, Egypt does not have a declared "official" target for energy savings in all sectors of the economy.[14]

Electricity tariffs. Currently, subsidized electricity tariffs for almost all residential consumers and small commercial users create substantial disincentives to adopt energy efficiency measures. Residential consumers of electricity receive high subsidies with the exception of consumers with very high consumption; see figure A2.3. The tariff for the first segment of consumption (up to 50 KWh), which benefits about 23 percent of all residential consumers, has been constant since 1993, compared to cost of service equal to 18.62 EGP/kWh in 2007/2008. In total, about 98.5 of all residential consumers in the first three segments (up to 350 kWh/month) benefit from subsidies.[15]

Figure A2.3. Electricity Tariffs, 2009



Source: Ghaly (2008).
Note: Exchange rate: EGP 5.44 = US$l and US$0.177 = EGP 1 (December 31, 2008).

The electricity sector accounts for about 16 percent of overall energy subsidies, which reached about US$8 billion in 2006/2007.[16] As a part of power-sector reform, electricity tariffs are slowly increased since 2004, with the goal of phasing subsidies out for all but low-income consumers. Electricity consumers with high tariffs, in the residential sector and in the commercial sector, would have significant incentives to lower their consumption and their electricity bills by complying with standards for electrical appliances and equipment, as well as with BEECs.

Climate change mitigation. Policies for climate change mitigation have not yet captured the imagination of Egyptian decision makers and led to some urgency in pursuing cost-effective energy saving and GHG emission reduction measures.

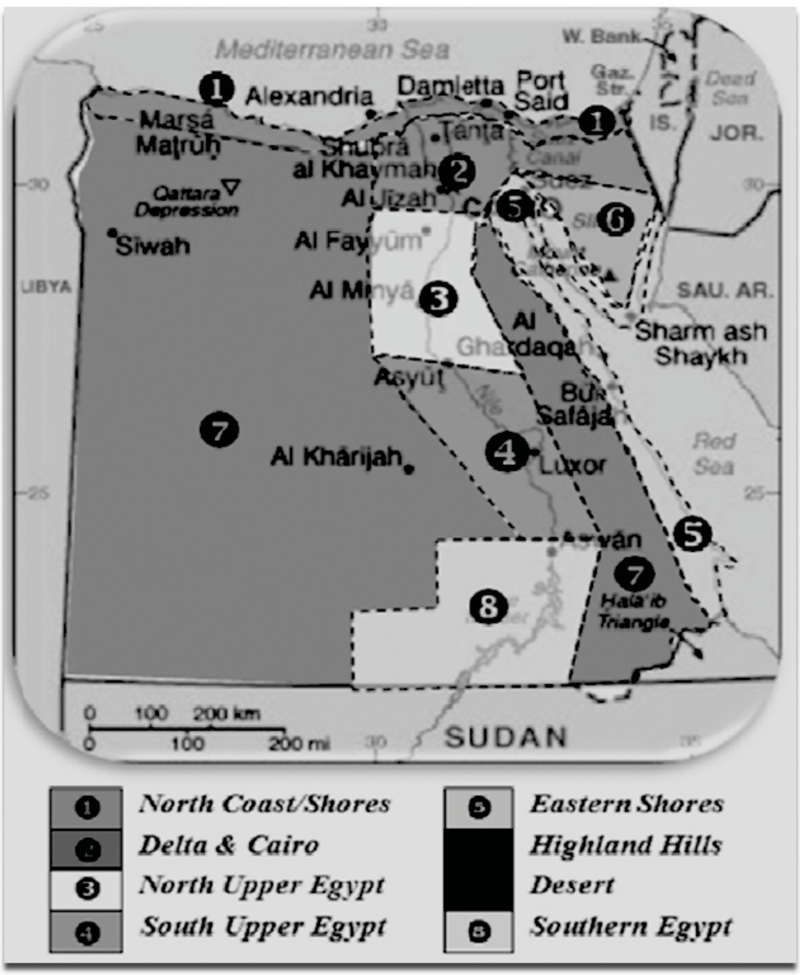
BEEC Development

The establishment of regulations for buildings is primarily the responsibility of the Ministry for Housing, Infrastructure, and Utilities, supported by the Housing and Building Research Center (HBRC).[17] The implementation and enforcement, however, is the task of local authorities under the guidance of the Ministry for Local Governments, by way of issuing building permits and approving completed construction.

BEECs, both for residential and commercial buildings, have been developed in Egypt with support from UNDP/GEF. They were enacted by ministerial decree in 2005 and 2009, respectively, and are included in the new building law as a mandatory article, as is a BEEC for public[18] buildings. None of the three BEECs is currently effectively enforced. If the codes were complied with, they could save about 20 percent energy compared with a baseline building and improve comfort in non–air-conditioned housing.

The codes are applicable to new buildings, additions, and retrofits and set minimum energy efficiency requirements for the building envelope, HVAC, service hot water, lighting, and electric power. Three alternate compliance paths are available: (1) prescriptive requirements for major building components (2) an equivalent alternating path (tradeoff), and (3) a whole building performance (energy budget) path. Under the latter, a building is compliant if its total energy consumption is less than that of a building that meets all prescriptive requirements. Code requirements take into account the eight different climate zones of the country; see figure A2.4. The code development[19] was based on a survey of building energy use in Cairo and Alexandria, where 50 percent of all construction occurs. It involved the training of Egyptian specialists in the use of the DOE-2.1E building energy simulation program and the compilation of the residential and commercial building codes. The resulting codes have many similarities to U.S. ASHRAE Standard-90.1, but they also include additional chapters on natural ventilation and thermal comfort.

Figure A2.4. Eight Climatic Regions of Egypt, Listed in the Residential BEEC



Source: R-BEEC, Figure 3-2, p. 9, translated & reproduced in Mosallam/Miraj (2009).

The codes even identify the documentation required for assessing compliance with the BEEC, such as approved design and construction documents, supplementary supporting documents with detailed calculations, system specification, and so on. They also lay out the duties of inspectors for technical inspection, including an inspection schedule for the various building components.

The UNDP/GEF supported project also included a detailed implementation plan,[20] comprising crucial elements that are considered international best practice to move toward compliance with a BEEC:

- Strengthening of the BEEC enforcement structure and administration to build within Egyptian institutions permanent capabilities for the design of green and energy-efficient buildings
- Establishment of a systematic compliance process (procedures, tools, forms, and field testing of the process)
- Compilation of a BEEC user's manual
- Development of a training program on BEEC and an outreach and public information program
- Estimation of savings and cost-effectiveness through ongoing building surveys and technical/economic analysis
- Implementation of a major demonstration program with 30 to 40 buildings

This plan has, however, not yet been realized. Essential compliance tools are still lacking, capacity building has not taken place, and, consequently, compliance with the code is negligible.

Some supporting initiatives are slowly getting underway. HBRC is supporting the piloting and evaluation of new building materials that might comply with BEECs in several demonstration projects (National Affordable Non-Conventional Housing Project). It has also established a unit that is responsible for checking compliance of public and commercial buildings with the BEECs and is supporting capacity building and certification on BEECs for third-party compliance agents that support developers in the supervision of construction projects. Curricula for a national program to train licensed Special Technical Inspectors in various aspects of building code requirements have been developed together with the U.S. International Code Council (ICC).

Green Building Standard

A nonbinding guideline for green buildings has existed in Egypt since 1999. More recently, the Egyptian Green Building Council was established in 2009. It is organized by HBRC and counts with the support of the Ministry of Housing, Utilities and Urban Development, the Ministry of Electricity and Energy and the Ministry of Environment. A green rating scheme is under development.[21] It will use current Egyptian BEECs as the basis for the energy efficiency rating scheme.

Appliance Standards and Labeling

The Ministry of Industry and Technological Developments is responsible for standard setting in Egypt. Standards and labels have been developed, within the UNDP/GEF project, for several appliances that are extensively used, especially in the residential sector. These include window air conditioners, washing machines, and refrigerators/

freezers. Accredited testing laboratories for those appliances were established within the New and Renewable Energy Authority to verify manufacturers' claims of reliability and power consumption of major appliances and electronic products and establish confidence in the market place. It is compulsory for manufacturers to abide by the specifications and put the energy efficiency label on all locally manufactured and imported appliances. However, enforcement, as well as awareness of retailers and consumers, seems to be limited.[22]

Efficient lighting technologies—in particular, compact fluorescent lamps (CFL)—are also being introduced. Guidelines for public tendering and equipment purchase have been developed. Under the umbrella of the public Egyptian Electricity Holding Company (EEHC), a CFL distribution program has been implemented by the distribution companies in 2009.

Enforcement of Building Codes in Egypt

National and Local Governments Role in Enforcing Building Codes

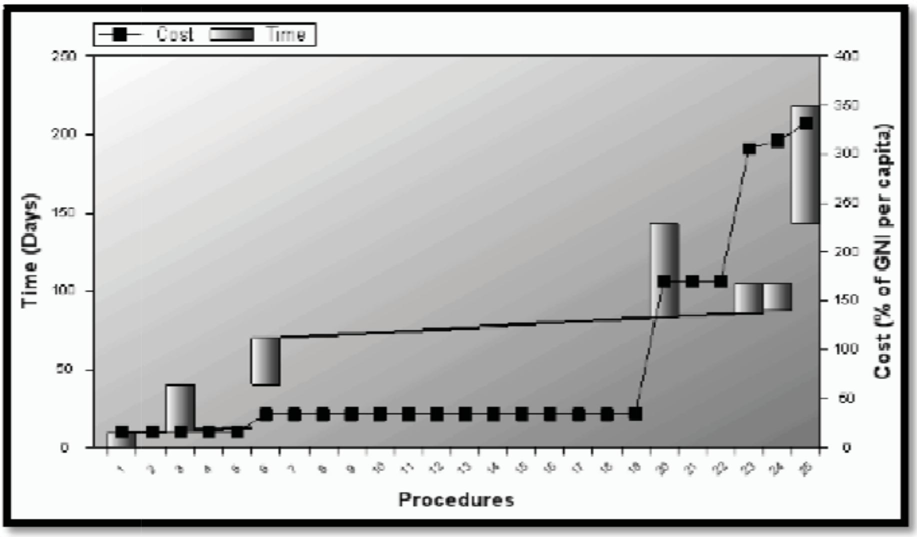
National-level agencies are responsible for the development of BEECs and for examining and evaluating compliance of commercial and public buildings with the respective BEECs. The latter is the task of the Building Technical Inspection Agency (BTIA) that is located in the HBRC. It is, however, understaffed, with only about a dozen engineers that may not have the necessary knowledge and capacity to enforce BEECs throughout the entire nation.

Ultimately, implementation and enforcement of BEECs are the responsibilities of actors at the local level. The BEECs are supposed to be implemented within the implementation framework of general building codes. In fact, the new building law includes the BEECs as mandatory articles to be complied with as part of the licensing process.

Egypt has quite elaborate procedures governing construction and the process of obtaining construction permits and approvals. During the past few years, it has become easier to deal with construction permits as a result of the new unified building law of 2008. It eliminates most preapprovals for construction permits and cuts down on the number of procedures, time, and costs to complete all procedures necessary for a construction project. Despite these improvements, Egypt is still only ranked 156 out of 183 countries for this criterion in the World Bank/IFC 2010 Doing Business survey.

In Cairo, for example, it takes about 220 days to complete about 25 procedures; see figure A2.5 and table A2.2. Much of it is due to inspections of the construction site. They are not scheduled at times when significant construction takes place, but are rather arbitrary, happening about every three weeks. Within the country, differences are beginning to emerge, since the new building law allows local authorities to set their own planning and building standards for particular urban areas within a specified range. Several cities have experimented with simplification of the rules, for example, by cutting down on the number of times a construction project is inspected.

Figure A2.5. Building A Warehouse In Cairo 2009—Time, Procedures, and Cost



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Source: World Bank/IFC: Doing Business 2010—Egypt, Arab Republic.
Note: GNI/cap = US$1,801.25. Total cost = US$6,000.

Table A2.2. General Procedures to Comply with Building Regulations

Cairo Procedures to build a warehouse (Data as of July 2007)

Procedure 1. Obtain cadastral documents from the Survey department.‡

Procedure 2. Obtain technical approvals from independent syndicate engineer.

Procedure 3. Submit building permit application to District department of the Municipality

Comments: The applicant must submit an extensive list of documents, including drawings signed by an accredited engineer, and a report from a structural engineer confirming that the structural skeleton and the foundations of the building will tolerate the required licensed works and are in compliance with safety provisions and will resist the natural disasters and in accordance with the Egyptian construction standards and illustrating the soil composition at the site.

Procedure 4. Receive inspection and obtain project clearance from Civil defense department.‡

Procedure 5.* Obtain project clearance from the Greater Cairo Water authority.‡

Procedure 6.* Obtain project clearance from the Greater Cairo Electricity authority.

Procedure 7.* Receive inspection prior to permit issuance from municipality.

Comments: An inspector from the municipality inspects the proposed construction site to verify the information included on the application.

Procedure 8.* Pay real estate tax at the tax authority.

Procedure 9. Obtain building permit from the district department.

Comments: Law 106 of 1976 establishes a 30-day statutory time limit for issuing building permits, but these 30 days are counted only after all preliminary approvals are obtained.

(Table continues on next page)

Table A2.2 (continued)

Procedures 10–19. Receive on-site inspection from the municipality (1) to (10).
Time to complete: 1 day. Cost to complete: No cost.
Comments: The municipality will inspect the construction site on a regular basis (usually once a month but inspections can occur once every two weeks). Each inspection takes at most one day. Doing business assumes the site is inspected every three weeks, on average.
Procedure 20. Receive final inspection by a committee from the Municipality.
Comments: Once construction is completed, the municipality makes a final inspection to certify that the warehouse conforms to the specifications outlined in the building permit and grants the occupancy license.
Procedure 21. Obtain letters from municipality about water and sewage connection and about electricity cables installation.
Procedure 22. Obtain certificate of natural disaster from an independent syndicate engineer.
Procedure 23. Obtain water and sewerage connection.
Procedure 24.* Apply for electricity connection.
Procedure 25.* Receive electrical inspection.
Procedure 26.* Obtain electricity connection.
Procedure 27.* Obtain phone connection with Telecom Egypt.
Procedure 28. Register the building with the real estate registry.
Comments: The company must submit a form, as well as the building permit for the warehouse and the primary purchase contract of the land on which the warehouse had been built.
Law 83 of 2006 amended Decree no. 70 for the year 1964 to decrease registration fees to a flat fee of EGP 2,000 instead of a percentage of the building value.

Source: World Bank/IFC: Doing Business 2010—Egypt, Arab Republic; Doing Business in the Arab World 2010; Doing Business in Egypt 2008—Subnational Report.
Notes: *Simultaneous with the previous procedure.
‡By 2009, procedures 1, 4, and 5 had been eliminated, cutting down substantially on the time and cost of receiving approvals.

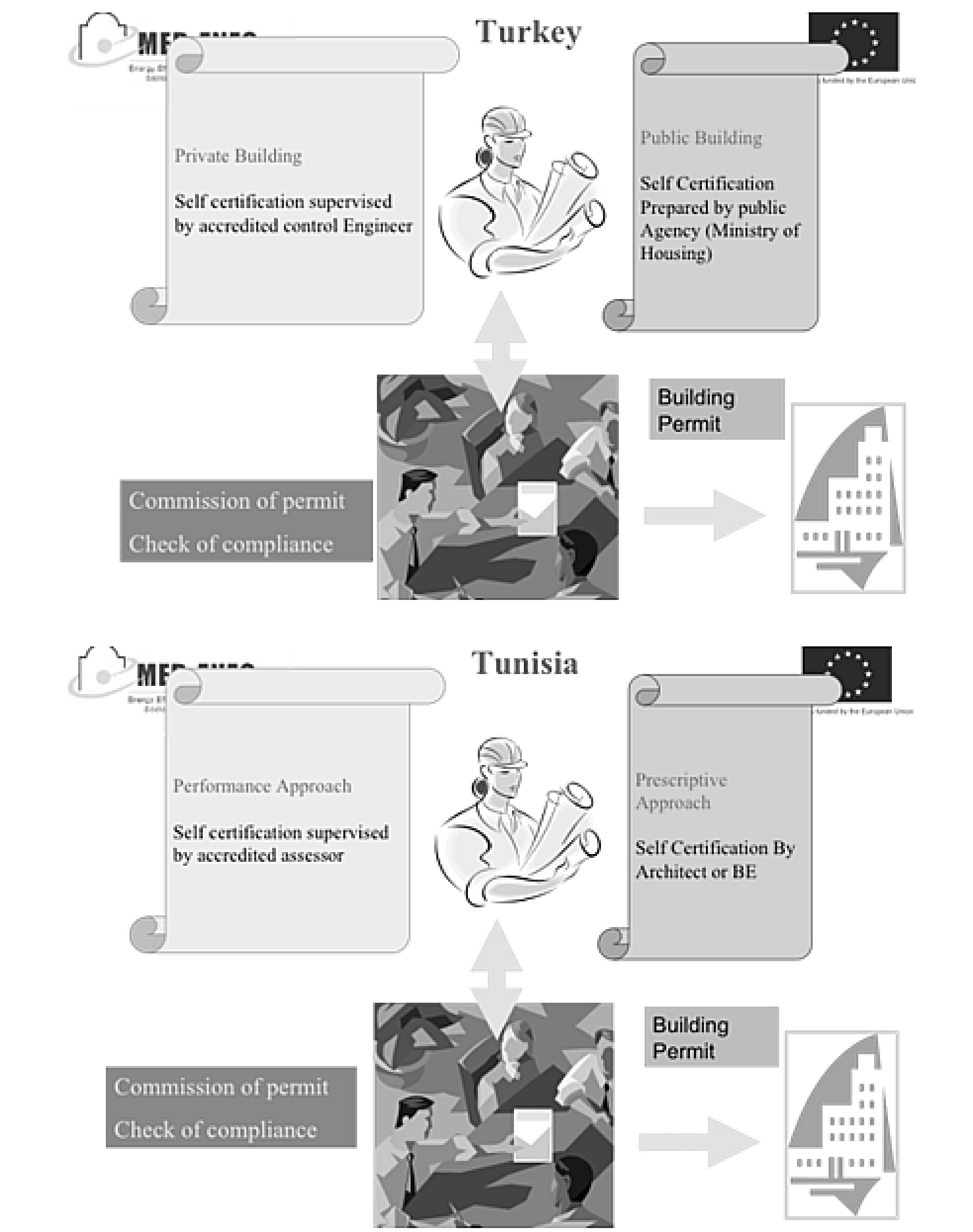
Emerging Private Sector Role in Enforcing Building Codes

The new building law also creates new implementing structures for the enforcement of building codes, shifting "from public enforcement to practitioner-focused enforcement. The rapid pace of urban development has left agencies with a growing backlog of building permit applications. The results are apparent: delays, higher costs for investors, and greater opportunities for rent seeking. Facing similar challenges, most OECD economies have chosen to rely on private engineers and architects, qualified under carefully designed accreditation systems, to carry out technical reviews and inspections. Learning from this experience, Egypt has created a role for private engineers."[23]

Developers of big construction projects hire qualified and accredited Resident Site Engineers (RSEs) to make sure that the building is constructed in accordance to all technical drawings and design plans that in turn have been confirmed to comply with all applicable building codes. It is expected that national training and certification will take place to enable RSEs to also become trained and certified in energy efficiency issues.

Further specifics of this approach in Egypt are not available. It might look similar to the structures put in place in Turkey (with the distinction in approaches between public and private buildings) or Tunisia (with differentiation between compliance approaches), which include self-certification by accredited engineers; see figure A2.6.

Figure A2.6. Examples for Public-Private Cooperation to Enforce Building Codes



Source: Mourtada (2009).

Challenges and Opportunities Ahead

In Egypt, the introduction of buildings and major related appliances that consume less energy would provide benefits to both individuals in terms of reduced energy bills and increased comfort and the entire nation in terms of energy security and lower investment for expansion of power-generation capacities.

Although the basic regulatory instruments exist in the form of BEECs for residential, commercial, and public buildings and standards and labels for some popular electrical appliances, actual compliance especially with the BEECs is basically nonexistent. The reasons are manifold, as described in the past sections:

- Electricity prices are subsidized for the majority of residential consumers and smaller commercial consumers.
- There is a lack of enforcement of the basic building code and, as a consequence, large informal building construction outside of government oversight.
- Municipal officials and the supply-chain participants have little necessary information, knowledge, and skills to embrace, enforce, or comply with BEECs and have little confidence in new materials and technologies that have no track record of local applications.
- The low income level of a large part of the population complicates the internalization of incremental costs of energy-efficient technologies in the absence of financing schemes.
- Markets for energy-efficient materials and components that would comply with BEECs are underdeveloped; testing facilities and certification are not available for major building materials and components.
- There is a lack of local champions with the power to influence government decisions.

It will require major policy efforts to remove some of these barriers, such as elimination of subsidies for all but the lowest-income households. This would best be accomplished as part of a broad national energy efficiency strategy.

It seems possible, however, to start with smaller steps toward introducing energy-efficient buildings in those areas where stakeholders might be more receptive.

Opportunities exist in the following segments of the building sector:

- *Commercial buildings.* Owners/tenants of commercial buildings face high energy prices and would benefit from lower energy consumption. Building/using a high-profile energy efficient or green building would lend visibility to its promoters. The government could introduce an incentive scheme for the first, say, 20 buildings that adopt the commercial BEEC and agree to monitoring and evaluation. Incentives need not be monetary, but could consist of offering a higher density allocation, say, in the form of additional stories.
- *Government-financed new cities*. The government is the major sponsor of low-income housing in many new cities. Following examples of other governments, for example, in Mexico (see case study, Appendix 4), the government could require that those residential buildings comply with energy and water-efficient requirements. Although this might increase investment costs initially by a small amount,[24] it would provide homeowners with lower energy bills. It would also provide a large-scale pilot project of energy-efficient materials and equipment that supply Egyptian manufacturers with a large-scale demand for more energy-efficient materials and components.

Targeting these two segments would lead to more experience with actual code compliance and experience of parts of the construction sector in the application of BEEC requirements and the use of different materials, equipment, and construction practices. It would be helpful to accompany these sectoral approaches with capacity building and awareness campaigns, both for the construction sector and for enforcement agents, both in the private and the public sector.

Notes

[1] This summary note was written by Anke S. Meyer, based on the consultant report by Ayman S. Mosallam and Rashid Miraj (2009) *Building Energy Efficiency Code Compliance—Country Case Study Egypt*, and on additional sources.

[2] Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2007 Revision, http://esa.un.org/unup.

[3] Other sources estimate the total annual requirements for new housing units at 300,000-400,000 units, for example, Saleh (2008).

[4] World Bank (2009a).

[5] See Everhart/Heybey/Carleton (2003).

[6] World Bank (2007).

[7] Information based on World Bank (2008a).

[8] http://www.jcee-eg.net/download.asp?path=library%2FEgypt_policy_Cairo_091201.ppt and http://www.jcee-eg.net/reee.asp?sublinkID=28.

[9] Abdin/Elfarra (2006).

[10] Mahmoud (2009).

[11] http://www.jcee-eg.net/download.asp?path=library%2FBuidling+energy+in+Egypt091208.ppt.

[12] See, for example, http://www.egelec.com/mysite1/pdf/Annual-Eng 2008 Final.pdf.

[13] See, for example, Georgy/Soliman (2007).

[14] Georgy/Soliman (2007).

[15] http://www.egelec.com/mysite1/pdf/Annual-Eng 2008 Final.pdf.

[16] World Bank (2009b).

[17] HBRC services include technical inspections, field and laboratory tests, technical training, technical consultations, studies/research and development of building codes and equipment standards. HBRC has eight different laboratories equipped with up-to-date technologies serving the building industry. See http://www.jcee-eg.net/reee.asp?sublinkID=28.

[18] The BEEC for public buildings parallels the code for commercial structures, containing the same requirements. The separation between the two codes occurred due to discussions whether public buildings should be subject to stricter requirements than commercial buildings and/or champion the process of code compliance, thus becoming a role model for the rest of the nation.

[19] See details in Huang et al. (2003).

[20] See Huang et al. (2003).

[21] See http://egypt-gbc.org/history.html.

[22] For more details see Georgy/Soliman (2007) and http://www.clasponline.org/clasp.online.worldwide.php?countryinfo=221 - Mandatory Label.

[23] World Bank/IFC: Doing Business in the Arab World 2010, p.15

[24] Some features that would lead to a reduction in energy consumption, such as design and orientation of buildings, would actually be quite cheap. Furthermore, traditional building design that is inherently more energy efficient might be revived.

Appendix 3. Case Study: Toward Implementation of the Energy Conservation Building Code in India

Introduction[1]

India introduced the Energy Conservation Building Code (ECBC) in 2007, a voluntary code for large commercial buildings with connected load at or greater than 500kW. This subsector was chosen due to its high growth, both in terms of construction area and electricity consumption, its high visibility, and relatively high energy prices for commercial customers. Since 2007, many steps have been taken in the preparation of implementation, including technical guidance documents and training of actors in the building chain. Much work still needs to be done to implement the ECBC effectively, especially in the areas of adopting compliance and enforcement procedures and training and of code enforcement agents in cities that aspire to comply with ECBC. The financing necessary to staff local government building departments and provide them or third-party agents with the necessary training has not yet been identified.

This case study illustrates the significant efforts needed to ensure that a BEEC will actually be complied with and enforced.

Sector Background and Energy Implications

Urban Population and Construction Patterns and Trends

Different from many other Asian countries, India is still an overwhelmingly rural country. The urban population of 325 million in 2005 accounted for only about 29 percent of total population. Due largely to migration from rural areas, the urban population is expected to grow to 472 million in 2020 and 611 million in 2030, reaching a share of about 41 percent of total population.[2] According to the 2001 national census, 22.6 percent of the total urban population lives in slums with very limited access to infrastructure services.

Data on the existing building stock are incomplete, and estimates about number of units, floor space, and urban/rural and residential/commercial (including public) shares vary substantially. With this caveat, the following numbers should be viewed as approximations. The bottom line is that construction in both the residential and commercial sectors will continue to experience fast growth.[3]

The total building stock in India has seen average 6 percent growth between 1990 and 2005. Total floor space doubled as a result, from 4 to 8 billion m^2. From 2005 to 2030, average growth is expected to increase slightly to 6.6 percent, resulting in 22 billion m^2 in 2020 and 41 billion m^2 in 2030. Commercial floor space accounts for about 10 percent of the total.[4] This growth pattern means that 80 percent of the buildings that would exist in 2030 have not been built yet, presenting a huge opportunity to realize energy savings and avoid lock-in of energy waste.

A 2006 report of the Indian real estate market[5] provides the following description of and forecast for the residential and commercial buildings markets:

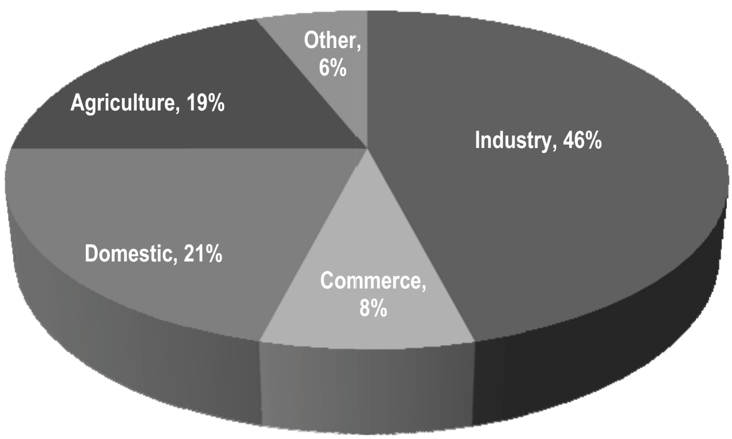
- 200 million households exist, with an average of 5.3 household members.

- Only 50 percent of housing is in good condition, and 70 percent of households have no more than two rooms.
- Together with necessary replacement, new demand due to population growth, and a tendency toward smaller households, it is forecast that demand for new housing could range between about 7 million and almost 10 million units per year.
- Commercial real estate in India has grown exponentially during the past two decades and is expected to grow in excess of the residential growth rate.

Energy Consumption and CO_2 Emissions Growing Fast

IEA[6] estimates that rising incomes, acceleration in industrialization and urbanization, and population growth would result in 3.3 percent growth of final energy demand, from 356 million toe in 2005 to 804 million toe in 2030. Energy consumption in the residential and commercial sectors constitutes the largest share (169 million toe, or 47 percent) of India's final energy use in 2005. This includes, however, a very substantial amount of biomass that is mostly used for cooking and water heating by rural households. Excluding biomass, the share of the residential and commercial sector would account only for 15 percent of total final energy demand. Currently, the residential and commercial sectors make up about 30 percent of total electricity consumption; see figure A3.1.

Figure A3.1. India Electricity Consumption 2007–2008 by Sector (in %)



Source: http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=IN.

Energy consumption in the *residential sector* grew on average by 1.6 percent per year in 1990–2005 and is projected to maintain this growth rate from 2005 to 2030. Electricity consumption is expected to grow at a much higher rate of 7 percent, driven by switching to electricity for lighting in rural areas and increasing appliance ownership. Space conditioning (fans and AC) is the most important electricity use, followed by lighting. By 2030, four out of ten urban households are expected to use AC in their homes.

Electricity use in the *commercial sector* has increased dramatically during the last two decades, more than tripling from 1990 to 2006 when it reached 35000 GWH. With the increasing importance of the sector and proliferation of HVAC and plug loads, this strong growth is expected to continue.[7] For example, in new construction, increased use of lighting and cooling result in an annual electricity use intensity of 173 kWh/m^2, 27 percent higher than the current average of 137 kWh/m^2 for existing commercial building stock.[8]

Building design in India has until very recently not taken into consideration energy efficiency aspects. As a result, the average—mostly for lighting and HVAC—is in excess of 200 kWh. With efficient designs a 20 to 40 percent reduction of annual energy consumption per m^2 could be achieved in a typical commercial office building. Even more savings could be accomplished with climate responsive architectural design, rational approach toward buildings with highly insulated building envelopes with integrated design features that maximize daylight and minimize direct sun. Using favorable climatic conditions with increased *mixed mode* kind of building design will help to minimize HVAC, mechanical ventilation, and lighting electricity consumption.

Development of ECBC

Drivers for Developing ECBC

Power peak demand shortages. India has a severe peak demand shortage of approximately 11 to 14 percent. The building sector has a substantial contribution to peak demand through ever increasing use of HVAC, lighting, and electrical appliances.

The fundamental causes of the power shortages affecting consumers at all levels are underpricing of power and deficient bill collection. High subsidies—especially for households, small commercial consumers, and the agricultural sector—crowd out funds for capital investment. Average residential electricity tariffs in India, at 7 U.S. cents per kWh, are about half the OECD average, excluding taxes; industry tariffs, at 9 U.S. cents per kWh, are slightly higher than the OECD average level.[9] Large commercial consumers pay even higher tariffs.

As a result of power shortages, about half of all commercial buildings (for example, retail malls and residential building complexes) have installed backup diesel generator sets, operating at very high cost.[10]

The peak demand shortage can be overcome in the short and medium term through energy efficiency measures, both on the supply and demand side.

Rationalizing energy prices. Since 1997–1998, energy prices have been rising much faster than inflation rates. Industrial and commercial enterprises and middle- to high-income households were particularly affected by increasing energy prices. These customer categories are expected to be more favorably disposed toward energy efficiency as a means to reduce energy bills. [11]

Increasing importance of the commercial sector and its impact on electricity consumption. Electricity consumption of the commercial sector tripled between 1990 and 2006 and is expected to continue to grow rapidly in the next two decades.

These factors, in addition to its high visibility, make the commercial sector a good target for the application of energy efficiency measures, including BEECs.

Policy Framework for Building Energy Efficiency

The Energy Conservation Act was enacted in 2001, ushering in systematic government efforts to promote energy efficiency and conservation. The Act requires that large energy consumers ("designated consumers") adhere to energy consumption norms. Energy conservation buildings codes (ECBCs) were clearly identified by the Act as a key policy intervention. The Bureau of Energy Efficiency (BEE, under the Ministry of Power) was created in 2002 to lead national energy efficiency efforts. States were also required to establish state designated agencies (SDAs, basically State Energy Offices). By 2009, 31 of the 35 states and union territories (UT) have done so.

The BEE launched both the National Energy Labeling Program for appliances and the development of the ECBC in 2006. For the 11th Five-Year Plan (2007–2012), BEE will extend the energy-labeling program to include 10 more appliances. SDAs are expected to initiate energy audits and their implementation in 10 government buildings in each State and one or two buildings at the UT level. BEE will also assist SDAs in the establishment and promulgation of ECBCs in the States, and facilitate SDAs to adapt ECBC.

More recently, the *National Action Plan on Climate Change* (see box A3.1) has added some urgency and additional proposals to the menu of energy efficiency measures in its Energy Efficiency Mission. Specific energy consumption will be mandated in large industries, and incentives provided for demand-side management and efficiency improvements. The Mission on Sustainable Habitat is charged with extending the implementation of the ECBC at the state and local level.

Box A3.1. India National Action Plan on Climate Change

On June 30, 2008, India released its first National Action Plan on Climate Change (NAPCC), outlining existing and future policies and programs directed at climate change mitigation and adaptation. The plan outlines eight "national missions" running up to 2017, and ministries are directed to submit detailed implementation plans to the Prime Minister's Council on Climate Change by December 2008. Some missions target energy use, promoting energy efficiency and renewable energy, as well as improved research capacity on climate change issues. Other missions target water efficiency, agriculture, forestation, and ecosystem conservation.

Relevant for building energy efficiency are the following two missions:

National Mission for Enhanced Energy Efficiency. The plan estimates that current initiatives, based on the Energy Conservation Act of 2001, will yield 10 000 MW of savings by 2012. Building on this, the plan recommends mandating specific energy consumption decreases in large energy-using industries, including a system for companies to trade energy-savings certificates. It also highlights the use of incentives, including reduced taxes on energy-efficient appliances. Finally, it recommends financing for public–private partnerships for demand-side management (DSM) programs that reduce energy consumption in the municipal, building, and agricultural sectors. [Lead Ministry: Power] Implementation plan: http://www.energymanagertraining.com/NAPCC/NMEEE-forPublicComments.pdf.

National Mission on Sustainable Habitat. The plan seeks to promote energy efficiency as an essential component of urban planning. It calls for extending the ECBC, and emphasizes urban waste management and recycling, including power production from waste. In the transport sector, it calls for stronger enforcement of automotive fuel economy standards, using pricing measures to encourage the purchase of efficient vehicles, and providing incentives for the use of public transportation. [Lead Ministry: Urban Development].

Source: http://www.iea.org/Textbase/pm/?mode=cc&id=4161&action=detail.

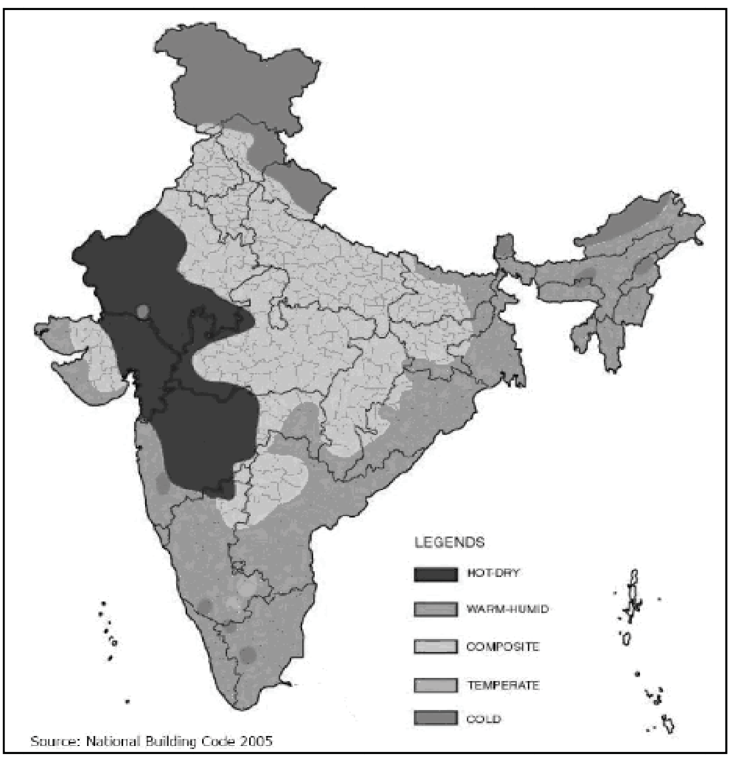
ECBC—The BEEC for Commercial Buildings

The ECBC was developed under the guidance of the BEE with technical assistance from the U.S. Agency for International Development (USAID) under the Energy Conservation and Commercialization (ECO) program. It was officially introduced in 2007 (revised in 2008) as a stand-alone voluntary code for new large commercial buildings and for additions and alterations to existing large commercial buildings.

States and Urban Local Bodies (ULBs) will have to adopt the ECBC for it to eventually become applicable. The government has indicated that the ECBC will become mandatory after gaining compliance capacity and implementation experience. To become mandatory, it needs to be incorporated into the building bylaws. The state governments—in charge of building bylaws—have the flexibility to modify the ECBC to suit local or regional needs, particularly climate variations, without reducing the stringency of the national model code. New Delhi has partially adopted the ECBC in 2009, making it mandatory for government buildings.[12]

India is divided into five climate zones, shown in figure A3.2: Hot-dry, warm-humid, composite, temperate, and cold. India has more than 3,000 cooling degree days, twice the number in Mexico.

Figure A3.2. Climate Zone Map of India



Source: National Building Code 2005, cited in: Ministry of Power (2008) Energy Conservation Building Code 2007, revised 2008, Appendix E.

The ECBC restricts the applicability of the code to large buildings (that is, with a connected load of 500kW or contract demand of 600 kVA and above).[13] In general, buildings with a conditioned floor area larger than 1,000m^2 fall into this category. The Energy Conservation Act, which empowers BEE to develop an ECBC, restricts the buildings to which the Act and thus the ECBC can be applied to large buildings "intended to be used for commercial purposes."

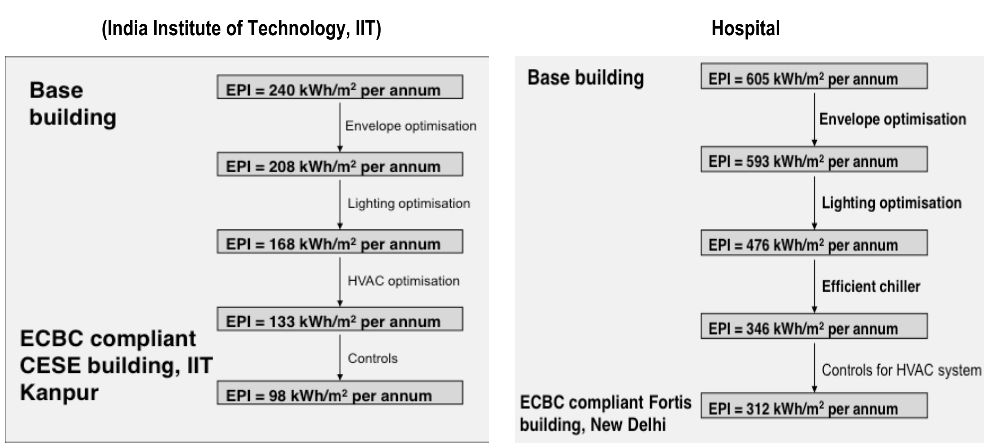
The building components to which the code applies include the building envelope (walls, roofs, and fenestrations), HVAC systems, service hot water and pumping, lighting, and electrical power.

The ECBC has both prescriptive and performance-based compliance paths. The former establishes minimum requirements for all components of the building envelope and energy systems, whereas the latter (whole building performance method) requires a simulation approach to prove efficiency over a baseline building. In addition, a system-based or tradeoff route is feasible also, allowing balancing of some high-efficiency components with other lower efficiency components. Code requirements were developed based on extensive data collection for different building types and construction materials and taking into account minimization of life-cycle costs.

In general, an ECBC compliant building is expected to use about 39 percent less energy than the national benchmark (110 kWh/m^2/year compared with 180 kWh/m^2/year). BEE estimates that annual electricity savings of 1.7 billion kWh could have been achieved in 2007/2008 if ECBC requirements had been complied with nationwide during that year.[14]

Several case studies (figure A3.3) were developed, showing that ECBC compliant buildings can achieve about 50 percent energy savings over the baseline design with initial cost increases of 10 to 15 percent and payback times of 5 to 7 years.

Figure A3.3. Case Studies—Energy Savings in ECBC-Compliant Buildings



Source: Bassi 2009.
Note: EPI—Energy Performance Indicator.

The ECBC is very similar to the U.S. commercial BEEC (ASHRAE 90.1 2004), with a focus on mechanical and thermal efficiency.[15] Unlike, for example, the Egyptian BEEC (see case study, Appendix 2) or the TERI-sponsored green building standard (GRIHA, see below), design features like natural ventilation are not addressed in the code. Instead, the ECBC refers to the National Building Code (NBC), for its ventilation guidelines in naturally ventilated buildings. Non–air-conditioned buildings are still very common in India. It is forecast that even in 2030, only 60 percent of all commercial space would be air-conditioned.[16]

Implementation of the ECBC: Supporting Measures

The IEA notes that several barriers impede the implementation of energy efficiency measures in India, "including inadequate institutional capacity, high transaction costs, lack of access to capital, a high private discount rate, and a lack of enforcement of standards and codes. There is an urgent need to increase the staffing and resources of administrative agencies at the federal and state levels."[17] These barriers all apply to the building sector.

Since 2007, BEE has worked intensively, supported by USAID and other donors, to develop the measures and documentation necessary to enable implementation of the code and thus eliminate at least some of the barriers.

Government assistance to compliance capacity development have included (1) training of professionals, (2) establishment of a panel of ECBC expert architects to provide advice to design professionals, (3) development of a detailed ECBC User Guide, and technical reference materials for envelope design, energy simulation, and so forth., and (4) support for development of curriculum in architectural/ engineering colleges (for details, see table A3.1). The government also established an ECBC Program Committee to facilitate development of ECBC compliant building designs, implement demonstration projects, and put in place compliance and evaluation procedures. Currently, the creation of a compliance check tool (ECOnirman) is under development.

BEE is responsible for the policy development underlying the ECBC and for supporting the development of its compliance tools, procedures, and forms. It cannot, however, directly support state governments in the administration and enforcement of the ECBC. This task falls under the purview of the Ministry of Urban Development. It includes support for integrating ECBC enforcement into local infrastructure for code administration and enforcement and developing the technical expertise of both construction professionals and code officials.[18]

At least two or three states are expected to adopt a statewide BEEC during 2010. Targeted are those states where the majority of new construction takes place, including Punjab, Haryana, New Delhi, and Gujarat.

Table A3.1. ECBC Implementation Support through the ECO-III Project

Implementation and Documentation Support
- ECBC Tip Sheet on Building Envelope, Lighting, HVAC, and Energy Simulation. More than 8,000 copies of the Tip Sheets have been printed for distribution to the concerned stakeholders.
- Documents on Glazing Design and Selection, Lighting Design, and Cool Roof Application Guide have been developed and are disseminated through the ECO-III website.
- Launch of ECBC User Guide. 5000 printed copies for distribution to concerned stakeholders.

Awareness and Training Workshops on ECBC
- Organize four ECBC Awareness workshops (New Delhi, Chandigarh, Vadodara, and Pune with BEE, PEDA, GEDA, and MEDA). The materials prepared for the workshops are being used to create national ECBC awareness by BEE and other organizations.
- A set of five-lecture ECBC professional training materials developed for energy efficiency professionals from the ECBC Tip Sheets.
- Standardize ECBC training program with a proficiency test under development.
- Number of concerned professionals/officials trained on ECBC: 1,000 (approx.).

Capacity Building on Energy Modeling and Simulation
- Organize five series of energy modeling awareness workshops and five energy modeling training workshops in association with Asia Pacific Partnership to directly address a capacity crunch in the area of energy modeling of buildings.
- Help establish International Building Performance Simulation Association —India chapter to raise the awareness and expertise of building simulation professionals.
- Work with BEE, Indian Society of Heating Refrigerating and Air-Conditioning Engineers (ISHRAE), Center for Environmental Planning and Technology (CEPT), and U.S. Department of Energy to update and improve the quality of the weather files for 107 Indian cities to be used in energy modeling programs (EnergyPlus and DOE2).
- Develop a comprehensive whole building performance compliance approach and provided a "How to" guidance for energy simulation community to show ECBC compliance.
- Highlight equipment power-density issue and its impact on infrastructure and addressing it on a national level.

Curriculum Enhancement for Academic Institutes
- Long-term Capacity Development Initiative: Focus on HR Development at the national level and help prepare next generation of architects and engineers.
- Enabled BEE-University partnership
    - 19 educational institutions involved
    - DesignBuilder/EnergyPlus distributed
    - E-Source Technology Atlas distributed
- Train the Trainer workshop for 19 faculty members in partnership with NIASA.

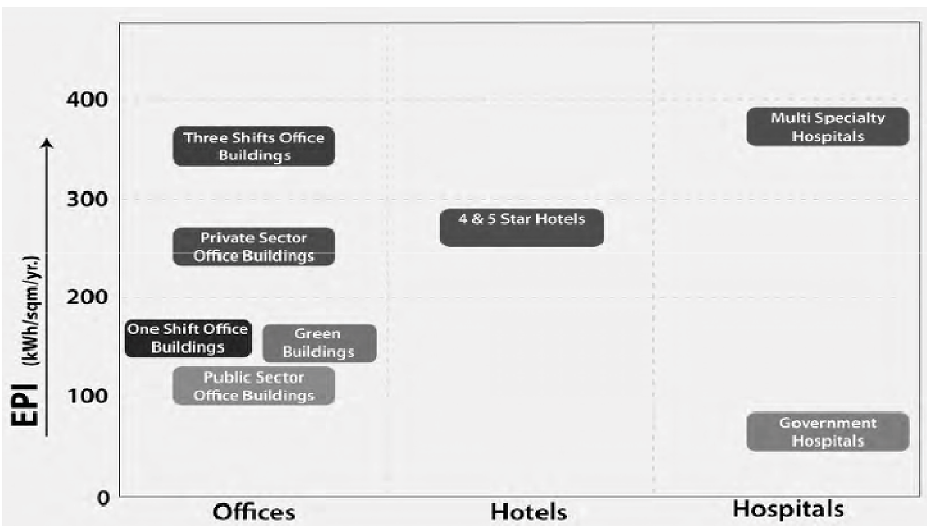
Next Steps
- Prepare ECBC Implementation Roadmap and Compliance Framework in partnership with BEE and Pacific Northwest National Laboratory.
- Prepare Roadmap for ECBC Compliance Check (Tool, Review, Inspection).
- Introduce Building Energy Efficiency Professional Examinations.
- Create Web-based curriculum for Building Science (Undergraduate) & Energy Modeling (Post-Graduate).
- Hold regional workshops to enhance the capacity of faculty members.

Source: http://www.eco3.org/updates.html.

Benchmarking Energy Use in Commercial Buildings

As noted earlier, data on construction activity and energy use in buildings are scarce. This absence of macro-level data makes it difficult to formulate adequate policies. The BEE therefore sponsored a number of building audits and consumption surveys of commercial buildings. Both activities are contributing to the establishment of energy consumption benchmarks for commercial buildings and savings potential for buildings of various types and in different climate zones. The creation of benchmarks would also help in identifying exemplary buildings as well as poorly performing buildings that could be targeted for implementing energy efficiency measures. The 2009 National Benchmarking Study conducted by ECO-III and BEE[19] used a standardized data collection process and includes data from 760 buildings, covering most states, all climatic zones, and three types of commercial buildings. Figure A3.4 shows the average energy performance indices for various subcategories of offices, hotels, and hospitals. The impact of hours of operation and use of air conditioning (most public-sector office buildings have no or little air conditioning) is clearly visible.

Figure A3.4. Energy Intensity Level for Different Building Types



Source: Kumar (2010).

BEE introduced a national star-rating program for commercial buildings and Business-Process-Outsourcing (BPO) buildings in 2009 to provide public recognition for energy efficient buildings and create a *demand-side pull* for such buildings. Ratings are based on the actual performance of buildings in terms of specific energy usage ($kWh/m^2/year$), excluding electricity generated from onsite renewable sources such as solar photovoltaic, measured after completion of one year of operation with full occupancy of the building. Buildings are rated on a one to five star scale with a five-star building being the most efficient. Bandwidths for the Energy Performance Index for different climatic zones have been developed for office buildings and for BPO buildings, based on the percentage of air-conditioned space. Table A3.2 shows the bandwidths for office buildings; EPIs for BPOs are more than twice as high.

The star rating will be extended to other climatic zones and building types, such as hotels, hospitals, and IT Parks. A first list of 49 buildings that are eligible for participation was published in 2009. Their Energy Performance Index ranges from 193 kWh/m²/year for a one-star building to 44 kWh/m²/year for a five-star building.[20]

Table A3.2. Proposed Bandwidths for Star-Rating Standards—Office Buildings

Table for Building Energy Star Rating Programme More than 50 % air conditioned built up area		Table for Building Energy Star Rating Programme Less than 50 % air conditioned built up area	
Climatic Zone- Composite		**Climatic Zone- Composite**	
EPI(Kwh/sqm/year)	**Star Label**	**EPI(Kwh/sqm/year)**	**Star Label**
190-165	1 Star	80-70	1 Star
165-140	2 Star	70-60	2 Star
140-115	3 Star	60-50	3 Star
115-90	4 Star	50-40	4 Star
Below 90	5 Star	Below 40	5 Star
Climatic Zone - Warm and Humid		**Climatic Zone - Warm and Humid**	
EPI(Kwh/sqm/year)	**Star Label**	**EPI(Kwh/sqm/year)**	**Star Label**
200-175	1 Star	85-75	1 Star
175-150	2 Star	75-65	2 Star
150-125	3 Star	65-55	3 Star
125-100	4 Star	55-45	4 Star
Below 100	5 Star	Below 45	5 Star
Climatic Zone - Hot and Dry		**Climatic Zone - Hot and Dry**	
EPI(Kwh/sqm/year)	**Star Label**	**EPI(Kwh/sqm/year)**	**Star Label**
180-155	1 Star	75-65	1 Star
155-130	2 Star	65-55	2 Star
130-105	3 Star	55-45	3 Star
105-80	4 Star	45-35	4 Star
Below 80	5 Star	Below 35	5 Star

Source: http://www.bee-india.nic.in/ecbc/Bandwith.xls.

Building Energy Efficiency in Existing Buildings

The ECBC also applies to the renovation of large existing buildings. The government is using its own buildings to apply energy audits and implement their recommendations. Already in 2002, BEE identified nine government buildings for energy auditing and demonstration of energy efficiency benefits. Implementation of measures on the basis of energy performance contracts involving Energy Service Companies (ESCOs) has been slow due to resolving issues pertaining to procurement and contracting mechanisms.[21] More recently, an Energy Assessment Guide for Commercial Buildings has been prepared and is being used to perform energy audits in 400 public-sector buildings under a new BEE initiative.

Institutional Arrangements: Federal, State, and Local Governments Roles

Building bylaws in India fall under the purview of state governments and vary with administrative regions within the state. As a guiding code for municipalities and development authorities to follow in formulating and adopting building bylaws, the Bureau of Indian Standards (BIS) developed in 1970 and regularly updates the NBC, with the most recent revision dating from 2005. The NBC covers basically all aspects of building design and construction, including in its latest revision guidance on energy conservation aspects and sustainable development, which are, however, not mandatory.

The construction permitting and compliance process in Indian municipalities. Multiple local governments are in charge of overseeing the construction sector and issuing construction and occupancy permits and approvals. The efforts required by businesses and developers to comply with the requirements vary significantly among states and municipalities. During the past few years many cities have introduced reforms to make the process more efficient, less time-consuming, and costly by reducing the number of procedures, computerizing building-permit applications, rationalizing and consolidating preapproval clearances and streamlining fee structures.

Table A3.3 shows the substantial differences between procedures required in Bengaluru, the city ranked first among 17 cities surveyed in India and on par with many cities in the OECD, and Mumbai, which came in last.

For large buildings (more than 20,000 m^2 built-up area) an environmental clearance needs to be obtained before start of construction from the Ministry of Environment and Forests, adding substantially to total time. The Environmental Impact Assessment (EIA) was made mandatory in India under the Environmental Protection Act (1986) for 29 categories of large-scale developmental activities. The EIA includes requirements for building energy performance that are a combination of terms in the NBC and the ECBC.

Reportedly, few inspections take place during construction, and in practice, many builders end up not obtaining the occupancy permit. According to a 2008 study by the National Institute of Urban Affairs, less than 35 percent of the buildings have adhered to building regulations in the National Capital Territory of Delhi.[22]

Permitting and compliance checks with construction procedures are done mostly by municipal governments. In some cases, such as compliance with fire safety code, outsourcing is taking place through certified private-sector inspectors.

Table A3.3. Procedures to Receive Construction and Occupancy Permits in Bengaluru and Mumbai

Bengaluru/Karnataka	Mumbai/Maharashtra
Procedure 1. Obtain attested copy of approved layout by the Bengaluru Development Authority (municipal). **Procedure 2.* Obtain no-due-tax receipt at the House Tax Department (municipal).** **Procedure 3. Obtain drawing plan/building permit approval from the Commissioner of the Bengaluru Mahanagara Palike (municipal).** License fee INR 60 per square meter of built-up area + scrutiny fee at 5% of the license fee. **Procedure 4. Obtain commencement certificate (with inspection) from the Bengaluru Mahanagara Palike (municipal).** Cost: INR 52,024 (INR 40 per square meter of built-up area) Comments: The authority inspects the site within 15 days of receipt of the notice about commencement of construction to verify that the positioning of the building is according to approved plans. If the site passes the inspection, the Commissioner will issue a commencement certificate in the form prescribed in Schedule VII. **Procedure 5. Apply for permanent electricity connection with the Bengaluru Electricity Supply Board (BESCOM) (state).** **Procedure 6. Receive inspection from electricity utility provider BESCOM (state).** **Procedure 7. File a completion certificate and apply for an occupancy permit at the Bengaluru Mahanagara Palike (municipal).** Comments: The building company must notify the Commissioner, Bengaluru Mahanagara Palike, about completion of the construction within a month. It must attach to the notice a certified application prepared by a registered architect/engineer/ supervisor in Schedule VIII to apply for permission to occupy the building.	**Procedure 1. Submit application and design plans at the Building Proposal Office of BMC and pay scrutiny fee.** Comments: The building company submits an application form with plans and all required documents, as prescribed by Section 373 of the BMC Act, at the Andhuri Building Proposal Office of the BMC. If all documents are in order and the file is complete, the building company can proceed to payment of the scrutiny fees. Fees are paid in the same building by cash or bank draft. Once the fees have been paid, the application file is forwarded to the concerned officer in the Building Proposal Department. Then the file is forwarded to the Survey Office, which will make its remarks on the application file and check the remarks from the Development Plan office (obtained during the design stage of the project). If the Survey Office is satisfied with its review, it will send the application file back to the Building Proposal Department within one week. The cost for this procedure is INR 28 per square meter of the built-up area/plot area, whichever is larger. **Procedure 2. Receive site inspection from the Building Proposal Office of the BMC (municipal).** Comments: A subengineer from the Building Proposal Office will conduct a site inspection within 3 to 4 days of receiving the file from the survey office. The date and time of the site inspection are arranged by the company's architect. The building company must be on-site when the inspection takes place. **Procedure 3. Obtain "intimation of disapproval" (building permit) from the Building Proposal Office and pay fees (municipal).** The cost for this procedure is INR 1 per square meter for Intimation of Disapproval + INR 2 per square meter (or a maximum of INR 45,000) as a deposit for debris clearance. The latter is returned after the completion of construction if the BMC has deemed all debris cleared. **Procedure 4. Submit structural plans approved by a structural engineer to the BMC (municipal).** **Procedure 5.* Apply for a "no-objection certificate" (NOC) from the Tree Authority (municipal).** **Procedure 6.* Receive inspection from the Tree Authority (municipal).** **Procedure 7.* Obtain a "no-objection certificate" (NOC) from the Tree Authority (municipal).** **Procedures 8-13* Request and obtain "no-objection certificates" (NOCs) from the Storm Water and Drain Department, the Sewerage Department, the Brihanmumbai Electric Supply and Transport (BEST) Undertaking, the Environmental Department, the Traffic and Coordination Department, and the CFO (municipal).** Comments: All commercial structures require fire-safety clearance. **Procedure 14. Obtain commencement certificate from the Building Proposal Office and pay development charges (municipal).** Cost: 836,100 (200 INR per square meter [land component] + 500 INR per square meter [building component]). Comments: On submission of all required NOCs mentioned in the IOD and on compliance of the IOD conditions, the applicant may submit request for the commencement certificate (CC). The documents and NOCs submitted by the applicants are verified by the staff and the necessary commencement certificate is approved. After payment of development charges and other applicable premium, the commencement certificate is issued within 7 to 15 days. The cost for the CC is INR 200 per square meter of land + INR 500 per square meter of building area.

(Table continues on next page)

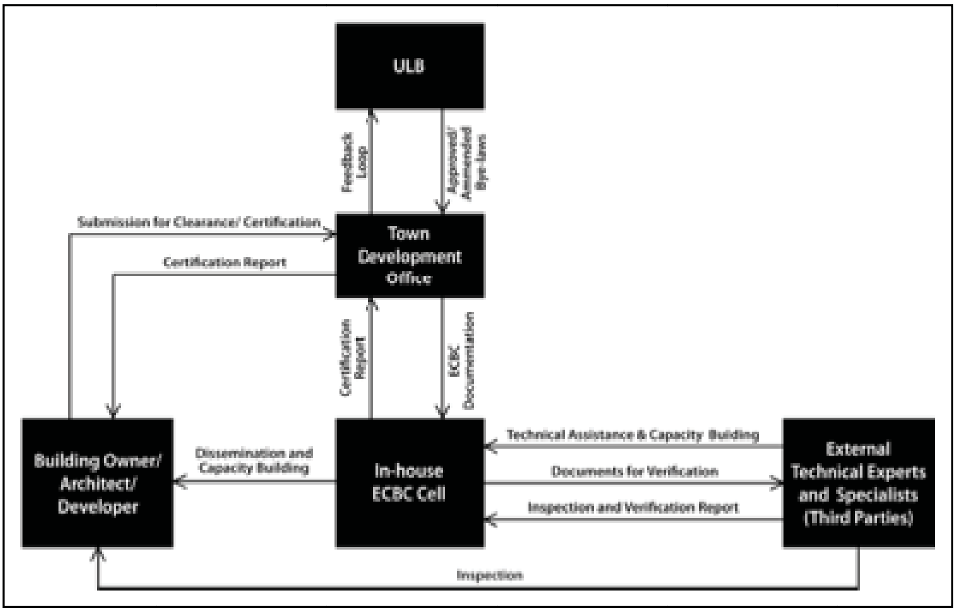
Table A3.3 (continued)

Procedure 8. Receive final inspection of the construction by the Bengaluru Mahanagara Palike (municipal). Comments: The authority decides after a physical inspection whether to approve the building. During the inspection, the authority checks whether the owner had obtained the commencement certificate and submitted all required documents. **Procedure 9. Obtain the occupancy permit from the Bengaluru Mahanagara Palike (municipal).** Comments: The authority should inform the applicant whether the application for occupancy certificate is accepted or rejected within 30 days of receipt of the completion notice. In case the application is accepted, the occupancy certificate is issued in the Form Schedule IX. **Procedure 10. Apply for permanent water and sewerage connection with Bengaluru Water and Sewerage Board (BWSB) (municipal).** **Procedure 11.* Apply for permanent phone connection at Bharat Sanchar Nigam Limited (national).** **Procedure 12.* Receive inspection from the Bengaluru Water and Sewerage Board (municipal).** **Procedure 13.* Obtain permanent electricity connection (with inspection) from BESCOM (private sector).** **Procedure 14.* Obtain permanent water and sewerage connection upon final payment from BWSB (municipal).** Time: 18 days **Procedure 15.* Obtain phone connection (with inspection) from the BSNL (national).**	**Procedure 15. Request and receive inspection of plinth (municipal).** **Procedure 16. Submit completion notice to obtain occupancy certificate and certificate of completion (municipal).** Comments: The company's architect must submit a formal letter stating that construction has been completed according to the standards set forth in the IOD and CC. **Procedures 17–23.* Request and obtain completion of NOCs from the Tree Authority, the Storm Water and Drain Department, the Sewerage Department, the Electric Department, the Environmental Department, the Traffic and Coordination Department and the CFO (municipal).** Comments: All commercial structures require a fire-safety clearance according to fire and safety rules and regulations stipulated in the Development Control Rule (1991) and the National Building Code. **Procedure 24. Receive completion inspection from the BMC (municipal).** **Procedure 25. Obtain occupancy certificate from the BMC (municipal).** Comments: The occupancy certificate allows the building company to occupy the building but is not considered a final document because the building company still requires the certificate of completion. **Procedure 26. Obtain completion certificate from the BMC (municipal).** Comments: The completion certificate is considered to be the ultimate document that the building company requires to fully occupy the building and connect it to utilities. **Procedure 27. Apply for permanent water connection at the Water Supply Department of the BMC (municipal).** **Procedure 28. Apply for permanent sewerage connection at the Sewerage Department of BMC (municipal).** Comments: An application is made to the Municipal Corporation for approval of permanent sewerage connection. **Procedure 29. Apply for permanent power connection and pay fees at Brihanmumbai Electric Supply and Transport (municipal).** **Procedure 30. Apply for permanent phone connection at Bharat Sanchar Nigam Limited (national).** **Procedure 31. Receive on-site inspection for connection to water by the Water Supply Department (municipal).** **Procedure 32. Receive on-site inspection for connection to sewage by the Sewerage Department (municipal).** **Procedure 33. Receive on-site inspection from BEST (municipal).** **Procedure 34. Obtain permanent water connection (with inspection) (municipal).** **Procedure 35. Obtain permanent sewerage connection at BMC (municipal).** **Procedure 36. Obtain permanent electricity connection from BEST (municipal).** **Procedure 37. Receive on-site inspection and connection to telephone by the utility provider (national).**
Total Time: 97 days **Total Cost: 1,158.7 percent of GNI per capita=US$14,810**	**Total Time: 200 days** **Total Cost: 2,717.7 percent of GNI per capita=US$25821**

Source: World Bank/IFC: Doing Business India 2009.
Note: * This procedure can be completed simultaneously with previous procedures
India's Gross National Income (GNI) per capita in 2007 = US$950. The exchange rate used is US$1 = 43.97 INR (Indian Rupees).

Integrating ECBC enforcement into the local code process. Proposals have been made regarding how to implement the ECBC as part of the local code process. This could include support by independent accredited agencies/experts (see figure A3.5) as is the case now for some aspects of the enforcement of the NBC, and potentially some dedicated ECBC staff of the local development office. Questions that have to be resolved are, among others, how to carry out the necessary capacity building and how to finance any additional staff.

Figure A3.5. Proposed ECBC Implementation at Urban Local Body Level



Source: Kumar/Kapoor/Rawal/Seth/Walia (2010).

Other Relevant Initiatives

Green Buildings

Two voluntary green building standards and certification systems have been developed in India. They both refer to the ECBC for energy efficiency credits:

- *LEED India*. LEED India for New Construction was formally launched in January 2007. The LEED-India rating system has incorporated several changes from the U.S. LEED rating system, such as more emphasis on water conservation and adoption of local Indian codes and standards. For example LEED-India would adopt the NBC guidelines, MOEF EIA guidelines for large projects, and ECBC for energy efficiency. Currently, 73 buildings have been certified in India and 501 are registered for rating. The total estimated potential for green building materials and equipment (within LEED rated buildings) is about US$4 billion by 2012.[23]

- *GRIHA*. TERI developed the Green Rating for Integrated Habitat Assessment (GRIHA) together with the Ministry of New and Renewable Energy (MNRE). GRIHA differs from LEED mainly in its ability to accommodate non- or partially air-conditioned buildings. 40 buildings have been registered so far and two have been rated. MNRE now requires that all new buildings of government and public-sector undertakings comply with the prerequisite of at least a three-star rating under the GRIHA scheme. MNRE will provide incentives, such as reimbursement of registration fees, cash awards, and so on to promote large-scale design and construction of green buildings.[24]

Additional incentives for the uptake of green buildings in the residential sector are being piloted. The "Mainstreaming Eco-Housing Initiative"[25] sponsored through a USAID/India project designed a one-to-five star rating system for multistory apartments. Developers whose projects adhere to the stipulations laid out by this initiative would receive mortgage financing from Indian banks at rebates from 50 to 150 basis points. The Bank of Maharashtra has entered into an agreement with a property developer in Pune to offer such mortgages. For certified Eco-Housing projects, the Municipal Corporation of Greater Mumbai and the Pune Municipal Corporation plan to offer rebates on developers' development fees and on residents' property taxes.[26]

Appliance/Equipment Labeling and Standards

Following Energy Conservation Act requirements, BEE has introduced energy labeling of many consumer appliances and industrial equipment since 2006. The products covered so far by the standards and labeling program are listed in table A3.4 by sector to which they are most relevant. Since January 2010, star rating for energy efficiency is mandatory for a several types of electrical appliances.

It is estimated that the standards and labeling program has resulted in annual electricity savings of 2100 million kWh, equivalent to avoided capacity generation of 600 MW during 2008–2009.[27]

Table A3.4. Standards/Labels for Products by Sector

ECBC Relevant	Other Domestic/Commercial	Other Sectors
Refrigerators, frost free* and direct cool	Color TVs	Distribution transformers*
Room air conditioners*		Induction motors
Fluorescent tube lights*		Agricultural pump sets
Liquefied Petroleum Gas Stoves		
Water Heaters (Stationary Storage)		
Ceiling Fans		

Source: Based on BEE: http://220.156.189.23:8080/beeLabel/index.jsp.
Note: *=mandatory label since January 2010.

Considering the growth in electricity consumption by appliances both in the residential and commercial building sector, the standards and labeling program is an important complement to the ECBC.

Other Policy Measures Relevant to Implementation of the ECBC

A number of ideas for incentives to comply with the ECBC are being discussed in India, including "fast-tracking" developers when they apply for installation of utilities or lowering fees if they are ECBC-compliant.[28]

The central government is empowered by the Energy Conservation Act to include large commercial buildings in the list of *designated consumers*. Designated consumers could be required to have energy audits of their premises carried out by qualified energy auditors and provide to the Government data on energy consumption and actions recommended in the audits and to designate an energy manager in charge of activities related to energy efficiency. These requirements could support the adoption of the ECBC, particularly for additions and alterations of existing buildings.

Challenges and Opportunities Ahead

The Indian government has embarked on a long-term program to improve the energy efficiency of buildings, starting with commercial buildings, including public-sector buildings. The program has so far resulted in development of the code document and supporting technical documentation for compliance support, awareness building and training and capacity building of sector professionals, particularly on energy simulation, and on curriculum development for future professionals in the sector. The next steps include a standards and labeling program for fenestration products, labeling for insulation materials and "Cool Roofs," other relevant building materials, labor force capacity building, as well as support of state and local governments for the implementation of the code, possibly through large-scale pilots in several states/cities. Such pilots would go a long way toward familiarizing the market with the costs and benefits of ECBC compliant buildings and provide a testing ground for compliance and enforcement procedures for the ECBC (see also table A3.5).

Table A3.5. Remaining Barriers and Constraints for Effective Implementation of ECBC and Actions Needed

Barriers and Constraints	Actions Needed
• Lack of information about energy use and efficiency in commercial buildings • Risk perception due to lack of confidence in performance of new technologies • Largely unskilled workforce that is also uneducated in building energy efficiency aspects • Underdeveloped materials and components market for compliance, including related testing and certification capabilities • Subsidized residential electricity prices • Limited ability to internalize incremental cost of EE technologies because of low income level • Large informal building construction outside of government oversight	• Start large scale pilots and demonstration by working with proactive states and municipalities so as to track-test and improve the preconceived compliance procedures and requirements and setting the stage for transition to mandatory ECBC • Maximize market-driven actions by disseminating actual cost and benefit information of ECBC compliant buildings or projects and the use of noncash incentives such as fast-tracked permit approval and high profile media exposure • Accelerate the schedule for mandatory ECBC to help spur the market for materials and components and support the development of testing and certification capabilities

Source: Authors.

One of the major impediments to achieving compliance with the ECBC is a construction sector that has a general lack of a skilled workforce and requires overall improvements in the quality of construction materials and the development and local production of materials and equipment that can comply with the requirements of the ECBC. For example, high-performance glazing materials are available, but at incremental costs of about 50 percent.[29] Furthermore, materials are not certified since testing labs do not yet exist. USAID is supporting the establishment of a regional energy efficiency center (Centre for Environmental Planning & Technology, CEPT University) in Ahmedabad (Gujarat) that is expected to become the first building envelope performance laboratory, especially for glazing materials. The Swiss government is supporting the development of a certification program for insulation materials.

Workforce training in the construction sector is currently taking place through initiatives undertaken by Construction Industry Development Council (CIDC). It includes training, testing, and certification programs for construction workers as well as Management Development Programs for supervisors, managers, and senior officers.[30] Building energy efficiency aspects emerging during the construction cycle could be included in such programs as well as in the courses of institutions like the School of Planning & Architecture, CEPT University, and the National Institute of Design.

The most challenging aspect of implementing the ECBC is the compliance at the local level. This will require a huge effort in familiarizing not only the local construction industry with ECBC requirements, but also training local government officials in building departments in reviewing the energy efficiency aspects of building plans and inspecting construction sites and checking compliance with ECBC requirements. Alternatively, independent certified energy professionals could check and certify the compliance with the ECBC; they would, however, also have to be trained and pass certification exams that include ECBC relevant materials.

The financing necessary to staff local government building departments and provide them or third-party agents with the necessary training has not yet been identified. Public benefit funds and/or DSM measures in other countries have been able to provide some funding for code education and capacity building and could be considered in India also.

BEEC implementation in other countries has shown that it is best to start actual code implementation on a pilot basis in those regions that have a relatively good track record in enforcement of building codes and where the local government is committed to a green/environmental/climate change agenda. Large-scale pilot projects could achieve a high visibility for energy-efficient buildings, provide the market with good estimates of the costs and benefits of energy-efficiency measures in new buildings, and test the use of compliance and enforcement procedures and requirements of the ECBC in different localities.

Notes

[1] This case study was written by Anke S. Meyer. Inputs and comments by Shabnam Bassi (BEE), Satish Kumar and Aalok Deshmukh (IRG/USAID ECO-III Project), and Prof. Rajan Rawal (CEPT) are acknowledged gratefully.

[2] http://esa.un.org/unup/index.asp, Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2007 Revision.

[3] Source: Planning Commission (Government of India) 2008.

[4] McKinsey (2009). Kumar (2010) estimates about 950 million m^2 of total floor space in currently existing commercial buildings . Using the same growth projections as the McKinsey study, the commercial floor space in 2030 would be about 3200 million m^2;

[5] Deutsche Bank Research (2006).

[6] IEA (2007).

[7] IEA (2007). The mitigation strategy of the energy efficiency mission under the National Action Plan on Climate Change for the residential subsector focuses on the adaption of mandatory standards for lighting, entertainment, kitchen and heating/ cooling appliances. This would result in savings of 75 MtCO2e annually, equivalent to 15 % of 2004 emissions in the power sector. World Bank/ESMAP (2009).

[8] In the BAU scenario, total electricity consumption doubles from 97 (in 2008/9) to 191 TWh by 2032. Aggressive efficiency measures in lighting and cooling can reduce the growth in consumption from new construction. Savings of 12 Mt CO2e (7%) per annum achievable by 2032. World Bank/ESMAP (2009).

[9] See IEA (2007).

[10] Personal communication by Satish Kumar, October 28, 2009.

[11] Three-Country Energy Efficiency Project (2006).

[12] See, for example, http://www.dailypioneer.com/197816/Make-ECBC-mandatory-for-all-buildings-Jairam.html.

[13] In the definitions annex of the ECBC, commercial buildings are defined as in ASHRAE, that is, including also all multi-family buildings with more than three stories.

[14] See Bassi 2007.

[15] For technical details, cp., for example PNNL (2009 India).

[16] McKinsey (2009).

[17] IEA (2007), p. 460.

[18] Some of this support could perhaps be provided by Energy Efficiency Services Limited (EESL). EESL was created in 2010 jointly by the Ministry of Power and several other agencies to take on the role of implementing agency for energy efficiency. In addition to taking on the task as a resource centre for capacity building of State Designated Agencies, utilities, and financial institutions, it will function as a Super-ESCO and as a Consultancy Organization for CDM, energy efficiency, and so forth. See http://www.energymanagertraining.com/NAPCC/NMEEE-forPublicComments.pdf and http://www.powermin.nic.in/JSP_SERVLETS/jsp/newsdis.jsp?id=618.

[19] Kumar/Kamath/Sarraf/Seth (2010).

[20] Conditions of rating scheme: http://www.bee-india.nic.in/ecbc/BPOBuildingBook.pdf; List of eligible buildings: http://www.bee-india.nic.in/ecbc/Listof49Buildings.pdf.

[21] Three-Country Energy Efficiency Project (2006).

[22] World Bank/IFC: Doing Business in India 2009, p. 20f.

[23] See http://www.igbc.in/site/igbc/index.jsp.

[24] See http://www.grihaindia.org/.

[25] See http://www.ecohousingindia.org/.

[26] See http://www.expressindia.com/latest-news/green-housing-project-what-pune-does-the-rest-of-maharashtra-follows/357129/;
http://www.punecorporation.org/informpdf/dev_permission/Eco_housing3.pdf

[27] http://www.bee.gov.in/news/NPC_Verification_Report_2009.pdf. This is more than the estimate of potential savings from ECBC implementation (p. 130).

[28] See Kumar (2008).

[29] Personal communication with Satish Kumar, 28 October 2009.

[30] Planning Commission (Government of India) 2008.

Appendix 4. Case Study: Mexico—Breaking Building Energy Efficiency Grounds with a National Low-Income Housing Program

Introduction[1]

Mexico has had a mandatory standard for commercial buildings since 2001. Developed by CONUE, the national energy efficiency agency, this federal BEEC has not been enforced due to a lack of adoption by local government into their building construction regulations. States and municipalities that are in charge of setting construction rules for their territories have not made any efforts to include energy efficiency requirements in their building codes. The BEEC has thus not become effective.

National energy efficiency standards for lighting and air conditioning units, for which the federal government does have means of enforcement, have been mandatory for more than 10 years. They are widely applied and fairly successful, saving more than 16,000 GWh, the equivalent of the power consumption of 10 million households in 2006 and resulting in almost 3000 MW of avoided power capacity, about 6 percent of installed capacity.

More recently, the National Housing Agency CONAVI developed a voluntary national regulation for residential construction (CEV) that contains sustainability requirements, including thermal performance for the building envelope and electrical and water saving equipment. Developers wanting to participate in CONAVI's subsidized low-income housing development program will have to satisfy those requirements. CONAVI has developed a CDM methodology based on its housing projects. The methodology was approved in 2009. The anticipated carbon credits are expected to provide some incremental cost financing for participating housing projects, as well as to support development of a monitoring and evaluation program.

The recent efforts by CONAVI represent an attractive approach to leverage market uptake of more energy efficient buildings through federal low-income housing subsidies. This could effectively demonstrate to both the supply chain and consumers the real benefits of applying and acquiring energy and water saving technologies. CONAVI is also starting to support several states and municipalities to incorporate CEV requirements into their building regulations and enforce compliance. This could be the beginning of a wider application of energy efficiency requirements in the Mexican building sector.

Mexico's Urban Population and Importance of the Building Sector

Urban Construction Patterns and Trends

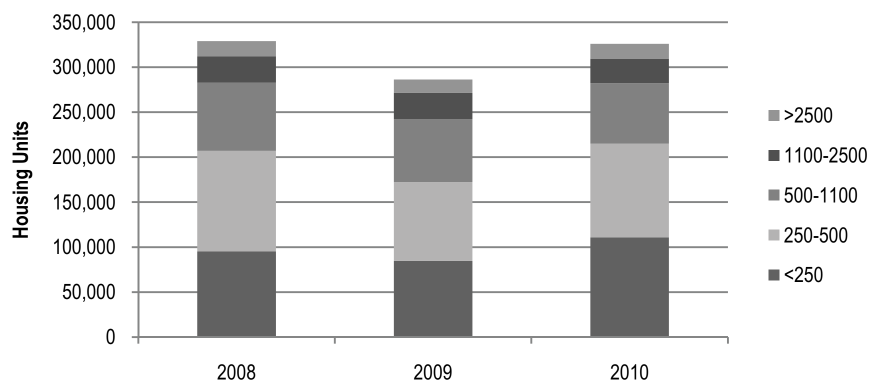
Mexico is a very urbanized country, with about three quarters of its population of 104 million in 2005 living in urban areas. Although population growth is expected to slow down, urban growth pressures will not. Mexico City has seen an influx of 4.7 million people in the past 25 years. Large cities located along the U.S.–Mexico border, particularly on the Mexican side, have seen an even larger relative population increase. For example, Tijuana tripled its population between 1980 and 2005. The share of the urban population is forecast to reach 84 percent by 2030.

The number of households in Mexico reached almost 25 million in 2005 and is projected to almost double by 2030. The total area of residential buildings is estimated at 1.4 billion m^2.[2] Since the end of the severe crisis in the1990s, the housing sector has been growing at an annual rate of 15 percent between 1997 and 2008.[3]

The federal government has set a goal of providing 1,000,000 new housing units per year between 2007 and 2012, based on the addition of about 650,000 new households annually and unmet demand.[4] This extraordinary growth will put enormous pressures on infrastructure and urban services, particularly in the hot and arid coastal and northern areas, where a significant portion of this new growth will occur.

During the past three years, about half of the targeted number of housing units has actually come the market. About one third of it is in the category of low-income housing with a value below MXN 250,000 (US$ 20,000); see figure A4.1.

Figure A4.1. Annual Housing Inventory by Home Value (in MXN 1,000), January 2008–January 2010



Source: Data from http://www.conavi.gob.mx/img/Avance enero_31_2010.pdf.

The commercial sector in Mexico has experienced faster growth than the industrial sector since 2000. The total built area in 2005 (including public infrastructure buildings such as schools and hospitals) was estimated at about 280 million m^2 and could more than double at current growth rates.[5]

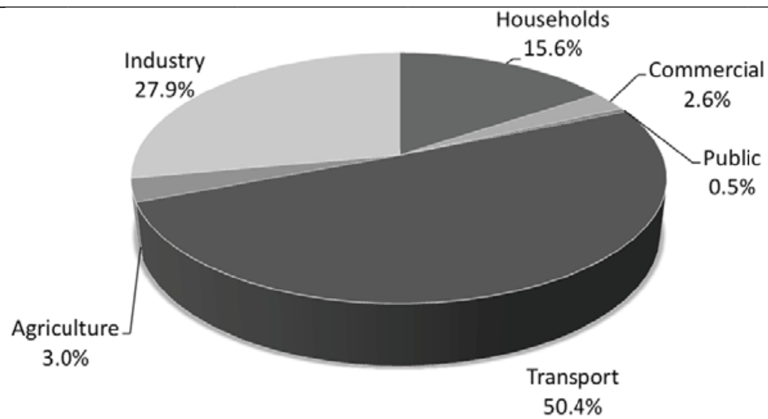
Energy Use and Efficiency in Different Types of Buildings

In Mexico, buildings account for only about 20 percent of total final energy consumption, compared to 40 percent in many other countries (figure A4.2). Their share in electricity use is significantly higher, reaching about 36 percent in 2008 (figure A4.3). According to some sources electricity use especially in commercial buildings is substantially underestimated. [6] The national power utility (CFE) defines users by voltage level and not by type of installation and thus seems to allocate a substantial part of commercial electricity consumption instead to medium industry. If this were reallocated, commercial electricity sales would almost double and the share of the building sector in 2005 electricity use would reach 50 percent instead of 36 percent.

With this correction, the building sector would overtake the industrial sector as the biggest consumer of electricity.

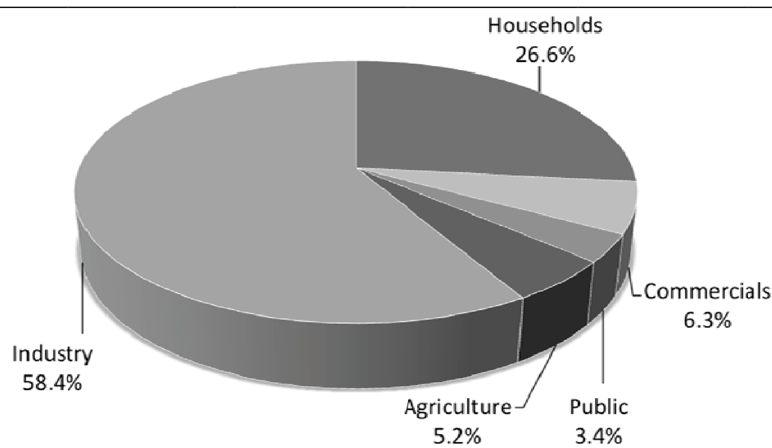
Air conditioning could become a major growth area in building energy use. In 2008, air conditioning, ventilation, and heating accounted for 12 percent of total electricity use in the building sector. Households are responsible for about 80 percent of it, even though only about 20 percent of households use air conditioning. Given trends in other countries with similar climate and growing incomes, air conditioning use could grow very fast and reach much higher penetration levels in a fairly short time. Today, households in hot regions of Mexico use about 2200 kWh annually, whereas consumption in temperate climate zone is only 1200 kWh.

Figure A4.2. Final Energy Use by Sector, 2008



Source: SENER. 2009. *Balance Nacional de Energía 2008*, México, D.F. http://sie.energia.gob.mx/sie/bdiController?action=login.

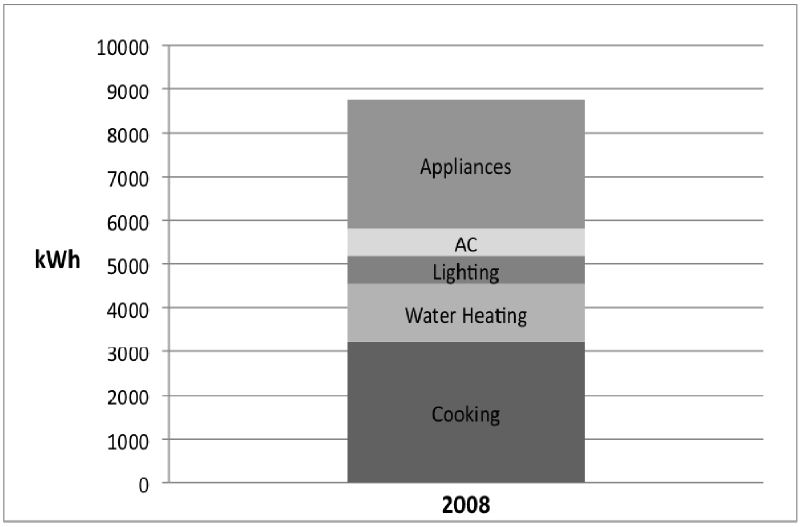
Figure A4.3. Electricity Sales by Sector, 2008



Source: SENER. 2009. *Balance Nacional de Energía 2008*, México, D.F. http://sie.energia.gob.mx/sie/bdiController?action=login.

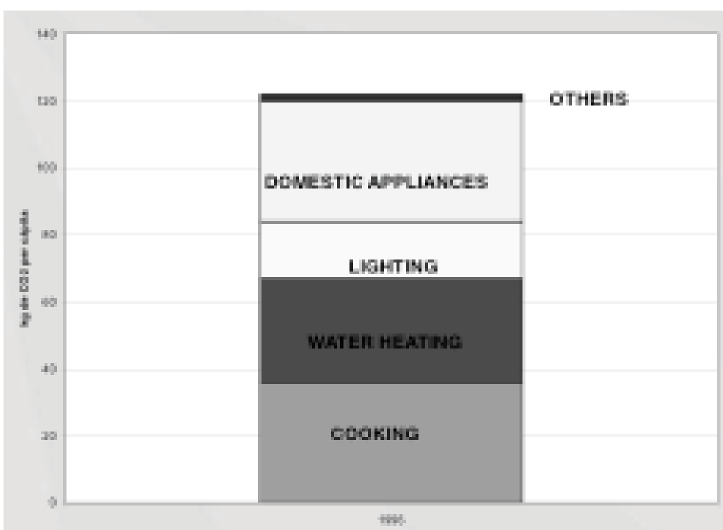
In the residential sector, LPG is used for cooking and water heating that constitute two major energy uses of a typical household. Electricity is used mostly for appliances, for lighting and for air conditioning (figure A4.4). This picture is essentially replicated with respect to the sources of GHG emissions in the residential sector (figure A4.5). No such breakdown is available for the rest of the building sector.

Figure A4.4. Energy Use in the Household Sector, 2008, Average Annual Consumption (8,753 kWh)



Source: PNASE 2009–2012.

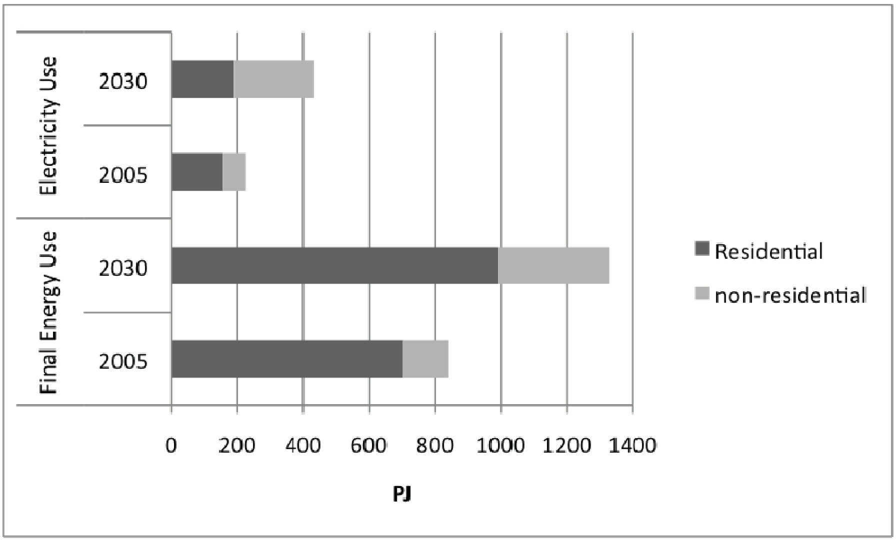
Figure A4.5. Greenhouse Emissions from Residential Sector



Source: Hirata (2009).

Energy use in the building sector is expected to grow substantially over the next 20 years, if more slowly than transport and industry. Driven by rapidly increasing use of air conditioning, electricity use would grow faster (see figure A4.6). BEECs requiring the tightening of the building envelope together with gradual tightening of standards for air conditioners would be able to limit the growth of electricity consumption, as the experience, for example, in California has demonstrated (see figure 1.5).

Figure A4.6. Building Sector Final Energy Use and Electricity Consumption, 2005 and 2030 (in PJ)



Source: http://www.sener.gob.mx/webSener/res/PE_y_DT/pub/balance2005.pdf (2005) and http://www.conuee.gob.mx/work/files/pronase_09_12.pdf (projections for 2030).

Development of BEECs and Sustainable Housing Regulations

Drivers and Barriers for Developing BEECs

In the 1990s, Mexico's national energy efficiency agency CONAE developed energy efficiency standards for electricity consuming appliances and the first BEEC for commercial buildings. The appliance standards have been quite successful, while the BEEC has not been implemented because of weaknesses of local authorities to update, develop, and enforce regulations.

In recent years, *climate change and sustainable energy policies* have had some influence on the national government to develop a more proactive policy toward energy efficiency, including for the effective implementation of BEECs. The National Sustainable Energy Program of 2009 sets objectives and proposes measures and responsibilities to reduce space conditioning energy needs by improving insulation in new construction (see box A4.1).

Box A4.1. Climate Change and Sustainable Energy Use Policy in Mexico

In December 2008, Mexico announced a long-term national goal to reduce greenhouse gas emissions to 50 percent below 2000 levels by 2050. In August 2009, a comprehensive strategy (Programa Especial de Cambio Climático—PECC) was adopted by decree[7] to reduce energy use and emissions in order to put the Mexican economy on a low-carbon development pathway. The strategic plan involves all sectors of the economy and is followed up by sectoral programs detailing initiatives to achieve emission reductions. General references are made to improving energy efficiency in various sectors.

The "Sustainable Energy Program" (*Programa Nacional para el Aprovechamiento Sustentable de la Energía 2009–2012*—PNASE), adopted in November 2009, outlines initiatives and responsibilities for all generation and end-use sectors for improved energy efficiency and use of renewable resources. By 2030, this should result in energy savings of up to 4,000 TWh, equivalent to about three years of current final energy consumption. Measures in the building sector are among those with the lowest abatement costs. For the building sector PNASE's objective is to reduce space conditioning energy needs by improving insulation in new construction and by promoting better practices in buildings, resulting in energy savings of about 15 percent by 2030. To achieve this, insulation should be applied for new public buildings; building codes should incorporate insulation requirements and compliance should be a condition for receiving building/occupancy permits for new commercial buildings and for new residential buildings in relevant climatic regions; broader application of "green mortgages;" a system of building energy ratings should be developed. Other building-related initiatives focus on improving the efficiency of lighting and appliances, including air-conditioning equipment.

Mexico City's Climate Action Program[8] of 2008 defines strategies and specific measures to reduce CO_2 emissions between 2008 and 2012 by 7 million tons. In addition to large water conservation programs, public transportation and waste management projects, measures include tax exemptions for new and existing residential and commercial buildings that integrate energy and water conservation, and renewable energy measures. Mexico City is also considering green building legislation. It would allow developers to increase the construction potential between 140 to 210 percent on a site, provided they implement energy- and water-efficient technologies.

Source: Commission for Environmental Cooperation (CEC) 2008.

Subsidies for most residential electricity consumers create substantial disincentives to invest in energy-efficient appliances and buildings. For residential customers subsidies vary by consumption level and location of the customer. Table A4.1 shows the tariff categories for the residential consumers. Consumers living in hot climates (1A to 1F), where air conditioning use is more likely, receive higher subsidies, both through lower tariffs in summer and higher consumption limits. In 2006, electricity subsidies not recovered through the utility bill amounted to more than US$10 billion, about 1 percent of Mexico's GDP, included in the budget of the federal government.[9]

Electricity tariffs for *commercial buildings* are defined by voltage level and demand level. On average, commercial tariffs cover the costs of supply. Tariffs 2 and 3 are for low voltage (up to 200 Volts) and apply to very small buildings. There are two others for: Tarifa OM and Tarifa HM are for medium voltage customers. The tariff structure consists of fixed monthly charges for tariff 2 customers only, demand charges depending on region and tariff, and energy charges that vary with the tariff, region, season of the year, day of the week and hour of the day. The resulting average tariffs between 0.11 and 0.21 US$ per kWh in 2008 are shown in table A4.2.

Table A4.1. Prices of Electricity for Residential Customers in Mexico for May 2009

Tariff Category and Climate Zone	No. of Customers (million)	Upper Consumption Limit for Subsidy (kWh/month)	Electricity Price (US$cent/kWh)*		
			Lowest Price		Average 2008
			Summer	*Winter*	
1 (temperate)	14.5	250	0.050	0.050	0.073
1A (hot, max 25°C)	1.5	300	0.044	0.050	0.067
1B (hot, max 28°C)	3.2	400	0.044	0.050	0.069
1C (hot, max 30°C)	4.0	850	0.044	0.050	0.073
1D (hot, max 31°C)	0.8	1,000	0.044	0.050	0.067
1E (hot, max 32°C)	1.0	2,000	0.035	0.050	0.069
1F (hot, max 33°C)	0.8	2,500	0.035	0.050	0.073
DAC	0.6	n.a.	?	?	0.226
	26.4				

Source: CFE. Conoce tu tarifa. 2008, cited in de Buen (2009a); 2010 information available from: http://www.cfe.gob.mx/casa/ConocerTarifa/Paginas/Conocetutarifa.aspx.
Notes: DAC: High consumption residential customers
* Based on the exchange rate of 13.5 pesos per US$. Tariff for consumption above the limit for the subsidy is uniformly 0.174 US$/kWh.

Table A4.2. Average Price of Electricity under Tariffs Applicable to Commercial Buildings in Mexico (2008)

Tariff	US$/kWh
2	0.20
3	0.21
OM	0.14
HM	0.11

Source: CFE. Conoce tu tarifa. 2008, cited in de Buen (2009a).

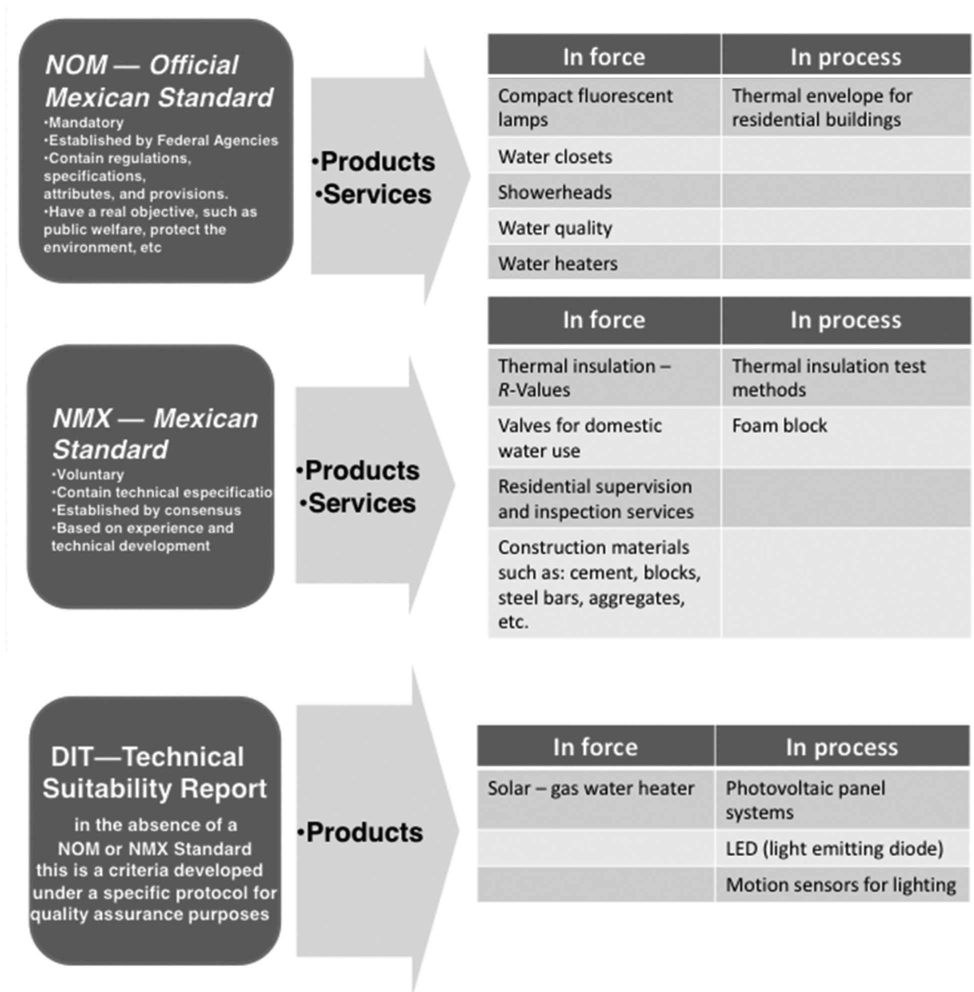
Growing electricity demand for air conditioning from the building sector substantially contributes to peak load. Peak demand has shifted from nighttime to late afternoon when space cooling is needed. Rates of growth of peak demand are substantially higher in hot regions where more air conditioning is used than in regions with temperate climate. Elimination of most subsidies and enforcement of BEECs would substantially diminish peak loads due to air conditioning and eliminate the need for additional peak load capacity.

Development of Codes and Standards for Building Energy Efficiency

Based on the Federal Law on Metrology and Standards, the National Standardization Program was established, requiring all federal government ministries to develop *mandatory official technical standards (Normas Oficiales Mexicanas—NOM)* for the areas they regulate. In the case of energy efficiency codes and standards, the Energy Ministry transferred the mandate to develop appliance standards and BEECs to the Mexican energy efficiency agency CONAE (Comisión Nacional para el Ahorro de Energía).[10]

Mexican standards (Normas Mexicanas—NMX) are voluntary regulations that can be enacted by accredited private standardization organizations. Even further down in the hierarchy of standards, *technical suitability reports* (DITs) can be developed to assure the quality of certain appliances and equipments. Figure A4.7 summarizes the three types of standards and lists the building-relevant standards under each of them.

Figure A4.7. System of Mexican Building Energy and Appliance Codes and Standards



Source: Hirata 2009.

To date, eight NOMs have been implemented for equipment and appliances that are used in residential, commercial, and industrial buildings. The minimum performance standards (and their corresponding test procedures) for refrigerators and AC units have been harmonized with those of the United States and Canada.

The energy efficiency standards for electrical end use appliances have been implemented quite successfully, resulting in significant energy savings of 16,065 GWh to end users by the year 2006 (equivalent to the power consumption of 10 million Mexican households in one year), and resulted in 2,926 MW of avoided power capacity (equal to 6 percent of Mexico´s installed capacity by the end of 2006). Specifically, the standard for window air conditioning units (NOM-021-ENER) saved an estimated 253 GWh in 2006, while the one for central units (NOM-011-ENER) the estimated savings totaled 37 GWh. Energy efficiency standards for water heaters and industrial thermal insulation have resulted in energy savings of 36 Pjoules of LPG by the year 2006 (equal to 10 percent of a year's use by residential and commercial end users).[11]

Mandatory energy efficiency standards for thermal insulation materials and components (NOM-018-ENER-1997), interior lighting systems in nonresidential buildings (NOM-007-ENER-2004), and the envelope of nonresidential buildings (commercial BEEC—NOM-008-ENER-2001) were issued also. The latter two are, however, not enforced. In the case of the lighting standard, the power utilities tend not to require the necessary compliance certificate before connecting the building. In the case of the commercial BEEC, no large city government has incorporated it in its construction regulations and it is thus not part of the requirements for receiving a construction permit (discussed later).

Three voluntary standards for solar water heaters (flat plate collectors, installations, and terminology) have been issued through a private-sector standardization initiative with a solar energy mandate (NESO–13). These standards are not mandatory but can be adopted voluntarily for use in public and private programs. To support the flat plate collector standard, a test laboratory has been installed and is already certifying solar collectors.[12]

BEECs

Mexico was one of the first countries in Latin America to adopt a BEEC. The mandatory BEEC for nonresidential/industrial buildings (NOM-008-ENER-2001) was developed in 2001 by CONAE, with support from several LBNL experts.[13]

The code sets minimum requirements for the design and construction of the envelope of new buildings and extensions of existing buildings. The objective is to optimize the thermal behavior of buildings by limiting heat gains through their envelope and the use of energy for space cooling. The code is performance-based. Prescriptive requirements are used in defining the reference building to which the proposed building must be compared. The R-factors for walls and roof of the reference building vary by climate. For compliance checks simplified calculation methods can be used. At the time of code development, the code-implied building energy efficiency measures were deemed cost-effective.

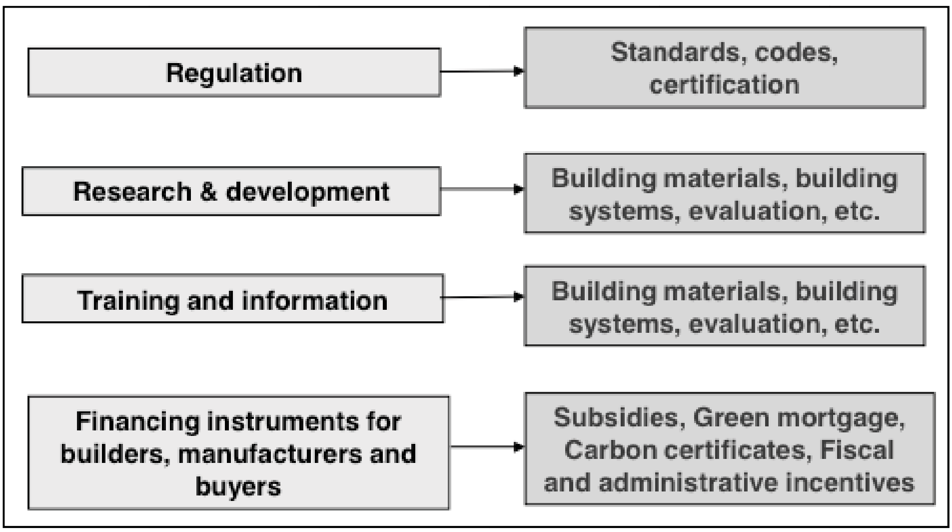
The BEEC has, however, not been applied anywhere, since it would have to be integrated into local construction regulations to become effective there. No state or municipality has included references to the BEEC in its construction regulations. This is a matter of lack of information of the importance of building energy use by local authorities. It can also be attributed to the resistance of developers due to the costs of compliance. They have already invested in very specific technologies that would become obsolete if new BEEC would require investments in equipment and training in new processes and in new supply lines for new materials.

For residential buildings a BEEC was drafted (NOM-020-ENER) several years ago, based on the same principles and calculation methods as the commercial BEEC. It was never enacted.

Regulations and Guidelines for Sustainable Housing Construction

The federal Housing Law (Ley de Vivienda) establishes a mandate for the National Housing Agency (Comisión Nacional de Vivienda—CONAVI) to propose measures for the planning, formulation and implementation of the National Housing Policy (see figure A4.8). Sustainability elements are explicitly mentioned. All housing that is subsidized with federal funds will have to comply with standards and rules determined by CONAVI.

Figure A4.8. CONAVI Establishes Housing Policies and Practices to Achieve Sustainability in Housing



Source: Hirata (2009).

In Mexico, housing construction is technically regulated at the local (states and municipalities) level through "Reglamentos de Construccion." Local rules differ greatly in their scope and requirements and are often inadequate to guarantee safety and quality of construction.

In this environment, CONAVI developed a national building regulation (Código de Edificación de Vivienda—CEV)[14] for housing in 2007. It is voluntary and can be accepted, adapted, and adopted by state and municipal authorities. The objective of the CEV is to regulate the urban housing construction process to improve public health, safety, and welfare.

The CEV covers basic requirements for energy efficient design and construction in its sustainability chapter (Chapter 27). They cover the building envelope, energy efficient systems and mechanical equipment, renewable energy systems, efficient and natural lighting, water saving and treatment, waste management and green areas.[15] Requirements would apply to new buildings as well as to renovation, modification, and extension of residential buildings.

Similar to the International Residential Code (IRC) in the United States, which is part of an entire family of codes, including the residential energy conservation code (IECC) (see Chapter 4), the CEV references more specialized codes and standards. For example, the sustainability chapter includes references to the existing standards for air conditioners, water heaters, and so on, as listed in figure A4.7.

Due to the lack of a BEEC for residential buildings, a guide for thermal insulation of residential buildings is included in the CEV. Reference values for the thermal resistance value (R) are listed for a number of cities throughout Mexico, and an annex contains the calculation method for the R-value for roof and wall construction materials. The CEV does not establish a requirement for the R-value, but just a requirement for the certification of the thermal characteristics of the material. This could become a problem as developers have no greater requirement than use any certified material.

In the meantime, this problem has been resolved with the development of a NMX for thermal insulation for residential buildings (NMX-C-460-ONNCCE-2008) by the Association of Companies for Energy Savings in Buildings (Asociación de Empresas para el Ahorro de Energía en la Edificación, AEAEE). The standard was enacted in August 2009[16] and establishes thermal insulation (R) values for roof and walls of new houses in different locations under three scenarios: (a) minimum, (b) comfort, and (c) energy efficiency. The R-values range from 8.0 to 18.0 for roof/ceiling and 5.7 to 13.0 for walls, depending on the climatic zone and the purpose of the use of insulation (from comfort to energy conservation).

In addition to serving as the national model construction code and contributing to the further development of building codes and energy efficiency codes at the local level, the CEV serves several other purposes:

- Development of sustainable indicators (Site selection, Green building design, Energy efficiency, Water use efficiency, Renewable energy, Solid waste management) as a baseline to define recommendations for policies, standards and regulations
- Minimum criteria for "green mortgages"
- Development of an evaluation system to differentiate levels of sustainability in construction
- Development of standards and rating systems for green residential buildings

CONAVI is promoting the CEV for adoption among local governments as a minimum building code and encourages developers to change their practices accordingly. In fact, the PNASE includes among its actions to promote the integration of CEV requirements into municipal construction codes. State and local authorities should require DROs (see box A4.5) to enforce that construction projects comply with the applicable energy efficiency codes. CONAVI is currently working with several municipalities to establish pilot projects for CEV adoption as local building regulations.

The energy savings that can be achieved with thermal insulation in low-income housing are substantial. According to simulations carried out by the AEAEE, savings of 25 to 34 percent of total electricity use could be achieved by using thermal insulation of the roof with R-15 and of R-16 for the walls and resizing of the air-conditioning units. Estimated costs for the thermal insulation ranges from US$600 to US$900, equivalent to about 5 percent of the construction cost of a low-income housing unit.[17]

Efforts to Promote Sustainable Building Practices

Federal Housing Finance Programs

Mexico has a strong housing finance program. Over 70 percent of the financing (not counting the savings of prospective owners) is generated by national agencies; see table A4.3. This includes subsidies of the federal government for low-income families. About two thirds of the Mexican population falls into the low-income category.[18]

Table A4.3. National Mortgage Financing Program—2009 Results

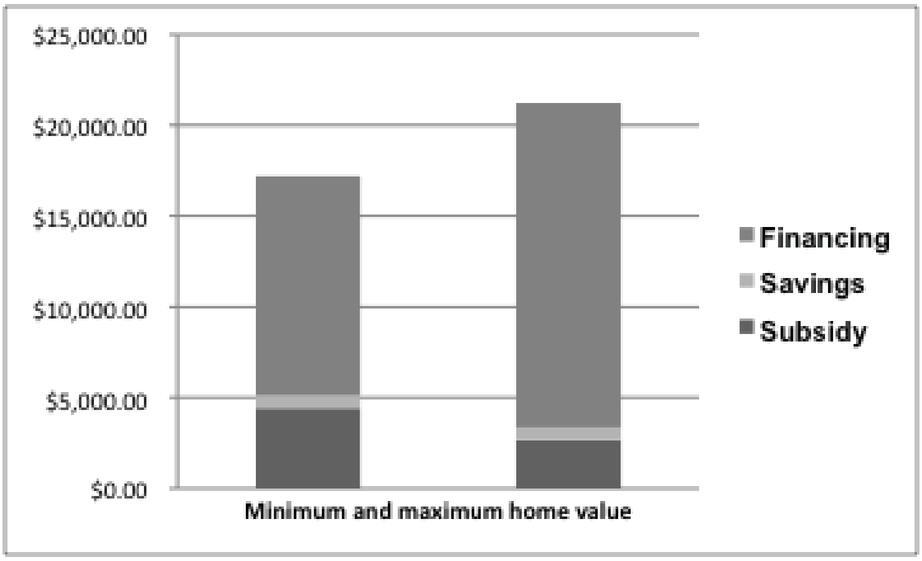
Entity	Credits/Subsidies Number	Investment Million Pesos
INFONAVIT	447,481	98,297
FOVISSSTE	100,082	47,421
SHF	45,761	5,573
CONAVI	159,540	4,873
FONHAPO	180,929	2,364
Private Financial Institutions	144,786	66,595
Other Institutions #	50,038	9,051
Total	1,128,617	234,174 US$18,000 million*

Source: CONAVI http://www.conavi.gob.mx/vivienda_en_cifras.html.
Notes: * Exchange rate: 13.01 MXN per US$1 (12/31/2009).
BANJERCITO, OREVIS, PEMEX, CFE, ISSFAM, PEFVM, FONACOT, HABITAT, L y FC, PET.

Several of these housing finance programs have incorporated CEV requirements to introduce more sustainable practices in the building sector:

- *CONAVI's low-income housing program Esta es tu casa* (This is your Home). CONAVI provides subsidies for families with income of less than four times the national monthly minimum salary and for housing units that are built to the CEV sustainability criteria with costs from US$17,000 to US$21,000; see figure A4.9. In 2009, CONAVI approved 160,000 transactions (loans and subsidies), amounting to US$375 million (see box A1.3).
- *INFONAVIT Green Mortgage*. INFONAVIT, the Mexican National Fund for Workers' Dwellings, introduced a Green Mortgage (Hipotecas Verdes[19]) scheme in 2007. Residential building owners can receive extra loan amounts if the properties they acquire include certified energy saving materials and/or equipment. This would increase the home value and also decrease monthly utility payments. Developers would benefit through an easier local permit process. IFC[20] provided financing in 2008 to a housing finance company to enable it to provide energy-efficient housing solutions for low- and middle-income homebuyers.

Figure A4.9. CONAVI Scheme for Financing of Low-Income Housing 2010 (in US$)



Source: Based on http://www.conafovi.gob.mx/tu_casa_con.html.

Both CONAVI and INFONAVIT require the on-site verification of compliance with their rules by a Verification Unit. The Verification Unit provides the document (Dictamen Único de Vivienda—"all-in-one verdict") to the borrower and it becomes part of the mortgage documentation. INFONAVIT requires the developer in addition to use certified materials and equipment or their analysis of their performance by a third party and to register the materials and equipment used in the construction as part of INFONAVIT´s registry for the appraisal of new housing offerings.

Box A4.2. Who Builds Low-Income Housing in Mexico?

The ten largest homebuilders in México account for 25 to 45 percent of the housing market:

- Low-income housing developments produced by these developers have 100 to 2,500 houses on average.
- Larger housing developments might contain more than 15,000 units.
- Because of the limited urban land availability, homebuilders have urban reserves equivalent to 2 to 5 years and are continuously acquiring more.

Source: Hirata 2009.

Carbon Financing

A large share of current housing construction is for low-income housing. The cost of such housing units is limited by the amount of financing the buyer can get approved for and it is thus difficult in incorporate many sustainability features. To facilitate the incorporation of energy efficiency and other sustainability requirements into low-income housing construction, the Mexican government submitted and got approved a methodology under the Clean Development Mechanism (CDM). Developers of housing developments participating in those projects will have to comply with all CEV sustainability requirements. The carbon financing proceeds will benefit developers/construction companies and also provide funds for monitoring and capacity building. For details of the carbon-financing program, see box A4.3.

Box A4.3. Carbon Financing for Sustainable Residential Housing

The Mexican government proposes to use financing from certified emission reduction (CER) credits to support sustainable residential housing as part of its program to provide subsidies for low-income housing.

On behalf of CONAVI, EcoSecurities submitted a proposal for a new small-scale methodology to the CDM Executive Board. It was approved in July 2009 under the name "AMS-III.AE Energy efficiency and renewable energy measures in new residential buildings."

The methodology will be applied to large housing developments with common characteristics, such as built area, building materials, cost, and socioeconomic level of occupants.

The measures to be complied with in totality include aspects related to:

- Site location conditions
- Water and power infrastructure
  - Street lighting to comply with the applicable NOM (NOM-013-ENER)
- Access to roads and public transportation
- Solar water heater in a solar-gas arrangement (includes a standard water heater as backup)
  - For the solar water heater, it requires CONUE´s certificate.21
  - For the gas water heater, it requires the applicable NOM (NOM-003-ENER).
- Thermal insulation
  - Thermal insulation materials have to comply with the NOM that certifies the thermal characteristics of the material (NOM-018-ENER).
  - The rules do not define an R-value requirement for the insulation.
- Use of reflecting materials in the exterior surfaces
- Use of water saving technology
- Waste management in the construction and in the operation

The program also requires the development of a database to provide information about GHG emissions from houses and the establishment of a monitoring system for the baseline (= traditional housing) and the sustainable housing.

It is estimated that incremental costs of energy efficiency and other sustainability requirements would amount to about 7 to 10 percent of baseline construction costs.

Under the baseline, it is estimated that each residential building would generate 1.5 tons of CO_2 per year. Estimated GHG emission reductions through the proposed measures to reduce electricity consumption are between 35 percent in temperate climates and 57 percent in hot climates.

Source: http://cdm.unfccc.int/UserManagement/FileStorage/OYS32HDPJQF574N6UWX1CR08KVG9TM

Institutional Arrangements: The Role of State and Local Governments in Building Code Enforcement

In Mexico, there is no national law that defines the basic premises for health and safety aspects of construction projects. Local governments are responsible for setting standards and rules for urban planning, urban design, and building construction. Local rules differ greatly in their scope and requirements and are often inadequate to guarantee safety and quality of construction (see box A4.4 for more details).

Box A4.4. Building Regulations in Mexico

In Mexico, authority for building regulations lies with municipalities. Of the 2,500 municipalities, only 72 have their own building regulations. Absent local regulations, the municipalities use state regulations. In many cities (even in the largest ones) certain aspects of building regulations, such as those related to water and electrical systems, are not always fully enforced due to their quantity and technical complexity and the lack of capacity and awareness of municipal officials. In general, building regulations in Mexico are highly variable from a topical and technical standpoint. None of the existing local regulations include reference to the commercial BEEC.

Source: Commission for Environmental Cooperation (CEC) 2008.

Municipalities have the primary right to issue licenses and permits for construction. The enforcement and compliance of building codes is under their authority. In municipal governments, it is generally an office within the urban development department that handles the permitting process. Also, they are in charge of inspecting for compliance with the code. Compliance is demonstrated through a set of documents that have to be presented and signed by accredited third-party, private-sector agents.

In the Mexican system of building code enforcement, the role of the private sector is very important, as three categories of auxiliary, nongovernmental entities have been given the legal role and responsibility to confirm compliance with standards and codes: the Director in Charge of Construction (DRO), the Construction co-responsible (CO) and the Verification Unit; see box A4.5.

Box A4.5. Third-Party Involvement in Building Code Enforcement

1. The Director in Charge of Construction (Director Responsable de Obra—DRO) is the person responsible for compliance with the applicable laws and codes related to construction and is considered an auxiliary to the local authority. The DRO is registered and authorized, in most cases, by the local urban development authority.

2. The Construction co-responsible (Corresponsable de Obra—CO) is a professional who shares responsibility with the DRO in specific fields. The Mexico City Construction Code, for example, establishes three specific fields for the CO:

- Structural safety
- Urban and architectonic design
- Installations (plumbing, electrical, and others)

3. Verification units (Unidades de Verificación) are individuals and/or private companies that certify the compliance with federal NOMs or NMXs for systems or installations. This certification or verification is defined in the Federal Law on Metrology and Standards as the "visual confirmation or test through sampling, measuring, laboratory tests, or documentation analyses to evaluate conformity in a given moment." They issue a document/certificate that states the compliance in the form of a signed statement by the legal representative of the Verifying Unit. In the case of a BEEC, this certificate is to be required by the power utilities (in the case of the nonresidential lighting standard) and the local, municipal authorities (in the case of the nonresidential buildings envelope standard).

(Box continues on next page)

Box A4.5 (continued)

The generic requisites to be a Verification Unit are the following:

- A professional degree in a field related to the system for which the standard is applied.
- Demonstrate that it has the adequate technical, material and human capacity as well as the quality procedures that guarantee the technical competence and trustworthiness of its services.
- Demonstrate that it has the installations, equipment, technical support, and adequate services necessary to satisfy the associated needs to the verification services. These include, among others: computers, software, secretarial services, individual offices, and all the necessary and updated bibliography.
- A set of manuals for: quality control; quality policy; organization and procedures; verification guides, instruction sheets; and formats used for the verification services. all in accordance with NMX-EC-17020-IMNC-2000
- The organizational manual should detail the structure of the requester's organization, including organizational chart, job description, responsibilities of the technical personnel that will perform the verification and the internal mechanisms for supervision.
- A signed code of ethics.

All of these requirements are to be accredited by the official accreditation entity according to NMX-C-442-ONNCEE-2004.

Source: de Buen (2009a).

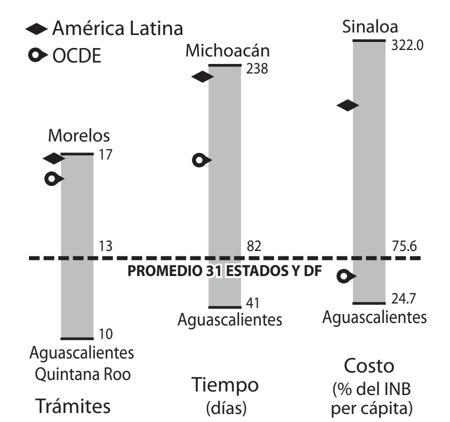
In comparison with many other countries, the process of obtaining construction permits in Mexico is fairly well established and involves relatively little time and costs. The best performers among Mexican cities do better than their counterparts in other OECD countries; see figure A4.10. Table A4.4 provides a list of the procedures in Mexico City to apply for construction permits, obtain inspections and occupancy permits and utility connections.

On average in Mexico, three inspections take place for a construction project. They are not based on completion of critical phases of a construction project, but take place randomly. In cities like Aguascalientes where accredited third-party inspectors are involved in carrying out the supervision necessary to obtain construction permits, inspections by municipal inspectors at the beginning and during construction have been eliminated.

Thus, in principle, the system of building code enforcement in Mexican municipalities is fairly well established. The system for verifying compliance with federally mandated codes and standards is already in place.

Some observers have, however, identified "extreme discretionality of the authorities" in, among others "the verification process."[22] This raises doubts about the effectiveness of BEEC compliance enforcement if energy efficiency requirements are added to the permit process.

Figure A4.10. Procedures, Time, and Cost to Obtain Construction Permits in Mexican States



Source: World Bank/IFC: Doing Business in México 2009.

Table A4.4. Dealing with Construction Permits in Mexico City

	Procedure	Days to Complete	Cost to Complete (MXN)
1	Obtención de licencia de alineamiento y constancia de número oficial	15	629
2	Obtención del dictamen de factibilidad de uso de suelo	75	708
3	Solicitud y conexión a los servicios de agua potable y drenaje y pagar las cuotas correspondientes por los servicios contratados	1	39,989
*4	Registrar permiso de construcción tipo B	1	75,836
5	Solicitud y conexión a los servicios de agua potable y drenaje	30	0
*6	Conexión y obtención del servicio de energía eléctrica	20	454
*7	Solicitud y conexión al servicio de teléfono	4	1,987
8	Aviso de terminación de obra a la autoridad municipal	1	0
9	Recibir inspección final de terminación de obra	1	0
10	Expedición de licencia de uso de suelo	6	0
11	Solicitar y obtener autorización de protección civil	7	0
12	Actualizar los registros del inmueble en el Catastro Municipal	1	0
TOTAL		162	119,603
			US$10,926

Source: http://www.doingbusiness.org/Subnational/ExploreTopics/DealingLicenses/Details.aspx?economyid=328.
Note: *These procedures can be completed simultaneously.

Challenges and Opportunities Ahead

Barriers on many levels have held back BEECs in Mexico. The lack of information of the importance of building energy use by local authorities and lack of knowledge of BEECs at the appropriate political level, combined with local autonomy over construction, has been a significant barrier to adoption of BEECs in Mexico. Compliance with the commercial BEEC is not part of the official list of requirements for a building permit in any municipality.

Developers have been resistant to incorporate energy efficient materials due to cost of compliance caused by sunk investment in very specific technologies that have costs at a competitive level, and new investment in the equipment and training in the new processes and in new supply lines for the new materials. In addition, low-income households have only a limited borrowing capacity for housing finance and this limits the investment that can be incorporated by developers in such housing.

Discretion is commonly practiced in building inspection, raising doubts on the effectiveness of compliance enforcement if energy efficiency requirements are added to the permit process.

Highly subsidized residential electricity tariffs reduce end user interest in acquiring higher first-cost technologies. Changes in subsidy design would be required to limit support to truly low-income households.

The federally funded and subsidized housing programs that require the application of energy efficiency investments have the potential to become successful large-scale demonstration projects for energy-efficient, sustainable construction practice. They are already beginning to generate changes that the earlier BEEC did not trigger. Developers and homebuilders who had been resistant to any changes are beginning to include sustainable technologies. Suppliers of building materials are adapting to the new requirements to be competitive in the supply of materials for new housing programs. In parallel, municipalities are also becoming more open to the incorporation of energy efficiency requirements into their building regulations and many of them seem to be willing to consider the adoption of the CEV.

To truly benefit from this opportunity and create lasting changes in the building sector additional measures are necessary:

- Strengthen the capacity to adopt and/or develop and mandate the regulations under CONAVI's sustainable housing program and INFONAVIT's Green Mortgage program.
- Design and implement a nationwide information program directed at municipal authorities to help them understand the importance and potential of energy efficiency in buildings and the relevant instruments and mechanisms in place (national standards and codes).
- Significantly increase and strengthen the capacity of the private-sector stakeholders accredited under the national standards and accreditation system to respond to the larger and expanded certification demand.
- Implement an integrated and coordinated effort of data gathering to have a better idea of the main characteristics of the building stock by region (such as built area, energy use, installed equipment, patterns of occupancy, materials, basic architectural elements). This would help in directing future efforts to design and implement energy efficiency programs in the building sector.
- Identify funding to implement the measures suggested above.

Notes

[1] This summary note was written by Anke S. Meyer, based on the consultant report by Odon de Buen (2009a) Building Energy Efficiency Code Compliance—Country Case Study Mexico, and the presentation "Breaking BEEC's Grounds—Mexico's Low Income Housing Program" by Evangelina Hirata (CONAVI) at the International Workshop: Mainstreaming Building Energy Efficiency Codes in Developing Countries, November 19/20, 2009, Washington DC. http://www.esmap.org/filez/pubs/1272009110711_BEEC_Evalgelina_Hirata.pdf.

[2] Estimate from de Buen (2009a).

[3] Hirata (2009).

[4] Plan Nacional de Desarollo 2007–2012; http://pnd.calderon.presidencia.gob.mx/pdf/PND_2007-2012.pdf

[5] Estimate from de Buen (2009a).

[6] http://www.funtener.org/importayconsumo.html.

[7] http://www.economia.gob.mx/pics/pages/.../DECRETO_APROB_PECC.pdf.

[8] http://www.sma.df.gob.mx/sma/links/download/archivos/cambioclimatico/programa.pdf.

[9] Irastorza, Veronica (2006), cited in de Buen (2009b).

[10] It has been renamed Comisión Nacional para el Uso Eficiente de la Energía (CONUEE).

[11] CONAE (2007). Ahorros Estimados por la Aplicación de las Normas Oficiales Mexicanas de Eficiencia Energética; http://www.energia.inf.cu/iee-mep/www/www.conae.gob.mx/normas/ahorros.html.

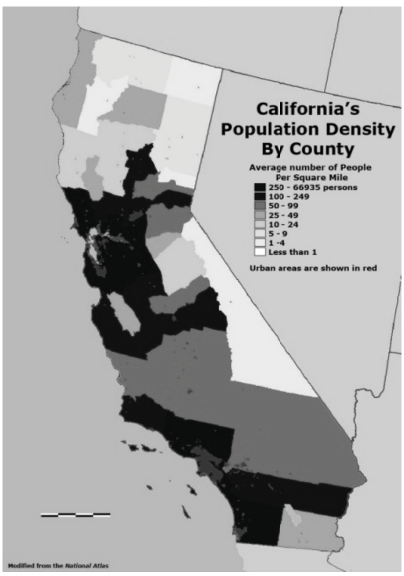
[12] The Government of Mexico City used environmental regulations and mandates to introduce a standard requiring that all new public-use installations (such as hotels and sport clubs) produce 30% of their hot water needs with solar energy starting in 2006 (de Buen 2009b).
[13] Huang et al. (1998).
[14] http://www.conafovi.gob.mx/publicaciones/cev001-332.pdf.
[15] The CEV was preceded by a 2006 guide for efficient use of energy in residential buildings, also published by CONAVI. It emphasizes the use of bioclimatic design principles that would reduce the need for air conditioning through the orientation of buildings, solar control, ventilation, and so on. http://www.conavi.gob.mx/publicaciones/guia_energia.pdf.
[16] http://www.ahorroenergia.org.mx/.
[17] Sanginé (2007), p. 7.
[18] Based on http://www.jchs.harvard.edu/publications/international/pickering_w00-2.pdf.
[19] http://portal.infonavit.org.mx/wps/portal/OFERENTES%20DE%20VIVIENDA/Cual%20es%20tu%20actividad/Desarrollar%20vivienda/hipoteca%20verde/!ut/p/c5/hY7RboMgAEW_ZR_QgOgKfbSAWGtb7LZUeFmstYQVYZvLUv36-banZbmPJzfnAA3m-ebbmubLBt84UAO9fKUizRNcQkgOhEC055KhZAurNJ65-puj-J93AbRx4Tx7Tqy93VlIDePsOExr6PIzKg4bYXnxFFK-y92i93iU6xtsq1iZwHr_bB8_60lWDju4ET462S4p3wQcthSp2kcXPRIk9HSP5GCz4eNCXhiV7rg0V7wLcQb2eeg7oIDGv5VQ8tVcyZJC0hLSFQLKdaZpR_De11OXpQ8_h-NZ7g!!/dl3/d3/L0lJSklna21BL0lKakFBTXlBQkVSQ0pBISEvNEZHZ3NvMFZ2emE5SUFnIS83X0NHQUg0N0wwMDBQRTkwMk5ENEpQQ0wwQzkyL0Jyam5oOTY5MDAwMTI!/?WCM_PORTLET=PC_7_CGAH47L000PE902ND4JPCL0C92_WCM&WCM_GLOBAL_CONTEXT=/wps/wcm/connect/infonavit/contenidos_infonavit/seccion_oferentes_vivienda/sa_05_01_00/sa_05_01_02/05_01_02_01.
[20] http://www.ifc.org/ifcext/media.nsf/content/SelectedPressRelease?OpenDocument&UNID=ADE3A9FC9EE1D22A852574C500733EA3.
[21] As there is no specific standard in place, CONUEE has been requiring a DIT (see Figure A1-25).
[22] Instituto Libertad y Democracia (2005).

Appendix 5. Case Study: BEEC Implementation in the U.S. State of California

California Urban Population and Importance of the Building Sector[1]

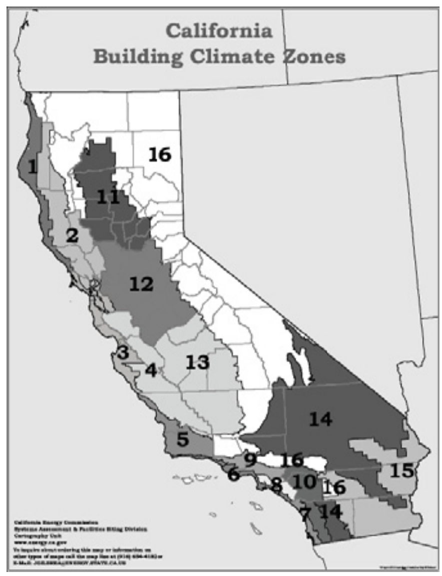
California is a very urban state. About 97 percent of its 37 million inhabitants[2] live in urban areas (see figure A5.1 and A5.2) By 2020, California's population is expected to increase to about 45 million residents. Beyond 2020 California's population size is less certain. Depending on the composition of the population, and future fertility and migration rates, California's 2050 population could be as little as 50 million or as much as 70 million.[3]

Figure A5.1. California Population Density



Source: http://education.usgs.gov/california/maps/california_population2.htm

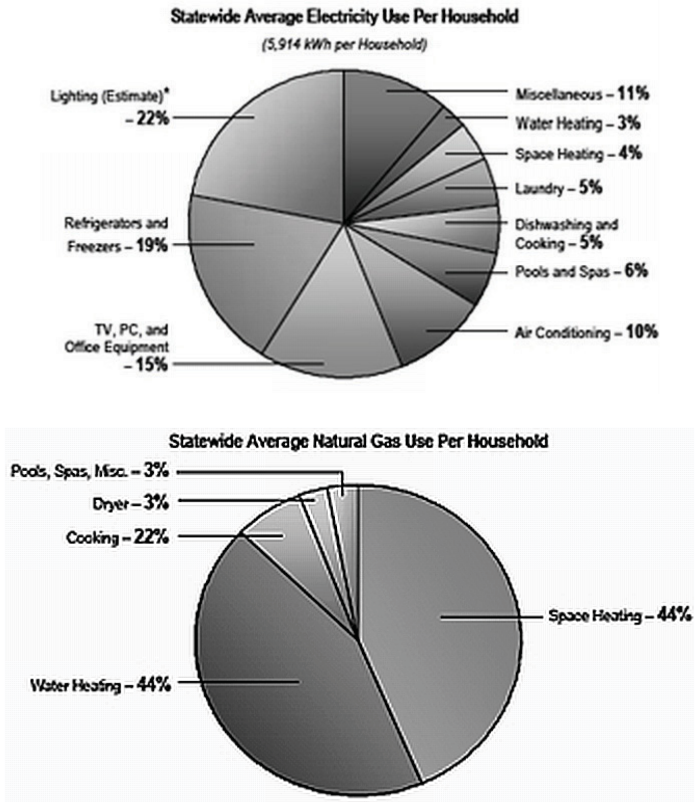
Figure A5.2. California Building Climate Zones



Source: http://www.energy.ca.gov/maps/building_climate_zones.gif

Approximately one-third of California's 12.6 million households live in multifamily structures, and two thirds in single-family homes. In 2008, the residential sector had an energy demand of over 25,000 MW and it represented approximately 32 percent of total state electricity consumption and 36 percent of its total natural gas consumption. Lighting is the leading electricity end use; while water and space heating dominate natural gas end use; see figure A5.3. Residential electricity demand is expected to grow to almost 31,000 MW by 2018.[4]

Figure A5.3. California Households Average Energy Use, 2008



Source: CPUC 2008, p. 10.

Almost all new homes in California are now equipped with central air conditioning, compared to only about one quarter three decades ago. In addition, new homes are much bigger now and are concentrated in hot inland communities. To meet this load, electricity capacity increased more than sevenfold. By 2006, peak demand for residential air conditioning units was 14,316 MW, causing over 30 percent of California's total peak power demand in the summer.[5]

Commercial buildings, which include office buildings as well as stores, restaurants, warehouses, schools, hospitals, public buildings and facilities, and others, cover more than 5 billion square feet of space. This sector is responsible for 38 percent of California's power and over 25 percent of its natural gas consumption. Lighting, cooling, refrigeration, and ventilation account for 75 percent of all commercial electric use, while space and water heating and cooking account for over 90 percent of gas use.[6]

Drivers for Developing and Strengthening Building Energy Efficiency Standards

California develops and regularly updates its own Building Energy Efficiency Standards (BEESs), which are more stringent than the national model codes.[7] According to the California Building Officials, "California's 2005 Residential Energy

Efficiency Standards are approximately 30 percent more stringent than similar standards at the national level. The 2008 Update … could move that figure to 50 percent."[8]

The first statewide energy efficiency standard for residential and nonresidential buildings, setting minimum standards for insulation, was developed in 1975 by the Department of Housing and Community Development, prior to the legislation that established the California Energy Commission (CEC). It was a reaction to the 1973 energy shortages and the realization that rapid growth of electricity demand in the early 1970s were largely due to wasteful use and would require an unsustainably large number of new power plants. The California legislature instead required[9] speeding up R&D for alternative energy and encouraged the adoption of BEESs. Ever since, it has been California's energy policy that energy efficiency is the resource of first choice for meeting its energy needs.

The CEC produced more stringent and comprehensive BEESs in 1978, dealing mostly with envelope issues. A performance-based compliance option was included in the residential code in 1983. Further revisions took place in 1995, 1998, 2001, 2005, and 2008. With each revision energy use in new buildings is reduced by 10 to 15 percent compared to the previous iteration.

More recently, climate change policy has driven the further development of California's BEESs. The Global Warming Solutions Act of 2006 mandates that California must reduce its greenhouse gas emissions to 1990 levels by 2020. The Integrated Energy Policy Report[10] finds that standards are the most cost-effective means to achieve energy efficiency, expects the BEESs to continue to be upgraded over time to reduce electricity and peak demand, and recognizes the role of the standards in reducing greenhouse gas emissions. California's Long-term Energy Efficiency Strategic Plan includes among its four Big Bold Strategies that all new residential and commercial construction will be zero net energy[11] by 2020 and 2030, respectively.

In 2008, the CEC developed and adopted several changes to the state's BEESs for new construction, both residential and nonresidential. Compliance manuals and compliance software have been developed also, and the changes have become effective January 1, 2010.[12]

Adopted BEESs are submitted to the Buildings Standards Commission (BSC) for approval and published as Part 6 of Title 24. The BSC is the state agency responsible for setting all building standards and codes. In 2008, it adopted the California Green Building Standards (GBS) code, which is a supplement to the 2007 California Building Standards Code. It is effective since August 2009 and applicable for all structures. The GBS will likely undergo revisions and be adopted as mandatory standards by 2012.[13] It is based on USGBC's LEED rating program and sets 15 percent stronger requirements for energy savings than currently mandated. [14] Both the BEESs and the GBC would have to be met.

Cities in California are encouraged to exceed Title 24 BEESs in new commercial and residential construction, with specific targets identified.[15] For example, for compliance with the statewide 2005 BEESs, San Francisco requires that new buildings achieve or surpass certain LEED or Green Point ratings; see table A5.1. San Francisco also enacted a green building ordinance that is effective for new buildings and renovations since November 2008.[16]

Table A5.1. San Francisco Locally Adopted Building Energy Standards

Occupancy Type	General Requirements	Minimum Energy Requirements
"Small Residential" [1]: 4 or fewer apartments and < 75' height	90 days after effective date: Green Point Rating, no GPR point goal 1/1/09: 25 GPR points 1/1/10: 50 GPR points 1/1/12: 75 GPR points	Starting 1/1/10: GreenPoint Rated minimum 15% Better Than Title 24 [1]
"Mid-size Multifamily Residential" [1]: 5+ apartments and < 75' height	90 days after effective date: Green Point Rating, no GPR point goal 1/1/09: 25 GPR points 1/1/10: 50 GPR points 1/1/12: 75 GPR points	Starting 1/1/10: GreenPoint Rated minimum 15% Better Than Title 24 [1]
"High-rise Residential": = or > 75' height	90 days after effective date: LEED Certified 1/1/10 and after: LEED Silver	Starting 90 days after effective date: LEED minimum, 14% Better Than Baseline using ECB method (or equivalent energy performance defined by the local jurisdiction)
"Mid-size Commercial": > 5,000 SF and < 25,000 SF; and < 75' height	1/1/09: LEED Checklist, no point goal 1/1/10: 5 LEED Credits achieved 1/1/11: 6 LEED Credits achieved 1/1/12 and after: 7 LEED Credits achieved 1/1/12: on-site renewable or purchase green energy credits	No energy requirement. LEED energy points may be used to achieve the LEED E&A Credit
"New Large Commercial Buildings": > 25,000 SF	90 days after effective date: LEED Certified 1/1/09: LEED Silver 1/1/12: LEED Gold 1/1/12: on-site renewable or purchase green energy credits	Starting 90 days after effective date: LEED minimum, 14% Better Than Baseline using ECB method (or equivalent energy performance defined by the local jurisdiction)
"New Large Commercial Interiors and Major Alterations": > 25,000 SF	90 days after effective date: LEED Certified 1/1/09: LEED Silver 1/1/12: LEED Gold	No energy requirement.

Note 1: Any residential building which contains 4 or more habitable stories and 3 or more dwelling units must meet the state's High-rise Residential Building Energy Efficiency Standards and meet the LEED minimum energy requirement or equivalent

Source: http://www.energy.ca.gov/title24/2005standards/ordinances/2008-09-26_ SAN_FRANCISCO.PDF.

Technical Aspects of California's BEESs[17]

The BEESs apply to any new construction that requires a building permit, whether for an entire building, for outdoor lighting systems, for signs, or for modernization. The standards apply only to the construction that is the subject of the building permit application and, except for lighting, only to buildings that are directly or indirectly conditioned by mechanical heating or mechanical cooling. Institutional buildings, including hospitals and prisons, and alterations of registered historical buildings are not covered by the standards developed by the CEC, another California agency sets the standards for these buildings. The BEESs' requirements for low-rise residential buildings affect the design of the building envelope and of the heating, ventilation, and air conditioning (HVAC), water heating, and lighting systems. Nonresidential buildings must meet all mechanical, envelope, indoor, and outdoor lighting requirements.

The BEESs provide two basic methods for complying with the energy budgets:[18] the prescriptive approach and the performance approach. Certain mandatory measures must be installed with either one of these approaches, but they may be superseded by more stringent measures.

Under the *prescriptive approach,* each individual energy component of the proposed building must meet a prescribed minimum efficiency. The prescriptive approach offers relatively little design flexibility but is easy to use. There is some flexibility for building envelope components, such as walls, where portions of the wall that do not meet the prescriptive insulation requirement may still comply as long as they are area-weighted with the rest of the walls, and the average wall performance complies. The stringency of the prescriptive envelope requirements differs by climate zones, of which California has 16 (figure A5.2). For low-rise residential buildings, the prescriptive approach offers several packages of measures. The prescriptive package D establishes the stringency of the BEESs for the performance approach. Approved computer programs model a house with the features of package D to determine the space conditioning and water heating budgets. For nonresidential buildings, the performance approach compares the proposed building to the standard design that is a building like the proposed design, but one that complies exactly with both the mandatory measures and the prescriptive requirements.

The *performance approach* is more complicated but offers considerable design flexibility. The performance approach requires an approved computer software program that models a proposed building, determines its allowed energy budget, calculates its energy use, and determines compliance with the budget. Compliance options such as window orientation, shading, thermal mass, zonal control, and house configuration are all considered in the performance approach.

The performance approach requires that the annual Time Dependent Valuation (TDV) energy is calculated for the proposed building and compared to the TDV energy budget. TDV energy not only considers the type of energy that is used (electricity, gas, or propane), but also when it is used. Energy saved during periods when California is likely to have a statewide system peak is worth more than energy saved at times when supply exceeds demand.

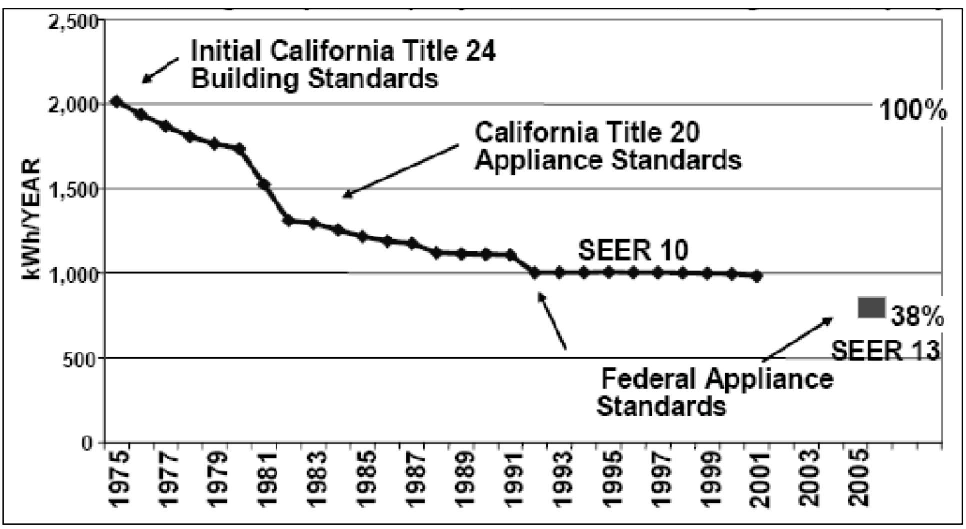
The application of certain measures with higher than mandatory performance can result in compliance credits for the performance approach. To take credit for these measures, the installer and inspector must be trained and certified and /or the installed products must be tested and certified.

Impact of BEESs

According to the CEC, California's BEESs, along with standards for energy efficient appliances, are the main reason why per capita electricity consumption has essentially stayed flat in California since the mid-1970s, while it continued to increase in other states. The standards saved more than $56 billion in electricity and natural gas costs between 1978 and 2006 and averted the construction of 15 large power plants. It is estimated that the standards will save an additional $23 billion by 2013.[19] The BEESs and appliance standards reduced peak power demand in 2003 by 5.75 GW and electric energy use by 11 TWh/yr. The electric energy needed to cool a new home in California has declined by two-thirds (about 2,400 kWh/yr to 800) from 1970 to 2006, despite the fact that new homes are now about 50 percent bigger and located in warmer inland climates.[20] The average drop of air conditioning usage by 3 percent per year while house size grew 1.5 percent per year is due to a combination of requirements of BEESs and appliance standards; see figure A5.4.

The revised 2008 standards are estimated to generate annual energy savings of 561 GWh for electricity and 557 GWh for natural gas, reduce electrical demand by 132 MW annually and annual CO_2 emissions by almost 0.5 million tons.[21]

Figure A5.4. Annual Usage of Air Conditioning in New Homes in California



Source: CEC Demand Analysis Office, cited in Goldstein 2006.
Note: SEER (seasonal energy efficiency ratio) is the federal central air conditioner efficiency standard. SEER 13 is the minimum rating required as of January 2006. Units with a SEER 13 rating are 30 percent more energy efficient than those with a SEER 10 rating.

Compliance with BEESs

No concise studies of the rate of compliance with BEESs exist for California. CPUC cites an estimated overall compliance rate of 70 percent with large variations for different measures (table A5.2). For example, fewer than 10 percent of HVAC systems installed have permits pulled and 30 to 50 percent of new central air conditioning systems are not being installed properly. These shortcomings have led to an estimated 20 to 30 percent increase in the peak energy needed on hot summer afternoons.[22] The CEC will be conducting a compliance survey in support of reaching the 90 percent compliance rate assurance by the governor for receiving ARRA funding.[23]

Table A5.2. California—Summary of Building Measure Noncompliance Estimates

Building Measure	Estimated Noncompliance rate
Residential	
Hardwired lighting	28%
Window replacement	68%
Duct improvement	73%
Nonresidential	
Lighting controls under skylights	44%
Cool roofs	50%
Bi-level lighting controls	n/a
Ducts in existing buildings	100%
Duct testing/sealing in new buildings	100%

Source: Quantec 2007.
Note: The study began shortly after the implementation of the updated 2005 BEESs. Utility-sponsored training and education programs aimed at improving compliance rates had not been completed yet. It was expected that compliance with the 2005 standards would improve as training efforts continued. Compliance also varies significantly between jurisdictions. Reasons for less than satisfactory compliance may include conflicts between State and local priorities, local government budget limitations, and market disincentives for contractors to comply with code requirements.

Technical support to improve compliance with requirements of the BEES has been quite ample.[24] The CEC develops compliance manuals (with forms that are required to be used to demonstrate compliance) for every version of the standards, has an established energy hotline, publishes a newsletter, sponsored a monitoring and training program targeted at local building departments between 1988 and 1996, provides presentations to International Code Council (ICC) Chapters, building departments and industry, has made available energy videos for energy code online training,[25] and has under development an Online Learning Center providing building plan examiners and building inspectors with education on their enforcement responsibilities. Numerous training programs targeted at the design and building community are sponsored by utilities (see next section).

Utility Funding for Compliance Improvement

California's System Benefits Charge (SBC) funds energy efficiency (EE), low income (LI), renewable energy (RE), and R&D programs.[26] It consists of a surcharge on bills of 0.00481 $/kWh, amounting to a total of $913 million in 2007 (table A5.3).

Energy efficiency program expenditures are dominated by lighting, but they also include support for BEESs. The statewide Codes and Standards (C&S) program was started in 2000 with the primary purpose to propose and support adoption of code enhancements. During the 2006–2008 program cycle, it had an annual budget of $4 million for support for training and certification and technical support for the regulated community for code adoption, code development, and compliance reviews. In addition, utility energy efficiency programs such as incentives to buy buildings or appliances with above-code features support the adoption of code enhancements.

Table A5.3. California System Benefit Charge 2007

	Details of Public Benefit Program Funding				
	R&D	EE	LI	RE	Total
million $	62.5	567.0	130.0	150.0	913.2
mills/kWh	0.33	3.00	0.69	0.79	4.81
% rev.	0.28	2.51	0.58	0.66	4.03
admin.	CEC	Utility	Utility	CEC	

Source: http://www.aceee.org/briefs/tbl1.pdf.
Note: The CPUC approved the 2006–2008 EE plans of the investor-owned utilities (IOUs) in Sept. 2005. These consist of about $1.7 billion investment in electric EE and about $300 million in natural gas EE (NG not in table). EE funding includes about 40 percent SBC and 60 percent new resource procurement. LI in table includes electric and NG funds. Not included in the table are $9 million/year for NG R&D in 07/08 and over $100 million/year public benefit spending by small IOUs and municipal utilities.

The 2009−2011 utilities' program plans will provide substantially more funds in general and for the C&S program specifically. This is due to three factors: (1) The plans are required to reflect the goals and strategies of the 2008 Energy Efficiency Strategic Plan, (2) utilities have to adopt a core set of about ten common, statewide programs, and (3) the overall number of efficiency programs had to be reduced to a more manageable number.

The proposed IOU funding for the 2009–2011 program cycle totals $4.2 billion, which would double the authorized 2006−2008 budget. The statewide C&S program amounts to $37 million. About 80 percent of the funds will go to the existing advocacy and Codes and Standards Enhancement (CASE) studies subprograms for both building codes and appliance standards. It supports conducting advocacy activities and directly influencing standards and code-setting bodies to strengthen energy efficiency regulations. CASE studies are developed for promising design practices and technologies and presented to standards- and code-setting bodies; see examples in box A5.1. The C&S program will include also compliance enhancement and reach code subprograms. The former will support building departments seeking to generally improve their operations and compliance processes, including role-based training and customized tools. Successful practices and tools will be identified and other jurisdictions encouraged adopting them also, thus avoiding duplication of efforts. The reach code subprogram will support the development of local ordinances that exceed statewide minimum building energy efficiency requirements.[27]

Box A5.1. Examples of California SBC-funded Activities for Improving Compliance with BEESs

1. PG&E's 2005-08 Residential New Construction program offered extensive training courses on emerging new technologies for the building industry, including courses on Title 24 standards changes, quality of insulation installation credits for contractors, and pilot programs relevant to incorporating energy efficiency into new homes. Other activities include attendance at building industry trade conferences/ outreach events and contractor/builder field visits as necessary. The target audience consists of builders, developers, energy consultants, HERS raters, architects, and other industry professionals.

Source: http://www.californiaenergyefficiency.com/calenergy_old/pge/2009.pdf.

2. BEESs in the early 1990s required a U-factor of 3.75 w/(m^2-K) for windows. However, test procedures for measuring U-factors were inadequate. Products whose actual U-factor was as high as 5.5 w/(m^2-K) could be considered to comply. Solving this problem required establishment of test procedures through the National Fenestration Rating Council and test laboratories. Utilities paid incentives for products that complied with the new testing requirements and funded the startup of labs with sufficient capacity to test all windows. This resulted in a significant upgrade to the BEESs in 1995, requiring that windows are tested to ensure that they meet the 3.75 w/(m^2-K) U-factor.

Source: See Goldstein 2006.

3. Most American homes transfer heat from the furnace and air conditioner to the space through air ducts. These ducts typically lose 20 percent or more of the energy in their heated or cooled air before reaching the room. Duct leakage can be reduced to below 6 percent with on-site pressure testing. California offered tested "leak-free" ducts as an efficiency measure available through the performance compliance path in 1998. The state noted that "leak-free" ducts would be required in the prescriptive packages in the near future. In response to the energy crisis of 2000, California required "leak-free" ducts beginning in 2002. Utilities encouraged this process by supporting the training of independent testing and rating experts who were recognized by the state for being able to offer certification of leak-free ducts.

Source: See Goldstein 2006. Cp section on HERs below.

The C&S program is coordinated with other SBC-funded utility programs. For example, an incentive program may provide incentives for measures in advance of the effective date of a new standard to prepare the market. Another way to prepare industry is the provision of education and training between adoption and effective dates of a particular standard. For example, C&S will provide 2008 Title 24 training to both market actors and internal program staff in advance of the January 1, 2010, effective date for the 2008 Title 24 standards. The training will help identify opportunities for ongoing coordination between incentive programs and C&S activities. Another program the C&S program coordinates with is the local government, HVAC, and Workforce, Education and Training program.

Within the commercial new construction program, IOUs programs are providing tools and resources to educate architects, engineers, lighting designers, and developers, but also home builders, design educators (and their students), and the owners of existing buildings about the latest energy efficiency techniques and proven new technologies. *Energy Design Resources* is an online resource center for information on energy efficiency design practices. *Savings By Design* offers design assistance and incentives to design teams and building owners to encourage high-performance nonresidential building design and construction.[28]

Energy savings from information and training programs are not currently credited for utility-savings goals, but a draft methodology to estimate savings has been developed. Savings from the Codes and Standards program during 2006–2008 are estimated to contribute around 10 percent of annual savings goals.[29] CPUC has not yet made a policy decision to approve this or another methodology.

Enforcement of BEESs

The primary enforcement mechanism is through the building permitting process. Until the enforcement agency is satisfied that the building complies with all applicable code requirements, including the BEESs, it may withhold the building permit (or, after construction, the occupancy permit). The standards apply only to the construction that is the subject of the building permit application and except for lighting, only to buildings that are directly or indirectly conditioned by mechanical heating or mechanical cooling.[30]

City and county building officials are responsible for the vast majority of Title 24 enforcement. The exception is building code enforcement for schools and state buildings, which is carried out by the Division of State Architects and the Department of General Services, respectively.

Enforcement officials are supported in their duties by third-party home energy raters. The California BEESs specify that third-party diagnostic testing or field verification of some energy efficient systems or devices is required for code compliance. HERS (Home Energy Rating System) raters are required to be hired by the owner to perform this work. The CEC has approved three providers who train, certify, and monitor HERS raters of which over 1,000 now exist: The California Certified Energy Rating & Testing Services (CalCERTS), California Building Performance Contractors Association (CBPCA), and the California Home Energy Efficiency Rating System (CHEERS).[31]

The 2008 BEESs also introduce new reporting requirements (‘registration’) for new building construction and alterations for which HERS field verification credit is claimed on the Certificate of Compliance. This applies to all compliance documentation throughout each phase of the construction process for those projects with HERS verification requirements for compliance. When registration is required, persons responsible for completing and submitting compliance documents (Certificate of Compliance, Installation Certificate, and Certificate of Field Verification and Diagnostic Testing) are required to submit the compliance form(s) electronically to a HERS provider data registry for retention.

For example, for low-rise residential buildings, prescriptive packages C, D, and E, as well as most performance method applications, require some sort of field verification and/or diagnostic testing. Most of the typical measures that require HERS field verification and/or diagnostic testing involve air-conditioning equipment and forced air ducts that deliver conditioned air to the dwelling. Examples of measures requiring HERS verification are refrigerant charge measurement and duct sealing. Compliance documentation includes the forms, reports, and other information that are submitted to the enforcement agency with an application for a building permit. It also includes documentation completed by the contractor or subcontractors to verify that certain systems and equipment have been correctly installed. It may include reports and test results by third-party inspectors (HERS raters). Ultimately, the compliance documentation is included with a homeowner's manual so that the end user knows what energy features are installed in the house. Compliance documentation is completed at the building permit phase, the construction phase, the testing and verification phase, and at the final phase.

Proposed Measures to Improve Compliance

California's long-term energy efficiency strategic plan includes goals and proposed measures for improving compliance with and enforcement of building energy efficiency and appliance standards (table A5.4). By improving enforcement at the local level, the California long-term energy efficiency strategic plan proposes to halve the current rate of noncompliance with codes and standards by 2012, halve it again by 2016, and achieve full compliance by 2020.[32] This is in line with the recent assurance by the governor to reach 90 percent compliance by 2017.

The SBC-funded statewide C&S program for 2009–2011, already described, proposes to implement the measures outlined in the plan.

Table A5.4. California Codes and Standards Compliance and Enforcement Goals

Implementation Plan and Timeline				
Strategies	**Near-Term (2009-2011)**	**Mid-Term (2012-2015)**	**Long Term (2016-2020)**	**2021 – Beyond**
2-1: Improve code compliance and enforcement.	• Conduct research to determine high-priority tactical solutions for code compliance and focus efforts accordingly. • Increase training and support for local building code officials. • Investigate regulatory tools such as licensing/ registration enforcement. • Evaluate proposed changes to the code and compliance approaches to simplify and expedite compliance. • Work with local governments to improve code compliance, adopt above code ordinances, and provide training/education.	• Continue to conduct further research relating to code compliance. Refocus efforts as needed. • Pursue appropriate involvement of HERS raters. • Pursue trade associations to improve "self-policing" of membership. • Investigate tools, software programs, "incentives", and policies to simplify and streamline permit process. • Apply feasible mechanisms to prove code compliance as a pre-requisite for partnership funding or incentives from the IOUs.	• Continue to conduct research. • Investigate aggressive "stick" and "carrot" programs with monetary penalties and incentives. • Investigate greatest opportunities of compliance improvement of appliances (Title 20) in the upstream and midstream markets, including working directly with manufacturers and distributors to improve appliance and equipment compliance.	• Continue to conduct research. Investigate and pursue solutions to the perceived and real "penalties" associated with non-compliance. • Investigate codes and standards that would regulate the operation of buildings that may include such things as maintenance requirements, regular updates to operating schedules, mandatory monitoring and controls points, system reporting requirements, etc.

Source: CPUC 2008, p. 70.

To create market demand for efficient homes, awareness of and information on energy efficiency has to be increased. The CEC has recently adopted HERS for existing homes (HERS II).[33] It will deliver whole-house home energy ratings that provide homeowners and homebuyers with information about the energy efficiency of the homes they live in or homes they are considering for purchase. The ratings will also provide evaluation of the cost-effectiveness of options to achieve greater energy efficiency in those homes. Funding from ARRA as well as from the 2009–2011 programs of the IOUs will support the implementation of HERS II.

Conclusions and Lessons Learned

California stands out among U.S. states by its long-standing and strong policy emphasis on implementing measures that reduce requirements for new energy supplies and, more recently, combat climate change. Early adoption of mandatory BEESs and their regular strengthening is one of the policy instruments that have contributed to a stable per capita electricity consumption.

Although compliance is not perfect, intensive and continuing training and education for all actors involved in compliance/enforcement, as well as in the building industry, have been instrumental in achieving one of the highest compliance rates in the country.

Substantial public benefits funds administered by utilities have provided most of the funding for programs to strengthen BEESs and improve compliance.

Finally, extensive use of third-party home energy raters to verify compliance with certain energy efficiency requirements and correct installation has supported enforcement officials in their duties.

Notes

[1] This case study was written by Anke S. Meyer.

[2] Estimate for 2008; see http://www.ers.usda.gov/Statefacts/CA.htm.

[3] See http://koordinates.com/layer/671-california-2050-projected-urban-growth/.

[4] See CPUC 2008, p. 9.

[5] Including small commercial air conditioning; see CPUC 2008, p. 57.

[6] See CPUC 2008, p. 30.

[7] The new BEESs, adopted on April 23, 2008 and effective as of January 1, 2010 are stricter than IECC 2009 and ASHRAE 90.1-2007; see http://www.energycodes.gov/implement/state_codes/index.stm.

[8] http://www.consol.ws/calbo/.

[9] Through the Warren-Alquist Act of 1974 which also created and gives statutory authority to the California Energy Commission.

[10] IEPR, see http://www.energy.ca.gov/energypolicy/index.html).

[11] "A zero net energy home employs a combination of energy efficiency design features, efficient appliances, clean distributed generation, and advanced energy management systems to result in no net purchases of energy from the grid," CPUC 2008, p. 13.

[12] http://www.energy.ca.gov/title24/2008standards/

[13] On January 14, 2010, the California Building Standards Commission approved the most environmentally stringent building code in the United States for new commercial buildings, hospitals, schools, shopping malls, and homes. The new code, named CAL Green, requires builders to install a number of environmentally friendly features in new buildings, including plumbing to cut indoor water use, efficient heaters, and air conditioners, and requires them to divert 50 percent of construction waste to recycling. Local jurisdictions will be able to keep their stricter existing standards, or adopt more stringent versions of the state code. The California Air Resources Board estimates that the code will reduce greenhouse gas emissions by 3 million metric tons in 2020. The new code will go into effect in January 2011. Source: http://www.pewclimate.org/states/news/ca-building-code-01-15-10 and http://gov.ca.gov/press-release/14186/.

[14] http://www.documents.dgs.ca.gov/bsc/2009/part11_2008_calgreen_code.pdf.

[15] http://www.energy.ca.gov/title24/2005standards/ordinances_exceeding_2005_building_standards.html.
[16] (http://apps1.eere.energy.gov/states/news_detail.cfm/news_id=11961 or http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA56R&re=1&ee=1).
[17] The information in this section is adapted from the compliance manuals, both residential http://www.energy.ca.gov/2008publications/CEC-400-2008-016/CEC-400-2008-016-CMF.PDF and nonresidential http://www.energy.ca.gov/2008publications/CEC-400-2008-017/CEC-400-2008-017-CMD.PDF.
[18] Energy budget can be defined as the maximum allowed energy use of the designed building, taking into consideration the same size and general characteristics and built to the mandatory and prescriptive requirements.
[19] http://www.energy.ca.gov/2007publications/CEC-100-2007-008/CEC-100-2007-008-CMF.PDF.
[20] http://www.aps.org/energyefficiencyreport/report/energy-bldgs.pdf.
[21] http://www.energy.ca.gov/2008publications/CEC-400-2008-016/CEC-400-2008-016-CMF.PDF.
[22] See CPUC 2008, p. 70.
[23] Personal communication from E. Geiszler (CEC), July 2009. See also http://www.energy.gov/media/3149SchwarzeneggerCalifornia.pdf.
[24] See, for example, Benningfield/Hogan 2003.
[25] Available at www.energyvideos.com.
[26] Utility regulation in California has early on addressed utilities' bias against investments in energy efficiency measures by decoupling profits from sales (see http://www.cpuc.ca.gov/cleanenergy/design/docs/Deccouplinglowres.pdf) and providing shareholder incentives (cp. 'risk reward incentive mechanism', for example, in CPUC 2009a).
[27] Cp. CPUC 2009b.
[28] See http://www.savingsbydesign.com/overview.htm.
[29] See http://aceee.org/pubs/u081/muni-programs.pdf, p11-2 – 11-5.
[30] http://www.energy.ca.gov/2008publications/CEC-400-2008-017/CEC-400-2008-017-CMD.PDF, which contains the nonresidential compliance manual and http://www.energy.ca.gov/2008publications/CEC-400-2008-016/CEC-400-2008-016-CMF.PDF, which contains the residential compliance manual.
[31] See http://www.energy.ca.gov/HERS/. Certification of HERS providers for the new 2008 BEESs is currently underway. See also Box 4-6.
[32] CPUC 2008, p. 90.
[33] http://www.energy.ca.gov/HERS/index.html HERS II is effective as of September 1, 2009.

Appendix 6. BEECs in Selected Countries in Asia, Latin America, Eastern Europe, Middle East and Africa

Country	BEEC
Indonesia	Voluntary commercial code 1989; green building standard 2010 http://www.thejakartapost.com/news/2010/01/25/government-issues-standards-green-buildings.html
Malaysia	Voluntary commercial code 1989; to be incorporated into national building bylaws – would make it mandatory Building energy benchmarking program http://www.ptm.org.my/EE_Building/download/OfficeBuildingBench.pdf Several low/zero energy office buildings have been completed
Vietnam	Mandatory commercial BEEC 2003 – not yet implemented due to lack of compliance documentation
Philippines	Voluntary commercial code 1989
Sri Lanka	Adapt Malaysian commercial code – voluntary 2000
Pakistan	Building Energy Code of Pakistan, May 1990, voluntary for both residential and commercial buildings A new 2009 draft BEEC was developed by the National Energy Conservation Center (ENERCON) under the Ministry of Environment. It covers both new buildings and retrofits and applies to building envelopes, building mechanical systems, lighting, and electrical power and motors; see http://www.enercon.gov.pk/DRAFT BEC.pdf
Brazil	The 2001 federal law on energy efficiency (10.295/2001) requires the Ministry of Mining and Energy to define performance standards for new non-residential buildings. In Brazil, the adoption of minimum prescriptions and criteria for compliance involves several issues: • Lack of capable professionals in the city halls to re- quest compliance with the standard; • The need of supporting materials and training for developers and building professionals; • In the Brazilian reality of construction practices, for small constructions, the lighting and HVAC systems are, usually, installed after the building is ready to occupation. This culture makes that the implementation of a compulsory energy standard of minimum requirements more difficult. Based on that, it was decided for an easier start, through the implementation of regulation for labeling commercial and public buildings, then carry out tests and training on the methodology and, finally, to increase the complexity of Brazilian building energy efficiency regulation. (Lambert et al. 2007) As a first step, a federal regulation for voluntary labeling of energy efficiency levels (for lighting, HVAC and building envelope) in commercial, public and service buildings (larger than 500m^2) has been developed. INMETRO developed certification procedures. The voluntary labeling program was supposed to be started in 2007 and to become mandatory 5 years later. *Source*: National climate Change Plan 2007, http://www.mma.gov.br/estruturas/smcq_climaticas/_arquivos/plano_nacional_mudanca_clima.pdf and Regulation for energy efficiency labelling of commercial buildings in Brazil by R. Lamberts, S. Goulart, J. Carlo, F. Westphal, Federal University of Santa Catarina, Brazil , 2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century, September 2007, Crete island, Greece http://www.inive.org/members_area/medias/pdf/Inive%5CPalencAIVC2007%5CVolume2%5CPalencAIVC2007_V2_002.pdf
Armenia	A Building Thermal Performance Code was adopted in 2007. It is not currently enforced; manuals have not been developed nor has training been provided. State-owned design institutes and inspectors under the Ministry of Urban Construction remain largely unaware of what the code entails (World Bank (2008b) p. 52f.) A UNDP/GEF project is under preparation that will support code compliance in residential buildings.

Country	BEEC
Ukraine	The Ukraine's building energy code of 2006, known as the 'Thermal Protection of Buildings ' (DBN B.2.6-31: 2006), became effective in January 2007 and is mandatory nationwide. The code is intended to ensure the rational use of energy for heating operations in buildings. It sets requirements standards including those for building envelope and thermal insulation. The code, which is modeled on the Russian Federationn Thermal Performance code, includes a performance-based rating compliance system, as well as an "energy passport" for documentation and compliance verification. http://bcap-ocean.org/state-country/ukraine To become effective, several issues still have to be resolved: definition of an audit methodology and build-up of an infrastructure of experts to carry out energy audits necessary for the certification of buildings for the energy passports; testing and certification of insulation materials and relevant building components. Several cities have already embraced energy certification for their public buildings, especially 14 cities forming the association of "Energy Efficient Cities of Ukraine" *Source*: Anatoliy Kopets (2009), Energy Monitoring/Targeting and Certification of Public Buildings in Ukraine; http://www.ecobuild-project.org/docs/ws2-kopets.pdf
Jordan	The BEEC, developed in 2008 by the Royal Scientific Society of Jordan, is an update to Jordan's 1998 energy code that is currently in force and only covers insulation. It is voluntary and based on ASHRAE 90.1-2007. It updates the standards on insulation and introduces requirements for other energy applications in buildings. The code is awaiting approval, after which it will be tested and enforced. *Source*: Energy Efficient Building Code for Jordan T. Awadallah, H. Adas, Y. Obaidat, I. Jarrar *Royal Scientific Society, Amman, 1438, Jordan 2009* http://gcreader2008.ju.edu.jo/PDF/403-d.pdf See also: Thermal Insulation Code of practice of 1985, updated in 2008; http://www.med-enec.com/en/NC/2008/08Jordan/Awadallah-NERC-EE Building Code-NC-JOR-11-08.pdf
Lebanon	Development of a Thermal Standard and its related technical documents, in addition to consultation, information dissemination and capacity building was undertaken, as a result of which Lebanon has adopted the developed Thermal Standard on a voluntary basis until the target year 2010; In a second phase, a process of voluntary application is foreseen. This however should be complemented by various steps including: energy audits, lab-testing and labeling of locally manufactured building materials, elaboration of a certification mechanism, financial incentives, and so forth. ; In a third phase, adoption of a mandatory BEEC should be envisaged. *Source*: Matilda El-Khoury (2005), Status of Building Energy Codes in Lebanon http://www.clasponline.org/files/WkshpTunisiaNov05_Lebanon_EEB.pdf see also http://www.med-enec.com/en/TOPIC/Market Studies/Market Study and Capacity Assessment - Lebanon.pdf
Tunisia	Thermal building code: Implementation strategy • Step 1: Development of prescriptive and performances approaches, compliance checks tools and insulation material certification. • Step 2: Awareness and capacity buildings campaigns (assessors certification). • Step 3: Enforcement in office buildings (public and private). • Step 4: Mandatory Plan Design review by an accredited controller (for Building's projects with expected energy consumption > 500 Toe/year). • Step 5: Development of "win-win" financial mechanisms (subsidies of thermal insulation in residential buildings). • Step 6: Enforcement in collective residential buildings (in process), • Step 7: Thermal performance label for buildings (added value) (in process) • Step 8: Enforcement in all buildings (after 2-3 years). Thermal Performance Label for Office Buildings in Tunisia (July 2008) (BEEC for residential building in final process) *Source*: Mourtada (2009) Market analysis and capacity assessment: http://www.med-enec.com/en/TOPIC/Market Studies/Market Study and Capacity Assessment - Tunisia.pdf
Kuwait	Residential and commercial BEECs are mandatory

Country	BEEC
United Arab Emirates	Green building standard of Dubai municipality starting 2009. Buildings that don't qualify won't receive permit (building plans will not be passed); modifications of LEED. Pilot program for 25 new buildings in design phase in October 2008 to try the use of rating system
South Africa	Two voluntary commercial building standards: SANS 204 regulates artificially ventilated commercial and public buildings SANS 283 regulates naturally ventilated buildings. Green Star SA rating system http://www.gbcsa.org.za/home.php. Its rating tools are based on those of the Australian Green Building Council. As of May 2009 there is no Green Star SA-rated and -certified property development, but several office buildings have been registered. South Africa is developing mandatory BEECs for residential and commercial buildings as part of its national energy efficiency strategy. The timescale is not entirely clear but appears to be for implementation between 2011 and 2015 (BRE 2008) Cp. Harris/Krueger (2005).
Côte d'Ivoire	Commercial BEEC (1995) is voluntary
Botswana	Building energy efficiency guidelines developed 2007 with Danish government support http://www.bauerconsultbotswana.com/1_Introduction.pdf

Appendix 7. Voluntary Low-Energy/Green Building Schemes

Certification, labeling, and rating programs have been developed in many countries for energy-efficient appliances, and for many types of appliances they are mandatory—for example, air conditioners. Such programs have also been introduced in the building sector. In fact, low-energy/green building schemes, that include labeling, rating and certification, are becoming quite popular in many countries, see table A7.1. Although most of them have been developed and are administered by the private sector and are voluntary, they are paving the way for more aggressive public targets to reduce the energy consumption and environmental footprint of buildings.

Several of the rating systems in Asian countries are government-led, such as CASBEE in Japan, and the systems in Taiwan, China; Hong Kong, China; and Singapore (GBPP, HK-BEAM, and GMIS, respectively). According to UNEP/SBCI (2007), adoption appears to be limited almost exclusively to government projects, except in Japan where CASBEE is mandated for all projects in several jurisdictions. The private sector is encouraged to adopt the higher performance standards voluntarily, but there appears to be very limited uptake. Even though private-sector green building councils may exist and support those rating systems (with consensus-based development and updates, education, project and practitioner certification, reviews, and manufacturer and other industry involvement), their influence and benefits are limited. In particular, the councils do not receive the essential revenues from certification of projects and practitioners, education and information programs, consulting, and coaching.[1]

Table A7.1: Examples of Voluntary Low-Energy/Green Building Energy Efficiency Labeling Schemes

LABEL	Definition	Criteria/Examples
Low-energy house	Buildings with energy consumption below prevailing BEEC requirements	*Energy star buildings in the United States* Residential buildings: (i) At least 15% more energy efficient than homes built to the 2004 International Residential Code (IRC) and include additional energy-saving features that typically make them 20–30% more efficient than standard homes (ii) Include additional energy-saving features that typically make them 20–30% more efficient than standard homes Commercial buildings: Score in the top 25 percent based on EPA's National Energy Performance Rating System. To determine the performance of a facility, EPA compares energy use among other, similar types of facilities on a scale of 1-100; buildings that achieve a score of 75 or higher may be eligible for the ENERGY STAR. Differences in operating conditions, regional weather data, and other important considerations are accounted for. http://www.energystar.gov/index.cfm?c=home.index

LABEL	Definition	Criteria/Examples
Zero-energy house	Buildings with energy consumption below prevailing BEEC requirements; any remaining energy required in the building is generated on -site from renewable sources	Passive solar design Super insulation Air tightness Mechanical heat recovery ventilation Triple glazed windows Intrinsic heating (solar heat gain, heat from the occupants, electric lighting and domestic appliances) Renewable energy Based on http://www.lowenergyhouse.com/index.html
Zero-carbon house	Buildings with energy consumption below prevailing BEEC requirements where any remaining carbon emissions generated from on-site or off-site fossil fuel use are balanced by the amount of on-site renewable energy production	*UK Code for Sustainable Homes* The Code uses a sustainable rating system indicated by stars that depend on the extent of achieving code standards in the areas of energy and water usage as well as other key sustainability criteria. The Code is progressively introducing the star rating system from 2006 (mandatory since 2008) to 2016. Ratings run from the minimum of one star, where a house is 10 percent more efficient than required by the 2006 Building Regulations standard, to a completely zero-carbon home with six stars. New homes should be zero-carbon by 2016; public sector supported homes already in 2013. The Code is a development guide for home designers and builders and the national standard for the building of sustainable homes with minimum standards for energy and water use and other sustainability categories. Tax deductions are available to new homes that reach the zero-carbon standard before the target date. http://www.communities.gov.uk/planningandbuilding/buildingregulations/legislation/codesustainable/
Passive house	A comfortable internal climate can be maintained without the use of a conventional central heating system or cooling system. The building heats and cools itself and is therefore passive. The cost savings from dispensing with the conventional heating system can be used to fund the upgrading of the building envelope and the heat recovery ventilation system. After the main criteria have been followed, additional energy requirements can be catered for using renewable resources	*PassivHaus in Germany and other countries* o The building must not use more than 15 kWh/m²/year in heating energy (about 30 kWh/m²/year for building retrofit) o The standard requires very precise levels of insulation for every construction element. Every external surface must have a U-factor lower than 0.15 W/m²K and there are tight restrictions on the relative window surface. o The total use of primary energy (e.g. fuels) for all uses combined (heating, hot water and specifically electricity) may not exceed 120 kWh/m²/year. o With the building depressurized to 50 Pa (N/m²) below atmospheric pressure using an approved air pressure testing method, the building must not leak more air than 0.6 times the house volume per hour. The German PassivHaus Institute established the standard for PassivHaus construction and, on completion, provides certification for buildings meeting the standard. It also certifies building components that are important to reach passive-house standard. More than 12,500 passive houses have been built (or refurbished) in Germany and more than 16,500 worldwide. http://www.passiv.de/ http://www.passivhaus.org.uk/index.jsp?id=668

LABEL	Definition	Criteria/Examples
Green building	Requires below-code energy consumption and compliance with other sustainability criteria (water efficiency, good indoor air quality, use of environmentally sustainable materials, and use of the building lot or site in a sustainable manner) over the life-cycle of a building	*LEED* (Leadership in Energy and Environmental Design) is administered by the U.S. Green Building Council (USGBC) with projects in more than 40 countries.[2] LEED promotes a whole-building approach and rates performance in five areas: sustainable site development, water savings, energy efficiency, materials selection, indoor environmental quality, and innovation & design, www.usgbc.org/LEED. Rating systems have been developed for various types of new and existing construction.
		BREEAM (Building Research Establishment Assessment Method, UK): Until 2006, approx. 65,000 buildings were certified and 270,000 were registered worldwide. The version of BREEAM for residential buildings became the basis for the UK code for sustainable homes to become mandatory by 2016. As of 2008, all new homes have to be rated against this code (http://www.breeam.org/index.jsp).

Notes

[1] Based on UNEP/SBCI (2007).

[2] USGBC is one of the 20 members (as of May 2010) of the World Green Building Council (GBC), which includes GBCs from Argentina, Australia, Brazil, Canada, Colombia, Germany, India, Japan, Mexico, the Netherlands, New Zealand, Poland, Romania, Singapore, South Africa, Spain; Taiwan, China; United Arab Emirates, United Kingdom, and United States. For further information see: http://www.worldgbc.org/home.

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Mainstreaming Building Energy Efficiency Codes in Developing Countries is part of the World Bank Working Paper series. These papers are published to communicate the results of the Bank's ongoing research and to stimulate public discussion.

Building energy efficiency codes (BEECs), which regulate the energy performance of building design and its compliance during construction, are broadly recognized as a necessary government intervention to overcome persistent market barriers to capturing the economic potential of energy efficiency gains in residential, commercial, and public service buildings. Compliance enforcement has been the biggest challenge to implementing BEECs. This paper summarizes the findings of an extensive literature survey of the experiences of implementing BEECs in developed countries, as well as in some early developing-country adopters, specified in case studies of China, Egypt, India, and Mexico. The paper also serves as a primer on basic features and contents of BEECs and commonly adopted compliance and enforcement approaches. It recommends increased international support in strengthening the enforcement infrastructure for BEECs in middle-income developing countries. For low- and lower-middle-income countries, there is an urgent need to help improve governmental oversight of building construction, which will lay a foundation for effective implementation of BEECs.

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