Building Energy Code Compliance in Developing Countries: The Potential Role of Outcomes-Based Codes in India

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ABSTRACT

Developing countries are witnessing tremendous growth in their building stock, which is putting pressure on power and other energy systems. India is an excellent example of this growth, and of increasing efforts to implement requirements to reduce building energy use. India's building energy code, the Energy Conservation Building Code (ECBC), addresses issues such as the building's thermal envelope, lighting systems, HVAC systems, electrical systems, water heating and fluid pumping systems. We know that building design and construction affect actual building performance, but factors such as user behavior, occupancy patterns, commissioning and maintenance also play a major role. Building energy codes focus only on design and construction because in developed countries, existing permitting processes provide a framework for influencing efficiency. Developing countries, on the other hand, may have weak, ineffective building permitting systems.

Like many developing countries, India is considering expanding implementation of its building energy code and using performance metrics to enhance or substitute for enforcement of the building energy code. In most of India, ECBC is currently voluntary, and significant enforcement gaps remain. Can performance metrics, such as energy use compared to a benchmark, help speed implementation of the building code? What would such a system look like? In short, are outcomes-based codes a viable option in developing countries with limited resources? This paper compares traditional and outcomes-based compliance pathways for a building energy code, explores approaches to integrating outcomes-based codes with traditional ECBC implementation and discusses specific issues in implementing outcomes-based codes such as benchmarking, incentives, measurement and verification. Given their novelty, it is difficult to recommend that India or other developing economies adopt outcomes-based codes alone. Rather, if governments would like to promote energy efficiency in actual building performance and have adequate resources, they might consider implementing both a traditional and an outcomes-based code system.

Introduction

As India moves forward with its Energy Conservation Building Code (ECBC), the code implementation and enforcement framework that India adopts will play a critical role in determining the effectiveness of enforcement. Effective enforcement can yield large energy reduction benefits in the long term. The ECBC, issued in 2007 by India's Ministry of Power and its Bureau of Energy Efficiency (BEE), is the country's first stand-alone national building energy code for new commercial buildings.[1] Several states, such as Rajasthan and Andhra Pradesh, have

[1] ECBC sets minimum energy performance standards for commercial buildings with an electrical connected load of 100 kW or greater or a contract demand of 120 kVA or more.

made it mandatory. The Government of India is developing a strategy to mandate compliance more broadly. One challenge is that the enabling legislation for ECBC focuses on the ultimate energy performance of buildings (energy use per m^2), while the ECBC requirements, drawing from international best practice, are based on building design and construction issues. Specifically, ECBC requirements address issues such as the building's thermal envelope, lighting systems, HVAC systems, electrical systems, water heating and fluid pumping systems. We know that building design and construction affect actual building performance, but factors such as user behavior, occupancy patterns, commissioning and maintenance also play a major role.

The intent of this paper is to share with decision-makers in India and other developing countries options for code compliance, both in a traditional code compliance framework and integrating outcomes-based codes to regulate post-occupancy building performance. Outcomes-based codes involve a new approach, which, in principle, could allow for improvements in the actual energy efficiency of a building as operated (and by analogy, in building design as well). Outcomes-based codes might also allow for incentives to reduce peak demand in particular, depending on policy design. However, outcomes-based codes are as yet untested in most jurisdictions. Toyko effectively has the first such system in the world: existing, large commercial buildings in metropolitan Tokyo have new, mandatory caps on CO_2 emissions from energy use, and an extensive monitoring and support system. The program resulted in an 11% emission reduction from energy use in these buildings in the first year (Japan's fiscal year 2010) (Yu and Evans 2013).

To our knowledge, there are no other examples yet of mandatory performance requirements on this scale. In the United States and Canada, several cities are considering implementing new outcomes-based regulations for high-performance, sustainable buildings. For example, Washington State is considering a proposed code under which developers would need to post a bond of approximately $4/square foot until the building could demonstrate compliance with its actual energy budget (Washington State 2013). The hope is that outcomes-based codes could foster innovation in design and construction as well as operations.

Developing countries are witnessing tremendous growth in their building stock, which is putting pressure on power and other energy systems. India is an excellent example of this growth, and of increasing efforts to implement requirements to reduce building energy use. India's building energy code, the Energy Conservation Building Code (ECBC), addresses issues such as the building's thermal envelope, lighting systems, HVAC systems, electrical systems, water heating and fluid pumping systems. We know that building design and construction affect actual building performance, but factors such as user behavior, occupancy patterns, commissioning and maintenance also play a major role. Building energy codes focus only on design and construction because in developed countries, existing permitting processes provide a framework for influencing efficiency. Developing countries, on the other hand, may have weak, ineffective building permitting systems. Like many developing countries, India is considering expanding implementation of its building energy code and using performance metrics to enhance or substitute for building energy code enforcement. In most of India, ECBC is currently voluntary, and significant enforcement gaps remain. Can performance metrics, such as energy use compared to a benchmark, help speed implementation of the building code? What would such a system look like? In short, are outcomes-based codes a viable option in developing countries with limited resources?

This paper compares traditional and outcomes-based compliance pathways for a building energy code, explores approaches to integrating outcomes-based codes with traditional ECBC implementation and discusses specific issues in implementing outcomes-based codes such as benchmarking, incentives, measurement and verification. However, given the novelty of outcomes-based codes, it is difficult to recommend that India or other developing economies adopt outcomes-based codes alone, without also or first pursing traditional codes.

Energy Code Compliance Approaches

Traditional energy codes generally have prescriptive, simplified trade-off or modeled performance paths for compliance. Put simply, a prescriptive path for compliance comprises tables that specify required minimum or maximum values for discrete components or features of a building. For example, the ECBC requires that roofs in 24-hour-use buildings, such as hospitals and hotels, in the Hot and Dry climate zone comply with either a maximum overall assembly U-factor of 0.261 $W/m^2 \cdot C^o$ or a minimum insulation R-value of 3.5 $m^2 \cdot C^o/W$ (BEE 2007). There are similar prescriptive requirements in the ECBC for other building types for insulation, U-values for windows and minimum efficiency for HVAC equipment. Most codes focus on the prescriptive path because of its ease of application: designers and builders can easily determine what they need to do to comply with prescriptive requirements and validate compliance. For example, if the roof of a hotel in Jaisalmer has an insulation R-value of 3.7 $m^2 \cdot C^o/W$, then it complies with the code; if it is 3.4 $m^2 \cdot C^o/W$ instead, then it does not. However, prescriptive codes have limitations. They limit flexibility in design and they do not address issues such as building geometry as a function of volume or floor area.

The simplified trade-off approach allows the applicant flexibility in compensating between energy requirements of building envelope components when prescriptive requirements cannot be met. The applicant may use this method if a building exceeds prescriptive window-to-exterior wall area allowance, for example, or if the designer wants reduced insulation levels for any of the building envelope components. Allowable trade-offs can be set either in the code or in code compliance software.

The modeled performance path for compliance, referred to in the ECBC as the whole building performance method, allows designers more flexibility in that one energy-saving measure can be traded for another. If, for example, the wall insulation does not meet the prescriptive requirements in the code, yet the HVAC system exceeds the prescriptive requirements, then the applicant can demonstrate compliance of the whole building with the code using a performance equivalency method. The performance method usually involves using energy simulation software to assess the proposed design and compare its predicted energy consumption to a reference building. The energy consumption in the reference building corresponds to the upper limit of energy use allowed for that particular building under a scenario in which the building meets all minimum prescriptive requirements in the code. As a basis for the calculation and in order to preclude 'gaming' to falsely show a design complies, inputs from the proposed design for items that are needed for the simulation but for which there are no prescriptive requirements (for example, occupancy schedules and internal gains) are also included in the code. Several codes refer to this method as a performance path because the applicant models the theoretical building for performance during the design phase to ensure compliance. Despite the common usage to refer to this compliance path as *performance* or simulated performance, this approach does not regulate actual building energy use. Different buildings of the same type and use evaluated under a simulated performance approach, and all meeting code, would not necessarily have the same anticipated energy use.

In an outcomes-based approach, the primary focus is on the energy used during the operation of the building rather than building design specifications. The outcome is typically based on energy usage of the building. If the building is supposed to use some amount of energy and it uses more than that, it fails to comply with an outcomes-based approach. While utility bills provide a very convenient way of determining how much energy a building is using on an annual basis, the two challenging aspects of an outcomes-based code are determining what amount of energy the building should use and determining what to do about a building that does not pass the outcomes-based code. Additionally, because building simulation software may not capture the effects of occupant behavior, designers may have difficulty designing a building that complies with an outcomes-based code. Table 1 provides a snapshot of compliance under traditional and outcomes-based codes and suggests how enforcement may look under each. As illustrated, traditional codes regulate the design and construction of a building, while outcomes-based codes more directly relate to the building's actual energy performance. In particular, this paper also explores the different compliance paths for each, and how stepping stones to outcomes- based codes, such as incentives and penalties, can affect traditional code compliance.

Table 1. Regulation of design and construction vs. building operation

	Design & construction			Operations
	Traditional codes			
	Prescriptive	Simple trade-off	Simulated performance	Outcomes-based
Compliance path	Specifies minimum or maximum values for discrete components or features of a building	Compliance of envelope with the code is demonstrated using simulation software	Compliance of whole building with the code is demonstrated using energy simulation software	• Standard for energy performance index or other performance indicator (post-occupancy) • Comparison of actual to benchmark data • Comparison of actual data to modeled building • Audit

Enforcement system	• Government inspectors • Third-party inspectors • Checks of design and actual construction to get permits • Compliance mechanism relies on withholding permission to construct or occupy a building	• Government or third party reviewer to confirm building benchmark • Government, utility or third-party inspector to review cases of non-compliance with energy performance benchmark • Potential compliance incentives: higher tariff or tax on excessive consumption; utility rates (preferential or penalty tariffs); property tax incentives; posting rating to inform buyers and potential leases; financial liability for poor construction/ design

Implementation and Enforcement under Traditional Compliance Paths

Traditionally, countries verify code compliance at the design and construction stages of a building. Building audits post-construction are expensive. At the design stage, a comparison study of building energy codes in the Asia-Pacific region (Evans et al. 2009) shows that local governments in most countries have a major role in verifying code compliance for all or part of a building's design. For the code to become mandatory in India, state and local governments or other third parties acting on behalf of the entities responsible for ensuring compliance would need to be involved. Indian local governments (or Urban Local Bodies) will need to play a large role in enforcement (plan review and construction inspection) as they do with other building code issues (Kumar et al. 2010b). However, several states and the national government are considering using certified third-party inspectors to review building designs and construction as built to assess compliance with the code (Yu et al. 2013). These would come as either an affidavit attached to the permitting documents, or as a recommendation submitted for local authorities to review.

While review of building designs is common in places with mandatory codes, not all countries inspect actual construction. However, in other fields like pollution monitoring and policing of speed limits, a number of countries have observed that actual checks do improve compliance (Evans et al. 2009). To our knowledge, no one has performed broad surveys that compare the results of building energy code enforcement programs across jurisdictions with varying inspection practices (Yu and Evans 2013);[2] still, such inspections may explain why jurisdictions with strong inspection programs have experienced improvements in building energy efficiency. This is the case with California, a state with a strong inspection program whose per capita electricity consumption has remained stable for decades despite major economic growth over that period. China has developed a robust system of third-party inspectors who follow a

[2] Several states in the United States conduct such reviews. China also conducts compliance reviews based on annual 2-week field surveys of primarily major cities.

detailed building "acceptance code"; the inspectors must report detailed information and present photos to show that the building complies (Evans et al. 2010). South Korea has a system with several checks that requires the signatures of an architect and certified engineer, as well as an inspection during and upon completion of construction by local government officials. They, too, have observed significant improvements in code compliance.

Thus, under the traditional prescription/simulated performance paths for compliance, the compliance process centers on design and construction. Below is an example of the compliance stages that Indian authorities might want to include in an ECBC enforcement system:

1. Government authority (code official, fire marshal, etc.) and/or authorized third party (e.g., code compliance verifiers, other architect or engineer, collaborators from other larger government authorities or utilities) must review and approve design plans and specifications of the building design, construction techniques, materials, etc.
2. During construction, local government authorities or authorized agents conduct inspections; if they find the work does not match the approved plans, they may order a work stop until the changes are approved under additional inspections. Any design changes must be documented by the designer and/or contractor and approved by a government authority.
3. When construction is finished, the local government authority or their agent makes a final inspection (includes tests of systems and equipment) to assess if the building is code compliant with all aspects of the building code (energy and non-energy).
4. Local government authority or their agent issues an occupancy permit (in many cases multiple authorities, such as the building department, health department and fire department may be involved).

Indian authorities (or those in other countries) might also consider two modifications of this traditional approach to begin to address the issue of actual building energy performance:

5. At the conclusion of the first four steps above, a local government authority or their agent could issue a conditional permit for occupancy and a final permit contingent on building commissioning.
6. As warranted, a government authority, authorized agent or third party could perform periodic (and random) inspections or energy audits; based on the results of these inspections, the authority would renew the occupancy permit, or order corrections to the deficiencies. This option would have to be very carefully implemented to avoid mistrust from the public. Such audits could either check for proper maintenance of major building components, or examine whether actual energy performance was in line with predicted or simulated performance. Several countries in Europe and elsewhere now require periodic energy audits or inspections of HVAC equipment.

Incentives for exceeding the minimum requirements or penalties for noncompliance are powerful measures for achieving code compliance. The national government is in a position to play a major role in this. Examples of incentives for stronger ECBC compliance that the Government of India may wish to consider include providing building owners with subsidized financing and/or relaxing certain legal requirements such as maximum floor space and maximum building height. These measures, however, do not ensure that the building will operate to save energy. Penalties for noncompliance are also common and may be more applicable for checking code compliance during the design and construction phases. These may involve fines, publicizing names of property owners who fail to comply, and for repeated noncompliance, considering license suspensions. Urban Local Bodies will more likely be in a position to enforce these penalties (with the possible exception of the last option).

At a national level, India can provide support, funding and guidelines to local authorities for carrying out inspection work. In turn, local authorities could choose to employ third-party code verifiers or other agents on behalf of the local authority to facilitate this process. We observe this in several countries. In the U.S., this has taken different forms. In one Virginia county, developers can hire county-approved, 'registered design professionals' (architects or engineers) who are authorized to conduct inspections on behalf of the county. In Wisconsin, it is mandatory that the registered design professional of the commercial project attest that the final construction is in accordance with the state code. As a penalty, designers who do not properly verify construction can lose their license; this provides a very effective incentive to comply. In addition, and when relevant, local or state agencies may involve third parties to mediate disputes between registered design professionals and contractors. Third parties have the benefit of quickly expanding enforcement capabilities in countries. They can also help reduce the burden on government resources by shifting the costs to developers and by concentrating expertise that can meet the needs of multiple jurisdictions. China's inspection system, for example, relies heavily on third-party inspectors, who are required to pass exams in order to obtain certification. This system has allowed China to rapidly increase the number of inspectors and compliance rates. The concern with private inspectors is the potential conflict of interest. Third parties must have a credible reason to do their job well based on the regulations, not based on the requirements of the paying client.

What Traditional Code Enforcement Does Not Consider

Measures under traditional compliance paths can add up to a robust code enforcement system. However, do these measures result in significant energy savings? Unfortunately, traditional codes do not consider many things. Current building energy codes leave out an appreciable share of energy used in buildings. Most traditional codes do not include process loads (from manufacturing and food preparation equipment) and plug loads (from energy-using equipment that is not built-in during construction or that may be portable in nature) which usually make up more than 20% of energy consumed (Cohan et. al 2010). Even with estimated/modeled loads, as in the case with a traditional, simulated performance path, theoretical and actual performance can differ substantially. Causes for this difference can include important building energy considerations not regulated by the code, such as imperfect commissioning and testing of building components, occupant behavior or component wear. By contrast, outcomes-based codes do address this gap.

Regulating Building Operation with Outcomes-Based Codes

The outcomes-based path for compliance accounts for all energy consumption. Moreover, India's Energy Conservation Act, the enabling legislation for ECBC, emphasizes improvements in the energy performance index (EPI) of buildings, and there is a hope that outcomes-based codes might provide clearer measurement of improvements in EPI than ECBC alone could.

These are important reasons to consider outcomes-based codes. At the same time, the lack of global experience in implementing outcomes-based codes can create challenges in solving the practical problems associated with such regulations.

Presently, Tokyo is the only example of a jurisdiction with mandatory performance requirements on all existing buildings (specifically, large, commercial buildings). In Tokyo, the Metropolitan Government set the benchmarks based on CO_2 emissions from measured energy use over several years. Large commercial buildings must reduce energy-related emissions over a 5-year compliance period (which minimizes the weather-related fluctuations and gives time for investment). During the first compliance period, the energy-related emissions target is set at 6% below the measured baseline level, and this drops to 17% below in the second compliance period. Building owners must report on their emissions and energy use annually; third-party agencies then verify these results. Companies that do not meet the target can either buy offsets or they must pay fines. Overall, compliance has significantly exceeded the targets to date. The Tokyo Metropolitan Government invested significant effort to develop this system. It worked with stakeholders to develop willingness, capacity and baselines over a ten-year period before the program's launch, providing extensive technical support on issues such as energy efficiency measures, monitoring and reporting (Yu and Evans 2013).

Global experience on mandatory, measured performance requirement is not very deep. Most EU countries have mandatory building energy labels based on estimated building use, but post-occupancy performance is not linked to specific, mandatory requirements. A few cities in the northwestern U.S. and southwestern Canada are taking steps towards implementation of pilot projects based on outcomes-based codes. Several countries in the Asia-Pacific and in Europe also have some regulations to check energy performance of buildings after a building becomes operational, although generally there are only weak links between the checks and *requirements or incentives* to improve operational performance. In Japan, Australia, several EU countries and other jurisdictions, there are requirements to prepare period reports or energy audits on buildings post-occupancy (sometimes called maintenance reports). Some countries such as Sweden and Denmark also have mandatory, periodic checks on furnace performance. In Italy, residential power rates are set based on the connected load in each residence, which means that there is a strong financial incentive to keep power loads (and consumption) below certain thresholds. However, these Asian and European models (with the exception of Tokyo) do not fully integrate the link between building benchmarks, actual performance and incentives or penalties associated with actual performance.

Because there is limited global experience on the results of outcomes-based codes, PNNL also used its Global Change Assessment Model (GCAM) to run a test scenario for India. GCAM is an energy-economy, partial equilibrium integrated assessment model, which incorporates complex interactions between the economy, energy, land use and climate systems. The model contains 14 aggregate world regions (India is a region in GCAM), and estimates energy and emissions in 5-year time steps from 2005 to 2095. The building energy model of GCAM provided in Eom et al. (2011 and 2012), and modified to better represent the Indian buildings sector energy scenario in Chaturvedi et al. (2014), provides projections for: (1) urbanization, economic growth and the resulting changes in population and income in urban and rural areas; (2) the expansion of floor-space in urban, rural and commercial buildings; (3) the increase in the demand for building energy services and changes in fuel mix; and (4) the competition between end-use technologies consuming different fuels at the price endogenously determined by GCAM. To test for outcomes-based codes, we took the Business as Usual (BAU) scenario for Indian buildings and adjusted it to reflect an increase in fiscal incentives to promote building energy efficiency. We presented this as an increase in the electricity price compared to BAU of 6% in 2020, 14% in 2035 and 21% after that. We selected an increased price to simulate an outcomes based code because most outcomes-based enforcement systems would link to a fiscal incentive or penalty associated with the amount of energy use at a facility. We found that this relatively substantial increase in electricity price had only a small impact on electricity consumption in buildings. Specifically, the resultant decrease in electricity consumption compared to BAU was 2% in 2020 and 2095 with slight variations during the century. This may also highlight that outcomes-based codes (which focus on incentives or penalties for compliance) may not provide easy short cuts to building capacity for energy efficiency improvements.

Implementation and Enforcement under Outcomes-Based Codes

To better understand the potential interactions, we feel it is helpful to describe the concept behind outcomes-based codes. At the heart of the concept of outcomes-based code compliance is energy benchmarking (at least in most jurisdictions explicitly exploring such codes). Benchmarking is the baseline for follow-up performance evaluation. There are at least two approaches to benchmarking. The first involves comparing a particular building to a similar set of buildings to establish a benchmark, and then scoring the particular building's actual energy performance against that benchmark. The other approach is to use simulated performance of the building as the benchmark. While the benchmarking concept seems simple in principle, there are many challenges in implementation, so it is worth examining the process in more detail.

The first type of benchmarking refers to the "comparison of whole-building energy consumption relative to a set of similar buildings" (Kinney and Piette 2008). The result is a profile of a group of buildings according to significant building energy-related indicators such as primary use, construction, physical (e.g. building size), geographic (climate zone) and operating characteristics. In the U.S., the Department of Energy's Energy Information Administration has developed a Commercial Buildings Energy Consumption Survey (CBECS) that contains metrics on energy use for several building types.

In India, BEE collected energy use data for 760 commercial buildings, in partnership with the USAID ECO-III Project; this was the first national-level initiative to collect and analyze standardized building energy use data in India (Kumar et al. 2010a). This dataset may grow to include more buildings that characterize local variations. The main challenges specific to this approach relate to the quality of the dataset for comparison and the extent to which it represents a fair basis for comparison. Over time, as more buildings are added to the data set, these problems might wane. The advantage of this approach is that over time, compliance checks could be automated. Detailed analysis of individual buildings would be limited, which reduces the cost and the needs for immediate capacity building.

The main challenge with the second approach (simulated performance as a benchmark) is the cost and the need for a large cadre of building energy simulators to implement the program effectively. India has struggled with capacity for traditional code compliance, and so such a simulation-based approach to benchmarking would likely take time to implement and may exceed the capabilities of local authorities to oversee. For that reason, we do not consider it in more depth.

Benchmarking is already in use by a number of institutions. For example, energy service companies and performance contractors relate energy service potential with 'best-practice' benchmarks (Kinney and Piette 2008). Several municipalities and some states also now require benchmarking in certain buildings (IMT, 2014). For example, New York City mandates it in all large new government buildings (PlaNYC, 2014). Control companies and utilities may provide direct tracking of energy use and combine data from several buildings. Through this process, analysts can derive scores or metrics that indicate a building's efficiency, which under outcomes-based codes, would become the target a building would need to satisfy.

An outcomes-based code system may also offer benefits in terms of enforcement if it is possible to partially automate compliance checks once a benchmark is set. For example, a country may more easily manage concerns over conflict of interest related to third-party code verifiers under an outcomes-based code path for compliance. If it is found later that a building was non-compliant through the outcomes-based path, then the responsible inspector may lose their license or be fined in proportion to the energy wasted; this provides a strong incentive for third-party inspectors to do their job correctly. In particular, government authorities can hold building occupants more accountable. Occupants could face strong financial incentives (higher utility bills for instance) depending on the energy they consume. Under this scenario, buyers or renters would need to know the energy benchmark for the building before occupying it. France and some other EU countries now require benchmarked building ratings and labels as part of all real estate advertisements.

In theory, under outcomes-based codes, designers, contractors, inspectors, and even manufactures of products could be held accountable in addition to building occupants. In other words, the work these individuals carry out can be assessed based on how the building performs. In practice, however, this may not be easily attainable. For example, the quality of construction has an appreciable impact on energy use (air sealing for instance) and inspections can be very subjective. As such, if developers are aware that energy performance will be measured post-occupancy, then it is possible that they will be inclined to perform a quality control check. However, this will only work if accompanied by strong incentives. Under this scenario, government authorities may have to punish developers who do their job poorly retroactively, such as by fining them in proportion to the energy wasted or by publicizing their names; or alternatively by offering rewards for good performance such as property tax deductions or utility rebates. These incentives would require considerable resources and time. Consequently, from the design and construction side, sound enforcement mechanisms for outcomes-based codes remain to be explored, but it could include revoking or suspending licenses for non-compliant designs. India and many other developing countries do have systems to provide and revoke licenses of professionals, but the capacity of licensing systems is limited. Some policymakers also feel that outcomes based codes could be particularly impactful on the building operations side. This might also include incentives, such as reductions in property taxes or incentives linking emerging demand-side management (DSM) programs to building energy performance.

Another consideration under outcomes-based codes is how the verification process will actually work. India may consider implementing periodic audits at set moments post-occupancy (in most of China and Japan it is every three years). Another option is a comparison of energy consumption to the benchmark, which could in turn trigger penalties. To our knowledge, no one has tested this method. An alternative to this is comparing a benchmark that could trigger an audit, which could in turn trigger penalties (the case in Scandinavia). For the latter two, building owners and electric utilities in India could disclose energy use data to local governmental bodies. Electricity sub-metering may be an added measure. Such meters could measure energy use and peak loads on a regular basis. The latter could be costly however, particularly if it is implemented on a nationwide, mandatory basis. Because utilities are in a position to collect energy use information, they could facilitate this process. Utilities can utilize meters to check per unit of energy consumed on a regular basis and issue reports on building energy consumption for public use. If a building is noncompliant, the utility bill payer could pay a surcharge; if instead minimum requirements are exceeded the utility could offer a credit or discount. This, of course will be highly dependent on the legal and institutional conditions of the country. The utility would need to be in agreement with this and the tariff regulator would need to specify regulatory rules.

Further research is needed to develop implementation strategies for outcomes-based codes too. For instance, a process is needed for "multiple-occupancy" buildings, such as those that have both retail and office space. Variable occupancy over time also complicates benchmarking. Consider the case of a company who decides to transform a typical office space into a data center. The two uses have very different loads, but the energy benchmark may not reflect the energy consumption of a data center. A more common occurrence is changes in the number of occupants. A considerable increase in the number of staff will translate into a much larger load.

There is potential for outcomes-based codes to work side-by-side with traditional methods in order to fill the gaps currently present in traditional compliance paths by directly regulating the operations of a building. Table 2 summarizes the advantages and disadvantages of each; pairing the two types of codes may help augment the advantages of each.

Table 2. Summary of advantages and disadvantages of traditional and outcomes-based compliance paths

	Traditional		Outcomes-based
	Prescriptive	Simplified trade-off and/or performance	
Advantages	– Easy to verify code compliance and code is easier to implement than performance approach assuming that acceptable data exist on the performance of each of the building components	– Better design flexibility – Allows consideration of new technology and design approaches not specifically meeting prescriptive criteria	– Actual performance is regulated/extends beyond initial occupancy – Reflects energy saved from any measure implemented (e.g., renewables) – May ensure effective metering is provided to foster improved ability to commission and operate buildings – Could be readily adaptable for building labeling
Disadvantages	– Requirements typically end once an occupancy permit is issued – Plug, process, refrigeration loads are not addressed – Other building components not	– Energy code compliance more complex than with prescriptive approach – Built on assumptions of energy use which over time may change given changes in occupant activities and schedules	– Requires energy use data and benchmarking to establish reasonable targets – Metering expensive – Need mechanisms to address multiple occupancy buildings and

	regulated: building orientation, geometry and window area – Renewables such as passive solar design cannot be prescribed and by design are indirectly precluded – Does not readily support application and use of new technology	– Based on a prescriptive foundation and as such exhibits some of the limitation with prescriptive codes – Usually requires training in using the building energy simulation software	variable occupancy scenarios – Enforcement mechanisms may be harder to build, weaker and/or more expensive

Conclusions

Traditional codes, such as ECBC, regulate the design and construction stages, when it is relatively easy to influence the long-term energy use patterns of a building in a cost-effective manner. The ease of influence and cost-effectiveness are important advantages, but only if an effective enforcement system exists. India is just beginning to establish an enforcement system for ECBC. There are options, such as creatively involving third parties, that may speed the expansion of India's enforcement capacity, but global experience shows that good enforcement does take time and resources.

Outcomes-based codes are a new, relatively untested concept. The key advantage is that, in principle, they influence not just the "footprint" of a building, but the actual building energy performance over time. This can foster greater innovation in design than the code alone could require. It can also push buildings toward low energy use from multiple angles (including maintenance and operations). Because outcomes-based codes could be tested by checking a building's metered energy use against a predetermined benchmark, in theory, this approach to codes could also require less infrastructure and capacity to enforce, though the case of Tokyo shows this is not necessarily true. Or possibly more realistically, outcomes-based codes could provide an additional set of incentives to strive for good enforcement of the ECBC particularly if local governments were still building ECBC compliance capacity.

Given the novelty of outcomes-based codes, it is difficult to recommend that India or other developing economies adopt outcomes-based codes alone. This is true even if from a policy or legislative perspective, the goals ultimately relate to actual energy savings and performance. Rather, if governments would like to promote energy efficiency in actual building performance, they might consider implementing both a traditional and an outcomes-based code system. For example, an ECBC-based system would provide a globally proven option for improving the energy footprint of new buildings. A new outcomes-based code process, in collaboration with electric utilities or local authorities (on property taxes or environmental regulations), might allow for faster implementation and greater improvements in efficiency. Combining the two might allow for relatively low-risk experimentation with new policy approaches and potentially significant energy savings in new buildings. At the same time, jurisdictions with limited resources may choose to focus on a traditional building energy code.

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