ESMAP
Energy Sector Management Assistance Program

Knowledge Series 019/14

Improving Energy Efficiency in Buildings

Energy Efficient Cities

MAYORAL GUIDANCE NOTE #3

For more information related to energy efficiency in cities, please visit ESMAP's website at: www.esmap.org/Energy_Efficient_Cities.

ADDITIONAL RESOURCES

ESMAP *Energy Efficient Cities Case Studies Database:* http://www.esmap.org/node/231

Mainstreaming Building Energy Efficiency Codes in Developing Countries: http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-8534-0

Global Buildings Performance Network: http://www.gbpn.org/

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EXECUTIVE SUMMARY

About one-third of global energy is consumed in residential, public, and commercial buildings (collectively referred to as buildings), where it is used for space heating, cooling, ventilating, lighting, cooking, water heating, refrigerating, and operating electric and mechanical devices. Global energy use in buildings is expected to grow as cities in developing countries continue to modernize and per capita income levels continue to increase.

Because of their high energy consumption, residential, public, and commercial buildings also offer unparalleled opportunities for energy savings. According to the International Energy Agency, buildings account for some 41 percent of global energy savings potential by 2035, compared with the industrial sector (24 percent) and the transport sector (21 percent).[1]

This guidance note outlines how cities can tap into a wide array of proven technologies, policies, and financing mechanisms to improve energy efficiency and capture cost-effective energy savings in buildings. It offers city leaders advice on how to get started in introducing energy efficiency measures, and provides lessons and examples from successful programs that have been introduced worldwide.

There are three primary ways in which energy efficiency can be improved in residential, public, and commercial buildings:

1 | Through improved design and construction techniques that reduce heating, cooling, ventilating, and lighting loads

2 | Through building upgrades and the replacement of energy-using equipment

3 | By actively managing energy use

The main junctures at which energy efficiency interventions can be launched are as follows:

- **When designing and constructing new buildings.** Well-designed and well-constructed new buildings represent the best opportunity for reducing heating, cooling, ventilating, and lighting loads. The most effective way to ensure that energy efficiency is factored into the design and construction process is by introducing and enforcing Building Energy Efficiency Codes. A building energy efficiency code sets out the minimum energy efficiency requirements of a building, including the thermal performance of a building's "envelope" and the energy efficiency standards of its internal equipment and devices.
- **By retrofitting existing buildings.** Retrofitting existing buildings and replacing energy-consuming equipment are critical for improving energy efficiency in cities where building stock turnover is low. Cities need to be opportunistic in order to capture this potential by incentivizing and/or requiring energy efficiency upgrades as part of all significant renovations and equipment-replacement activities. For this to happen, an enabling environment and effective project financing and delivery mechanisms must be in place.
- **By establishing and maintaining energy management systems.** Establishing and maintaining effective energy management systems for monitoring and controlling energy use in large public and commercial buildings is a low-cost means with which to improve energy efficiency and reduce energy demand.

There are a number of **key barriers** that must be overcome in scaling up energy efficiency in buildings. These include the high cost of gathering reliable information on a building's energy performance; a lack of technical capacity with which to design, construct and maintain energy efficient buildings; a lack of incentives to invest in energy efficiency; limited access to financing; and difficulties in coordinating the building sector's many stakeholders. **Overcoming these barriers** requires strong commitment and leadership from city authorities as well as a willingness to work closely with national and regional governments, building and home-owners, developers, financiers, the building trades and industries, and energy utilities.

Cities looking to systematically improve energy efficiency in buildings should initially consider the following steps:

- **Carrying out a rapid energy efficiency assessment of the building sector** that identifies key opportunities and challenges, assesses stakeholders and resources, and determines priorities and next steps;
- **Implementing energy efficiency initiatives in public buildings—**such as municipal offices, schools, and hospitals—in order to lead by example; and
- **Tapping into the expertise and resources of key stakeholders—**building owners, energy utilities, national and regional governments, and international donors—to initiate energy efficiency programs for residential and commercial buildings.

IMPROVING ENERGY EFFICIENCY IN BUILDINGS

The technical potential for energy savings in buildings is tremendous, especially with "passive" designs that cut or even eliminate the need for active energy use. In cold climate regions, for example, super-insulated and air-tight residential buildings (often called passive houses) use only 10 to 25 percent of the active heating energy that is needed to heat the average new residential building today.[2] Passive design techniques for buildings in warm climates, such as white roof, sun shading and natural ventilation can also achieve significant cooling load reduction. In addition, market competition and government energy efficiency (EE) policies can lead to new generations of EE equipment that also help bring down the energy use in buildings.

Energy use and efficiency in buildings is generally characterized along end-use categories such as space heating, cooling, and lighting. EE in these end-use categories is generally determined by the design and construction (which includes the materials and components used) of a building and by the technical efficiency and operational management of a building's energy-consuming devices. Energy consumption is further influenced by variations in building function, climate, energy prices, billing methods, and human behavior.

This guidance note offers city leaders strategic advice on how to turn potential EE opportunities into tangible benefits. In following these steps, cities can achieve large energy cost savings, help create new businesses and jobs, increase energy security, and improve the quality of life of their constituents.

This guidance note first presents a summary of the main EE opportunities in buildings,[3] followed by a description of some of the common barriers and challenges. It then outlines a range of specific policy tools and instruments available to overcome barriers and challenges. The note then provides specific guidance and empirical examples of three areas of intervention: delivering EE in new buildings (Part I); developing and implementing strategies for retrofitting existing buildings (Part II); and managing energy use in public and commercial buildings (Part III).

THE OPPORTUNITIES

Scaling up EE in buildings is a value proposition for both mature and fast-growing cities. Given that most of the buildings in existence today were constructed with little or inadequate attention to EE, the global building sector is a huge untapped source for energy efficiency gains.

City authorities should aim to pursue EE measures that make financial or economic sense, depending on local resources, on the basis of lifecycle cost and benefit. Simple payback time is a quick means of evaluating the financial attractiveness of EE measures. Many EE interventions can pay for themselves under five years, although their relative cost effectiveness depends on factors such as whether they are applied in new or retrofitted buildings, local climate conditions, and energy prices.

The entry points at which to increase energy efficiency in buildings fall into three focal areas: (i) reducing heating, cooling, ventilating, and lighting loads through improved building design and construction; (ii) increasing the efficiency of energy-using equipment through upgrades and replacement; and (iii) actively managing energy use in buildings. Table 1 shows the technical approaches to maximize energy efficiency in each focal area.

Table 1 | Approaches for Improving Energy Efficiency in Buildings

Focal Area	Technical Approach
Reducing heating, cooling, ventilating, and lighting loads for new buildings or when renovating existing buildings	Apply local climate-sensitive passive design techniques, such as building form, orientation, surface color, sun shading, building envelope insulation, air tightness, ventilation, etc.
Increasing the efficiency of energy-using devices and equipment	Optimize system design and operation to match actual heating, cooling, and lighting loads through commissioning and retro-commissioning Upgrade or replace heating, ventilation, and air conditioning (HVAC) systems, indoor lighting, water heating, home appliances, and other electric and mechanical devices
Manage energy use in public and commercial buildings	Monitor, analyze, and control energy use through energy performance benchmarking Establish new maintenance standards, label building energy performance, and communicate energy performance indicators to building owners/tenants Organize information and awareness raising campaigns

Source | Author

BARRIERS AND CHALLENGES

There are a number of barriers and challenges inherent in improving EE in buildings. And while many of these at first can seem daunting, experience from different countries and cities over the past three decades demonstrates a number of ways they can be surmounted. Table 2 outlines and provides examples of some of the most common challenges and barriers.

Some barriers to greater EE are specific to certain stakeholder groups. For example, high transaction costs relative to returns and the perceived unreliability of repayment often deter commercial banks from financing building EE projects. Other barriers are sector-wide, such as energy subsidies and/or a widespread lack of data and information on EE opportunities, costs, and benefits. Addressing systemic problems such as these typically requires policy interventions and support at the national and regional level, although municipal governments can be influential in policy design and implementation.

Table 2 | Common Barriers to Improving Energy Efficiency in Buildings

Barrier Categories	Common Barriers
Lack of knowledge and know-how	Lack of reliable and credible information about energy performance and the costs and benefits of efficiency improvements Lack of implementation capacity: shortage of relevant technical skills in local markets to ensure compliance of building EE codes Risk aversion to unfamiliar materials, methods and equipment, or uncertain outcomes
Institutional and regulatory deficiencies	Lack of national and/or local commitment to EE in general, and to EE in buildings in particular Government internal procedures and lines of responsibility that discourage EE in public buildings (e.g., budgetary and procurement policies not conducive to contracting EE services) Poorly designed social protection policies that undermine price signals for efficient use of energy (e.g., generally subsidized energy prices)
Financing challenges	Local government budget constraints Lack of long-term financing at a moderate cost High transaction costs due to small individual investments Unattractive financial returns Unreliable repayments
Market failures and inefficiencies	Split incentives: EE investment decisions are made by actors that do not receive direct financial benefit Suboptimal decisions or choices due to insufficient information Fragmented building trades: multiple professions involved in different stages or decision processes

Source | Author

SOLUTIONS

Before committing significant private and public financial resources, it is important for city leaders to develop a clear view of the main opportunities, issues, and options available in improving the EE of new and existing buildings.

A key first step is to carry out a **sector EE assessment** that can cover either the entire building sector or a specific segment of it. The basic approach for conducting EE assessments for buildings is described in a separate guidance note for city EE assessments.[4]

City governments should also **lead by example** by initiating cost-effective measures that boost EE in municipal buildings and/or testing new EE policy initiatives.

It is critical for city governments to work with national and state/provincial governments, as well as other stakeholders—such as energy utilities, banks, building owners, and energy service trades—to address the major barriers to scaling up EE in buildings.

The most common policy and regulation instruments and tools to increase EE in buildings are listed below. These measures tend to be accompanied by specific support programs, as a portfolio of actions is generally more effective than a single, stand-alone EE intervention.

1 | Energy regulatory policies. Usually formulated at the national or regional level, energy regulatory policies address general inefficiencies in energy markets. Examples include policies to replace general pricing subsidies with targeted social assistance schemes, that require users of network-based energies be charged based on metered consumption, and which introduce incentives encouraging energy utilities to carry out demand-side management activities.

2 | Mandatory standards and codes. Generally developed at the national and regional level and updated periodically, mandatory standards and codes address key market failures or inefficiencies, in this case, defined as situations in which rational decisions taken by market participants have led to negative or suboptimal economic outcomes for society as a whole. The case of split incentives (see Table 2) is a main reason for introducing mandatory building energy efficiency codes (BEECs). Minimum energy performance standards (MEPS) for major energy-consuming equipment are targeted at manufacturers, but supported by demand-side promotions (e.g., rebate programs for appliance replacement) implemented by energy utilities or city authorities.

3 | Labels and certificates. These are means of recognizing and encouraging EE efforts that go above and beyond the mandatory requirements outlined above. Examples include the voluntary Energy Star program for buildings, components, and equipment in the United States and the Green Mark scheme for buildings in Singapore.

4 | Financial facilitation schemes. These include fiscal and monetary incentives to encourage investments in energy efficiency. Examples include tax credits, cash rebates, and capital subsidies, as well as special funding vehicles and risk-sharing schemes to increase funding and lending for investments in EE. This topic is discussed in a separate guidance note on mobilizing municipal EE financing.[5]

5 | Requirements for energy management. Several cities in the US and the European Union have introduced mandatory energy performance benchmarking and disclosure programs that require large public and commercial buildings to monitor and

report their EE performance and compare with peers, thus, helping to improve operational and maintenance practices and identify opportunities for cost-effective retrofits. Energy management requirements can also help municipal governments better target support for building retrofits and bridge existing information gaps related to building energy performance and costs.

6 | Public sector financial management and procurement policies. These can have a significant impact on municipal efforts to retrofit public buildings and upgrade inefficient energy-consuming equipment. This topic is discussed in a separate guidance note on integrating energy efficiency requirements into public procurement procedures.[6]

7 | Awareness-raising and capacity-building initiatives. Outreach and public information initiatives can help increase the knowledge and know-how of stakeholders and enable the design and implementation of effective EE programs and investment projects. These may involve general awareness campaigns, as well as initiatives to train specialized trades such as architects, building managers, and construction workers.

A city's ability to develop and deploy these tools and instruments varies, depending on the particulars of the local governance structure. Table 3 provides a general map of the key policy tools, the barriers they intend to address, and the potential role of municipal authorities.

Table 3 | Key Policy Interventions and Support: Matching Barriers with Policy Tools

Policy Tools	Issues Addressed	Examples of Intervention	What City Government Can Do
Energy Regulatory Policies	Weak financial incentive to invest in EE by consumers Disincentive for energy utilities to invest in DSM activities due to lost sales	Remove general price subsidies for public, residential, and commercial users Decouple energy utility revenue from sales*	Support and participate in national or regional policy reform programs
Mandatory Standards and Codes	Split incentives, fragmented building trades, fragmented building ownerships, etc. Underinvestment in EE by equipment makers	Building energy efficiency codes Minimum energy performance standards for equipment	Set and/or enforce standards Encourage or mandate (public sector) purchase of EE equipment
Labels and Certificates	Lack of credible and consistent energy performance information and/or recognition of excellence	Energy Star label for equipment or buildings Green building rating systems	Promote the adoption of nationally/internationally recognized labels and certificates

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Table 3 | Key Policy Interventions and Support: Matching Barriers with Policy Tools (*continued*)

Policy Tools	Issues Addressed	Examples of Intervention	What City Government Can Do
Financing Facilitation	Insufficient financial incentive Lack of commercial lending to EE Risk concerns of commercial lenders	Subsidies for EE investments Dedicated EE fund and credit line Partial risk/credit guarantee	Use public funds to leverage private and commercial investments
Energy Management	Lack of transparent and consistent monitoring and control of energy use	Energy performance benchmarking and disclosure	Require energy performance benchmarking and disclosure for large public and commercial buildings
Public Sector Financial Management and Procurement Policies	Disincentive for EE efforts in budget-supported public entities Difficulty for public entities to contract energy service providers, or make EE equipment preferred purchase choices	Revise budgetary rules to allow retention of energy cost savings for other justified public spending Revise public procurement rules to allow for contracting of energy service providers and adopt EE purchase requirements	Make adjustments based on a city's own policy-making authority
Capacity Building and Awareness Raising	Inadequate knowledge and skills for BEEC compliance Lack of general awareness and sensitivity to energy waste Lack of specific knowledge and skills to perform energy management duties	Train building trades on BEEC requirements and proper approaches Public campaign to promote efficient use of energy Train building managers of large public and commercial buildings	Organize trainings and sponsor awareness campaigns

*Examples at http://www.epa.gov/statelocalclimate/documents/pdf/guide_action_chap6_s2.pdf
Source | Author

PART I: ENERGY EFFICIENCY IN NEW BUILDINGS

Newly constructed buildings represent the best opportunity and greatest potential for reducing heating, cooling, and lighting loads and introducing EE technologies that can pay for themselves over the course of their life cycle.

These gains can most effectively be achieved by introducing and implementing building energy efficiency codes (BEECs). The development and implementation of BEECs is an elaborate process, requiring a variety of data and analyses. It also requires extensive consultation with, and the active participation of, a broad set of stakeholders.[7] An effective compliance enforcement system is crucial to ensure that buildings are designed and constructed according to BEEC requirements. Depending on the standard content of a finished building, EE requirements for installed equipment and devices are either directly covered by BEECs or referred to in separate EE standards, such as minimum energy performance standards for appliances.

Whether a well-designed and constructed new building achieves expected energy savings will largely depend on user behavior and operational management. Assuming that both are present, there are two primary ways to capture EE opportunities when constructing new buildings:

1 | Mandatory enforcement of BEECs

2 | Incentivizing investors and developers to go beyond them

Box 1 | Enforcement of More Stringent BEEC Brings Greater Benefit

The city of Tianjin in China reduced the heating load of residential buildings built after 2005 by 30 percent (compared with those in compliance with the national code) through enforcement of its new and more stringent residential BEEC. Residential buildings built between 2005 and 2009 have saved energy equal to avoided investment in a new 300 MW-thermal district heating plant that would consume 200,000 tons of coal annually. This represents a significantly larger economic benefit than the incremental cost of complying with the more stringent BEEC.

Source | ESMAP 2011

MANDATORY ENFORCEMENT OF BEECs

The mandatory enforcement of BEECs is generally stipulated by national and/or state/provincial governments and then implemented through city governments. Initial compliance is often voluntary so that a government can develop the necessary capacity to enforce BEEC standards and stakeholders in the building supply chain can develop the necessary skills, materials, and products to meet them. In general, cities can enact and enforce more stringent BEECs than regional or national governments, provided that they are technically feasible and economically justified. Such proactive efforts can bring substantial benefits to cities (Liu et al. 2010; Box 1).

While some municipalities enforce BEECs on their own, a third-party enforcement option can be of particular interest to developing countries and cities that are in the process of building up a general building code compliance system. A third-party approach, which requires significant efforts to develop private sector capacity, enables a government to

Box 2 | Key Components of a BEEC Implementation Program

- **BEEC Administration and Enforcement.** A unit must be established within the general building code enforcement department with budget and staffing to administer and implement a BEEC program.
- **BEEC Compliance Process.** A BEEC compliance process must be established. Key elements would include the development of administrative procedures, compliance forms, checklists and procedures, user manuals or guidebooks, compliance tools, and software.
- **Training and Capacity Building.** Programs should be launched to raise awareness about BEECs among code officials, designers, architects and engineers, manufacturers, and suppliers.
- **Demonstration Projects.** Funding should be provided to cover the additional up-front costs of adopting new BEECs in the design and construction of more energy efficient buildings and the installation of more energy efficient equipment and materials, as well as monitoring and evaluation.
- **Setting a firm date for enforcement.** Developers, designers, contractors, manufacturers, and suppliers should be apprised of new regulations with as much lead time as necessary so that when the rules take effect, each can comply.
- **Evaluation of energy savings and BEEC effectiveness.** For future code revisions, the evaluation of actual results and experiences is important so standards and procedures can be improved. This evaluation process can include formal surveys, but should also be based on issues raised by designers, builders, and other involved parties.

Source | Liu et al. 2010

leverage limited resources while also normalizing BEEC compliance checks within the regular construction supervision process.[8]

An effective compliance enforcement system ensures that buildings are designed and constructed according to BEECs. Depending on the local system for enforcing the general building codes, the government may or may not need to cover the entire process of BEEC enforcement (Table 4).

Cities that have done well in implementing BEECs tend to have some or all of the following factors in common:

- Strong political support, which is expressed by adopting strict BEECs and providing incentives (Table 5) for building owners to exceed BEEC standards

Table 4 | Institutional Options for Enforcement of Building Energy Efficiency Codes

	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	Checking of compliance statements; 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 to check compliance
Noncompliance Risk	Low, provided adequate funding and training of inspectors	Low to moderate. Third party depends on certification for income (but also on satisfied builders)	High, unless owner places high value on EE Moderate if self-certification to government Low if builders are certified
Examples	**United States: prevailing option**	**China (with some public oversight), France, Mexico, some in UK, some in US, pilot in Turkey**	**Germany (to owner)**

Source | Liu et al. 2010

Table 5 | Market Incentives for Adopting or Exceeding BEEC Requirements

Type of Incentive	Intended Beneficiary	Direct/Indirect Benefits	Example of Practice
Grants (partial) ■ 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 EE building materials, equipment, and construction) Direct: reduce incremental costs Indirect: provide information on costs/ benefits of EE buildings	Singapore (Green Mark) Denmark, Tunisia
Subsidized Loans/ Interest Rates	Developer, Owner	Reduction of first cost	Austria, Germany, Japan, Netherlands, South Korea, USA
EE or Green Mortgages	Owner Lender	Secure otherwise impossible mortgage Recognition; marketing advantage; lower default risk	Mexico, USA
Tax Benefits (e.g., reduced import tax duties or VAT rates for EE equipment)	Developer, Owner	Reduction of first cost	USA
Nonmonetary Incentives Expedited Permits Relaxed Zoning Restrictions (size, density)	Developer	Reduced costs of doing business; increased earnings	South Korea, USA
Awards	Developer, Builder	Public recognition and marketing advantage	China, USA (Energy Star buildings)
Rating Systems	Developer, Owner	Recognition; marketing advantage; higher market value of rated building	Energy Star (USA), LEED and other green building rating systems in China, India, European Union countries, etc.

Note | Most incentives to go beyond code are conditional on a building achieving a certain EE rating or the building or an appliance achieving a certified percentage of energy savings that go beyond BEEC requirements.

Source | Liu et al. 2010

- Popular support for EE buildings
- Extra funding at the beginning of a BEEC enforcement campaign, which allows for the development or enhancement of enforcement capacity, the hiring of extra staff, and the training of code officials and building professionals
- A strong EE champion in the local administration
- A streamlined inspection and review process, which includes correction lists and change orders to be fulfilled before construction and occupancy permits are issued
- Strict plan reviews that set expectations at every construction site, as compliance tends to improve if the enforcement of regulations is considered firm and fair
- The training of code officials, designers, and the building industry to improve the understanding and application of codes and make code officials more aware of technical issues

INCENTIVIZING INVESTORS AND DEVELOPERS TO EXCEED BEEC STANDARDS

The main drawback of mandatory BEECs is that they are minimum requirements that are usually based on the average or even below-average performance of the building market. This weakness can be addressed by regularly updating BEECs—at three- to five-year intervals, for example—so that EE requirements can be tightened as technologies improve. In general, there are no inherent incentives in BEECs for those able to innovate and/or exceed BEEC levels. This is where an EE rating system for buildings—and, increasingly, green building rating systems—can be an important means of recognizing market leaders.

There are a number of well-established green building rating systems that cities may adopt, for example the Building Research Establishment Environmental Assessment Method (BREEAM) that originated in the UK and the Leadership in Energy and Environmental Design (LEED) that originated in the US. Singapore's Green Mark scheme is sanctioned by the government and used as a tool for achieving national green building targets (Box 3).[9]

Box 3 | Singapore Building Construction Authority Green Mark Scheme

Singapore's Building Construction Authority (BCA) Green Mark Scheme was launched in January 2005 with a strong focus on energy efficiency. It provides a meaningful way to differentiate the EE of buildings in the real estate market, thereby creating a positive effect on corporate image, leasing, and resale value of buildings.

The Green Mark Scheme is a key component of the government's Green Building Masterplan. It integrates mandatory requirements and voluntary ratings and financial incentives for high achievers and is used as the basis for technical capacity building and to help determine government financial incentives for new construction or retrofits.

As a result of the scheme, the number of green buildings in Singapore rose from 17 in 2005 to almost 1,700 in 2013. The current Green Building Masterplan aims to green 80 percent of Singapore's building stock by 2030.

Source | http://www.bca.gov.sg/

PART II: RETROFITTING EXISTING BUILDINGS

In cities where the building stock is stable or growing slowly, the retrofitting of existing structures and the replacement of old energy-consuming equipment is often the best means to achieve EE gains.

The equipment inside an existing building can generally be replaced over periods ranging from 10 to 20 years, whereas a building's shell, or envelope, is often unchanged for decades except for basic maintenance. Renovating a building's envelope is often necessary to reduce heating and cooling loads. Technical approaches to buildings renovations need to be guided by specific climate conditions and sound economic justifications.

Despite the EE potential in retrofitting buildings, it has generally been difficult to develop "bankable" retrofitting projects and secure the necessary long-term financing to undertake them. In cities where large-scale building retrofits have been initiated—such as Chicago and London—strong city government leadership has been essential (Box 4).

This section outlines how cities can encourage and carry out retrofitting in the municipal, commercial, and residential sectors.

RETROFITTING MUNICIPAL OR PUBLIC BUILDINGS

To provide examples of their benefits, city authorities may wish to initiate retrofitting projects in municipal buildings. There are three key elements cities should consider when

Box 4 | City-Led, Large-Scale Building Energy Efficiency Retrofit Programs

London's public building retrofit program, known as **RE:FIT,** aims to retrofit 40 percent of London's public buildings by 2025 through a combination of financing, which includes bank loans, public funds, and the London Green Fund, a dedicated climate investment fund. All retrofits are initiated under guaranteed-savings contracts by prequalified energy service companies or ESCOs. A pilot retrofit program to reduce energy use in 42 public buildings, implemented from 2008 to 2010, demonstrated overall energy cost savings of £1 million per year against a total investment of £7 million. This success convinced the Mayor of London to expand the program to all the city's public buildings. As of 2012, the retrofitting of 111 buildings had or was close to being completed at a total investment cost of £13.3 million. The program currently has a pipeline of 400 buildings with estimated investment of £44 million (http://www.london.gov.uk/priorities/environment/climate-change/energy efficiency/buildings-energy efficiency-programme).

Retrofit Chicago is a municipal government initiative that is retrofitting one million square feet of city-owned assets. The work is being carried out by ESCOs under guaranteed-savings contracts financed by the Chicago Infrastructure Trust, a public-private partnership backed by funds provided by large private investors. The program has also established a voluntary initiative with the aim of reducing energy use by at least 20 percent within 5 years and has created a residential partnership providing a one-stop-shop at which building owners can access free EE measures, receive rebates on new equipment, and take advantage of low-cost financing for other upgrades (http://www.cityofchicago.org/city/en/progs/env/retrofit_chicago.html).

Source | Author

starting a public building retrofit program: **the scope and depth of a retrofit scheme,** the **delivery mechanism** of the retrofit program, and the **financing and repayment** arrangements for the project. These issues are usually addressed through a market study that involves consultation with stakeholders—such as the government departments, schools, and hospitals that own or operate the buildings that are to be retrofitted—as well as with energy service providers and potential financiers. The choice of which retrofit option to pursue is based on detailed energy audits, which are usually performed by the entities who undertake the retrofits, such as energy service companies or ESCOs.

The scope and depth of a retrofit scheme. Cities need sufficient evidence-based information on the costs and benefits of different retrofit measures and options. There are three levels of efforts a city can consider, depending on the availability of resources:

1 | Housekeeping activities amount to fine-tuning or improving the management of a building's energy systems. These low-cost, low-risk efforts can generate savings of 5 to 20 percent over payback periods of 12 months or less.

2 | A partial retrofit typically involves the cost-effective replacement of inefficient equipment or components such as light fixtures, ventilators, air conditioners, pumps, and windows. While components may be replaced individually, it is generally more effective to replace them as part of a package. A partial retrofit package may entail moderate to significant costs, but can result in savings of up to 30 percent over a payback period of less than 5 years.

3 | A comprehensive retrofit takes an integrated "whole building" approach that addresses the EE of individual components and, by upgrading a building's envelope to reduce a structure's heating, cooling, and lighting loads. Such retrofits usually yield energy savings of 40 percent or more but are generally considerably more expensive and complicated to implement than partial retrofits. Payback periods associated with such retrofits can extend to a decade or more.

Delivery mechanisms. The implementation of retrofit projects is generally outsourced to energy service providers. Depending on the complexity and financing arrangements, cities may follow several commonly used contracting models. The guaranteed-savings contracts used in Chicago and London are best suited for cities that can arrange separate financing for a retrofit. They only require ESCOs to implement the retrofit projects, and can guarantee a stable stream of annual energy cost savings to repay the financers.[10]

Financing instruments. Although public-building retrofit projects can be financially viable, many cities in developing countries have difficulty in accessing the long-term, low-cost financing with which to fund or bring them to scale. For instance, national regulations may limit a city's ability to borrow or raise funds in the financial market, while commercial banks may often be reluctant to lend to cities with low credit ratings. It is therefore critical to have a credible mechanism that captures energy-savings cash flow that can be used to repay borrowed money. An innovative approach used in Armenia is described in Box 5.[11]

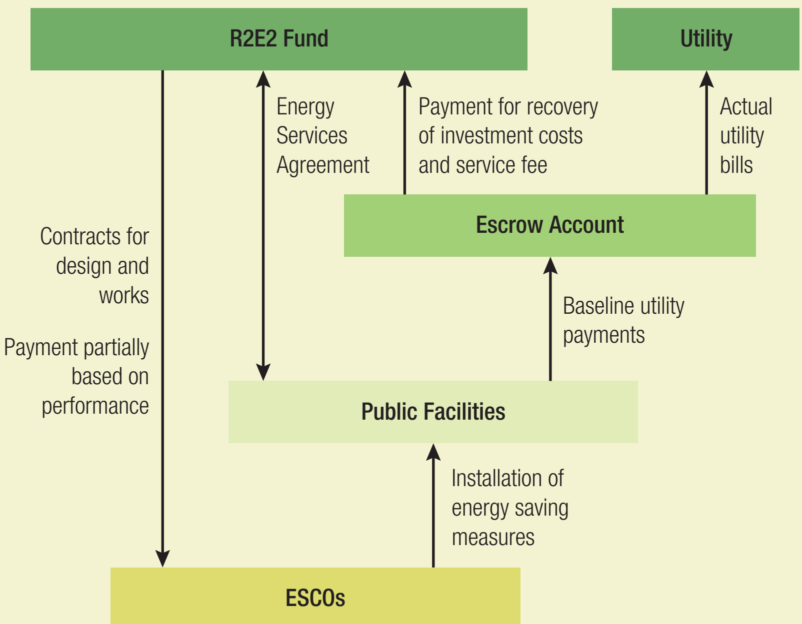
RETROFITTING COMMERCIAL BUILDINGS

City governments can use a combination of regulatory and incentive instruments to help scale up EE investments in private-owned commercial buildings. Overcoming financing

Box 5 | Capturing Energy-Savings Cash Flow for Repaying Energy Efficiency Investments

The R2E2 Fund is a national investment facility for renewable energy and energy efficiency in Armenia, which finances municipal building retrofit projects through the scheme illustrated in the chart. It enables municipalities to retrofit their public buildings, using energy-cost savings through an escrow account to repay extra budget investment provided by the R2E2 fund.

Two critical conditions are needed for this scheme to work: (i) a dedicated EE fund whose main objective is to invest in financially viable public sector EE retrofits and (ii) participating cities' ability to set aside utility payments in a protected escrow account.



Source | Author

and incentive barriers remains the main challenge. The 1200 Buildings Program of the City of Melbourne, Australia, is a notable large-scale commercial building retrofit program.[12] A key government intervention under the program was the establishment of a long-term, low-cost financing mechanism, the Environmental Upgrade Finance, by which the city collects a surcharge from building owners who have voluntarily agreed to participate in the scheme. The surcharge, part of which is generally passed on to a building's tenants, is then used to repay the capital advanced by participating financial institutions. The surcharge will remain on the property until the funds advanced by the financier are repaid in full.[13]

Government financial incentives—such as grant subsidies for commercial retrofits—could be used to encourage comprehensive retrofit projects. This can help prevent the cherry picking of partial retrofit projects by market participants.

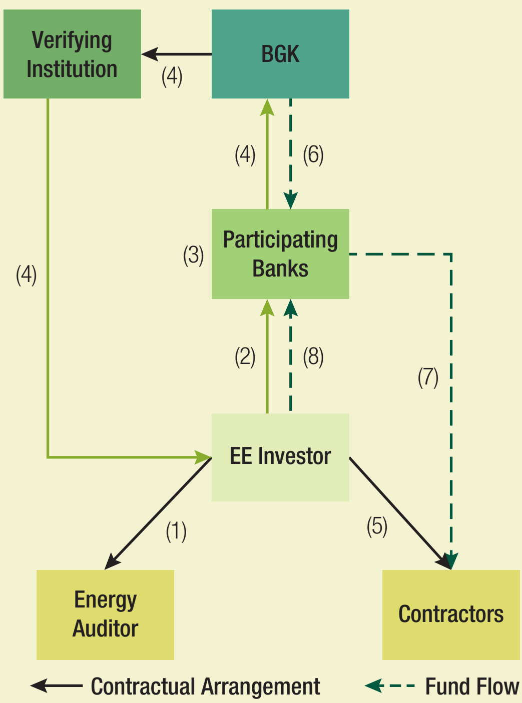
RETROFITTING RESIDENTIAL BUILDINGS

Encouraging retrofits of buildings in the residential sector is generally more challenging than in other sectors because of the highly disaggregated nature of home ownership and the small size of individual investments and returns. Most efforts in this area have focused on equipment replacement such as large-scale campaigns to replace incandescent lamps and inefficient air conditioners and refrigerators. The often-used approach for equipment upgrades is to encourage or require electric utilities to carry out demand-side management (DSM) programs.

Comprehensive retrofit of older residential buildings in cold climate regions can yield large energy savings.[14] For this to happen, three key issues must be resolved: securing long-term, low-cost financing; finding ways to aggregate small investments (delivery mechanism); and establishing a reliable repayment mechanism.

Examples of successful financing and delivery mechanisms for large-scale residential retrofits in cold climate regions are often associated with grant subsidized national programs, such as the Thermo Modernization Program of Poland, which subsidizes commercial bank-originated residential retrofit loans (Box 6). Supporting the establishment of such national programs would benefit cities.

Box 6 | Implementation Arrangements of Poland's Thermo Modernization Program



1) EE investor (e.g., condominium association) **hires** an energy auditor to conduct an energy audit and design EE measures
2) EE investor **submits** both loan and grant **application** to the participating bank
3) The participating bank **appraises** application package
4) BGK (the national development bank) **reviews** whole application package and **commissions** an independent **verification** of the energy audit submitted
5) Once approval by BGK, Contractors start to **implement EE measures**
6) Upon project completion, BGK **disburses the grant** (up to 20% of loan amount) to the participating bank to reduce the outstanding principal of the EE loan
7) Participating bank **makes payments** to contractors after receiving their invoice
8) EE investors **repay bank loan** by installments, for example, through increased condo fees

Source | Author

Successful experience of large-scale residential retrofit at the city level is still emerging. The Property Assessed Clean Energy (PACE) scheme in the US is an innovative financing and repayment scheme that supports EE and renewable energy projects in residential and commercial buildings by providing up-front capital that is subsequently paid back through a special assessment on participants' property taxes or a special surcharge. Two examples of city-level PACE programs are provided in Box 7.[15]

Box 7 | Innovative Residential Retrofit Programs at the City Level

Babylon, NY: Begun in 2008, the Long Island Green Homes program uses funds from the town's solid-waste reserve fund to provide financing for efficiency or renewable energy projects. After undergoing an audit, the town pays contractors directly; property owners pay back the cost via a trash bill surcharge with 3 percent interest.

Boulder County, CO: The ClimateSmart Loan Program provides financing to residential and commercial property owners for efficiency or renewable energy projects. The program was established with US$40 million in funding financed by tax-exempt bonds issued by the county.

Source | http://ase.org/resources/property-assessed-clean-energy-financing-pace

PART III: MANAGING ENERGY USE IN PUBLIC AND COMMERCIAL BUILDINGS

Energy management for public and commercial buildings provides a quick "win" for cities and builds long-term capacity to develop EE projects and monitor and control energy use. As the experience of Lviv, Ukraine, shows, a city government's commitment and organizational efforts can go a long way toward improving energy management and saving operational costs in public buildings (Box 8). [16]

The most effective means to sustain, expand, and enhance the energy monitoring and targeting efforts in large public and commercial buildings is through the introduction of a system of **mandatory energy performance benchmarking and disclosure (EPB&D).** The principle behind EPB&D requirements for buildings is the old adage: you cannot manage what you do not measure.

Mandatory EPB&D requires building owners to periodically submit building performance information to the government, potential buyers, and/or the public at large. The main components of an EPB&D program are the *benchmarking* of a building's energy performance and the *disclosure* of that information to selected entities. The benchmarking of a building's energy performance is a comparison of how efficiently a building uses energy compared to a baseline measurement. Benchmarking is supported by a specially designed tool/software.[17] Energy use is measured on a per-square-meter (m^2) basis and controlled for building size, operational type, tenancy type, and weather (Box 9).[18]

Box 8 | Lviv, Ukraine: Energy Management System in Public Buildings

The Ukrainian city of Lviv was able to reduce annual energy consumption in its public buildings by about 10 percent and tap water consumption by about 12 percent through a Monitoring and Targeting (M&T) program to control energy and water consumption. The M&T program, which was launched in December 2006 and became fully operational by May 2007, provided the city management with monthly consumption data for district heating, natural gas, electricity, and water in all of the city's 530 public buildings. Under the program, utility use is reported and analyzed monthly and targets for monthly utility consumption are determined annually based on historical consumption and negotiations on an adjustment (in cases of foreseeable changes in consumption patterns). Actual consumption is reviewed monthly against the target, with deviations spotted and acted upon immediately. The performance of buildings is communicated to the public through a display campaign. This program generated an estimated net savings of 9.5 million UAH (US$1.2 million) as of 2010 against a program cost of about 1 million UAH.

Strong city government leadership and commitment were key success factors of Lviv's public buildings energy and water M&T program. A new Energy Management Unit (EMU) was established within the city administration and resources were mobilized to train all personnel with line responsibility on building utility use in an administrative division, unit, or building. The M&T system established acountability, created transparency, and enabled informed control of energy and water use in public buildings, laying a solid foundation for sustained improvements in energy and water efficiency.

Source | Author

Box 9 | Elements of an Energy Performance Benchmarking and Disclosure Program for Buildings

For the benchmarking component of the program the following processes need to be defined and documented:

- **Benchmarking methodology.** Methodology for comparing a building's energy performance needs to be clearly defined and simple to use through specially designed software.
- **Schedule of reporting.** A date should be chosen as a deadline for the first submittal of benchmarking data and a schedule defined for future submissions.
- **Reporting system.** The system for how and where a building reports data should be clear, technically simple, and provide guidance for owners. A central database is preferred.
- **Disclosure trigger points.** There are different points that can trigger disclosure of building performance information.
- **Enforcement.** Enforcement of the policy is essential to ensure participation. It can be done through penalties, incentives, or marketing triggers, such as proof of compliance at sale.
- **Compliance support and outreach.** Stakeholder outreach and education, trainings for skilled energy efficiency workers, and communication of these efforts.

The disclosure component of the program can be organized in two distinct ways, transactional disclosure and scheduled public disclosure. Transactional disclosure is triggered at the point of sale for a building, with the information only being provided to the buyer or interested parties. For rentals, information can be provided to prospective tenants during negotiations. Alternatively, public disclosure of information can be triggered by a schedule of disclosure predetermined by the policy. For example, New York City makes the energy use of every large private-sector building—gathered via a citywide mandatory benchmarking process—available to the general public (available at: http://www.nyc.gov/html/gbee/html/plan/ll84_scores.shtml).

Source | Dunsky et al. 2009

CONCLUSION

City governments can exert significant leverage on improving energy efficiency in buildings. As the examples in this guidance note show, achieving energy savings at scale requires strong leadership to orchestrate the necessary efforts to overcome the knowledge, institutional, and financial challenges.

For cities that are just embarking on the pursuit of EE in buildings, the following actions by the city government are recommended:

- A rapid EE assessment of the building sector to identify key opportunities and challenges, assess stakeholders and resources, and determine priorities and initial steps.
- Lead by example by improving EE in public buildings, such as municipal offices, schools, and hospitals. As a first step, establish a long-term energy management system/program for municipal buildings (e.g., the M&T program implemented by Lviv).
- Tap into available resources of building owners, energy utilities, national and regional governments, as well as international donors to initiate EE programs for residential and commercial buildings.

ENDNOTES

1 International Energy Agency, *World Energy Outlook 2012,* page 328.

2 http://passiv.de/en/02_informations/01_whatisapassivehouse/01_whatisapassivehouse.htm

3 The guidance note focuses on measures which improve the operational energy efficiency of buildings and does not deal with the embodied energy of buildings, which includes energy used in manufacturing building materials and components, as well as in building construction.

4 ESMAP. 2014. City Energy Efficiency Assessment: Mayoral Guidance Note #5 (Knowledge Series 021-14). Written by Feng Liu and Stephen Hammer. Washington DC: Energy Sector Management Assistance Program.

5 ESMAP. 2014. Financing Municipal Energy Efficiency Projects: Mayoral Guidance Note #2 (Knowledge Series 018-14). Written by Dilip Limaye and William Derbyshire. Washington DC: Energy Sector Management Assistance Program.

6 ESMAP. 2014. Driving Energy Efficiency Markets through Municipal Procurement: Mayoral Guidance Note #1 (Knowledge Series 017-14). Written by Jas Singh. Washington DC: Energy Sector Management Assistance Program.

7 Detailed description of the process is provided in *Mainstreaming Building Energy Efficiency Codes in Developing Countries: Global Experiences and Lessons from Early Adopters* (Liu et al. 2010).

8 Chinese cities have been practicing and improving the third-party enforcement system for years and provide good experiences and lessons on the subject. More details in Evans et al. 2010. *Enforcing Building Energy Codes in China: Progress and Comparative Lessons*. Washington, DC: American Council for an Energy Efficient Economy.

9 A case study of the Green Mark Scheme is included in Managan, K. et al. 2012. *Driving Transformation to Energy Efficient Buildings: Policies and Actions* (2nd edition). Milwaukee, WI: Institute for Building Energy Efficiency, Johnson Controls Inc. Retrieved from: http://www.institutebe.com/InstituteBE/media/Library/Resources/Energy%20and%20Climate%20Policy/Driving-Transformation-to-EE-Buildings.pdf

10 *Driving Energy Efficiency Markets through Municipal Procurement Mayoral Guidance Note #1* (ESMAP Knowledge Series 017-14) has more specific advice on using energy savings performance contracts (ESPCs) to deliver EE retrofit projects in the public sector based on global experiences.

11 *Financing Municipal Energy Efficiency Projects: Mayoral Guidance Note #2* (ESMAP Knowledge Series 018-14) contains more specific advice on how to select appropriate financing options.

12 http://www.melbourne.vic.gov.au/1200buildings/Pages/Home.aspx

13 http://www.sustainablemelbournefund.com.au/sites/default/files/EnvironmentalUpgradeFinanceBrochure.pdf

14 The approaches to (thus cost implications of) are retrofitting building envelopes in cold climate is different from those in warm climate (hot and humid) where, for example, there is less emphasis on thermal insulation but strong emphasis on shading.

15 http://ase.org/resources/property-assessed-clean-energy-financing-pace

16 Lviv, Ukraine—Energy Management System in Public Buildings, http://www.esmap.org/node/1246

17 The Energy Star Portfolio Manager is a widely used energy benchmarking tool in the United States. It is available for free to users (http://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager). For most commercial building types, Portfolio Manager generates an operational energy rating from "1" to "100" (100 is best) comparing the building's energy performance to that of similar buildings nationwide.

18 Dunksy Energy Consulting. 2009, November. A Roadmap for the Northeast US: Valuing Buildings Energy Efficiency through Disclosure and Upgrade Policies.

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Liu, Feng, Meyer, Anke and Hogan, John. 2010. *Mainstreaming Building Energy Efficiency Codes in Developing Countries* (Working Paper # 204). Washington DC: World Bank.

Pacific Northwest National Laboratory. 2011. *Advanced Energy Retrofit Guide: Office Buildings*. Retrieved from: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20761.pdf

ACRONYMS AND ABBREVIATIONS

£	British pound (currency)
BEEC	Building energy efficiency code
DSM	Demand-side management
EE	Energy efficiency
EPB&D	Energy performance benchmarking and disclosure
ESCO	Energy service company
LEED	Leadership in Energy and Environmental Design
M&T	Monitoring and targeting
MW	Megawatt
PACE	Property Assessed Clean Energy
UAH	Ukrainian Hryvnia (currency)
US / USA	United States of America
US$	United States dollar (currency)
VAT	Value added tax

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2 | *Financing Municipal Energy Efficiency Projects,* by Dilip Limaye and William Derbyshire

3 | *Improving Energy Efficiency in Buildings,* by Feng Liu

4 | *Toward Sustainable and Energy Efficient Urban Transport,* by Om Prakash Agarwal

5 | *City Energy Efficiency Assessments,* by Feng Liu and Stephen Hammer

6 | *Planning Energy Efficient and Livable Cities,* by Serge Salat, Mansha Chen, and Feng Liu

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