Mapping Energy Efficiency:

A Global Dataset on Building Code Effectiveness and Compliance

INITIAL FINDINGS AND INSIGHTS FROM THE DATA COLLECTED

THE WORLD BANK
Development Economics • Global Indicators

Knowledge for Change

The World Bank 1818 H Street NW Washington DC 20433 Telephone 202-473-1000

www.worldbank.org

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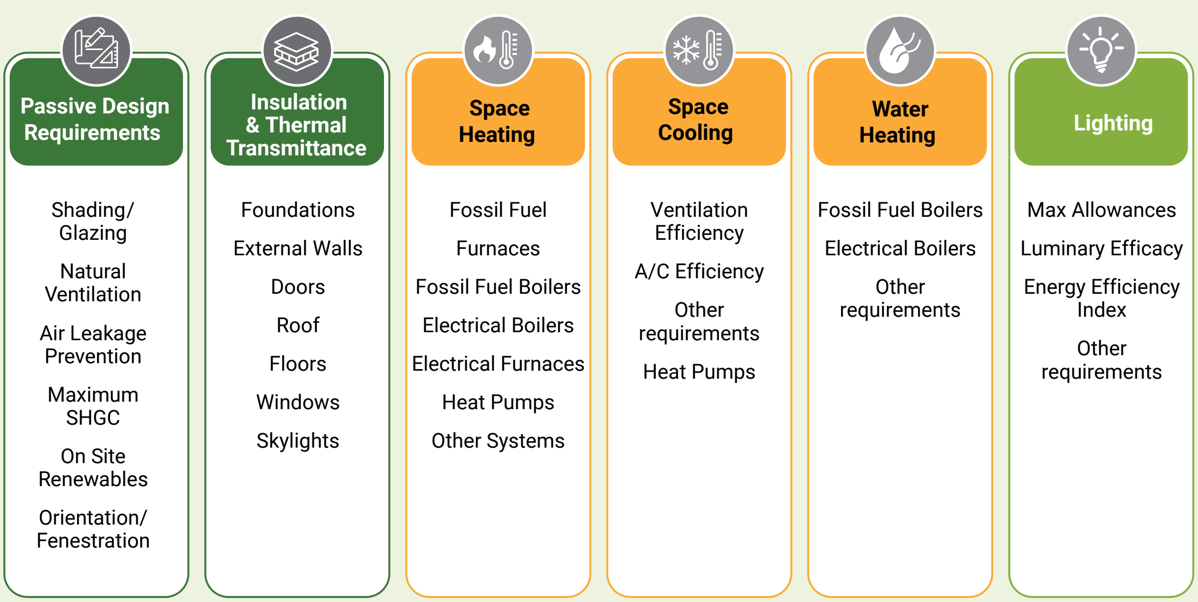
1. Why create this new data set?

Addressing the issue of emissions will increasingly become a central topic in the fight against climate change. Buildings account for a third of total final energy consumption globally and are responsible for 37 percent of emissions.[1] Half of all buildings that will exist in 2060 have not yet been built. The African continent alone will need to build 88 billion square meters to accommodate the estimated population growth during this time span. Two nations—China and India—will account for another 50 billion and 44 billion square meters of newly constructed buildings.[2]

This note covers high level findings of the Building Energy Efficiency Codes and Standards Global Dataset developed by the Global Indicators Group and funded by the Knowledge for Change Program. The dataset includes quantitative and comparable measures on building energy codes and standards applicable to new and existing buildings, as well as their enforcement mechanisms and levels of compliance in 88 countries across the world. The data collected covers key variables relevant to building energy efficiency along three key dimensions: coverage, stringency, and enforcement. The methodology adopted for the dataset follows the life cycle of a building: from planning and designing a building to the construction process and finally to the operation of the building once in use.

Figure 1 // Building energy efficiency elements measured in the dataset



The data collected addresses an important knowledge gap in developing countries and responds to the pressing need to leverage legal and institutional frameworks to mitigate and adapt to climate change by mandating minimum energy efficiency performance standards in new and existing buildings. Building energy codes play a central role in decarbonizing the built environment. They introduce a minimum acceptable level of performance in buildings, mandate requirements for both the design as well as the operation of buildings,and encourage the construction industry to incorporate a dimension of sustainability into every building. Progress is achieved when building energy codes are forward-looking and focus on aspects of building design that achieve energy savings in a cost-effective manner. Successful building energy codes also balance the need for thermal comfort with environmental objectives, that is, they allow for architects and engineers to propose ways of reducing the environmental impact of structures through a combination of passive design features, construction materials, and new technologies for heating or cooling as long a minimum level of energy efficiency is achieved.

This cross-country benchmarking exercise allows the World Bank Group and the development community to identify and compare regulatory frameworks that achieve carbon emissions reductions. These could also be evaluated on the basis of their success—and their ambitions—in transforming the construction industry and the built environment in developing countries. The data collected, in combination with other datasets already available, can also provide a basis for research applicable to policy. In providing a factual baseline, the dataset facilitates the comparisons needed to evaluate the relative maturity of the regulatory environment governing energy efficiency of the built environment. The data may also be used to uncover gaps in regulatory performance and areas of improvement for policymakers interested in aligning regulations to emission reduction goals and other sustainability and resilience objectives. This can guide the World Bank Group in providing an evidence base for improved operational practices and policy making in how cities are built and manage climate change mitigation and adaptation.

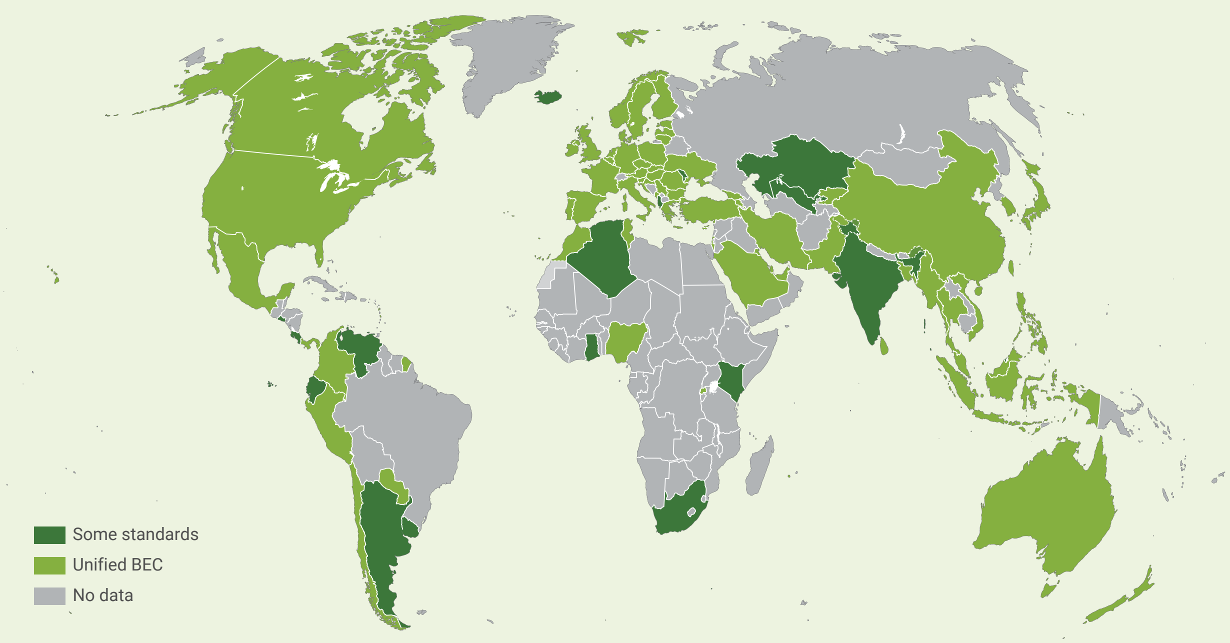
The dataset combines primary data collected directly through desk research from building energy codes and related standards with data collected through surveys in each jurisdiction that evaluated compliance and enforcement. A standardized questionnaire was used, allowing for cross-country comparisons and benchmarking.

2. Main Findings

This section details the main findings based on the 88 countries covered in the dataset. The dataset focuses on countries that have mandatory building energy codes (BECs) or energy efficiency standards for buildings. Countries not covered in the dataset either had no mandatory BEC or standards, or the laws were not accessible for data collection purposes. The results of this dataset reveal the challenge ahead for most countries in developing and improving energy efficiency standards. Substantial differences exist even within income levels and climate zones. Even in the European Union, which since 2002 has adopted a common regulatory framework for minimum performance standards, the Energy Performance of Buildings Directive (EPBD), there are important differences in stringency and enforcement levels.

2.1 PREVALENCE OF BUILDING ENERGY CODES AND STANDARDS

Figure 2 // Which countries have BECs and/or standards?



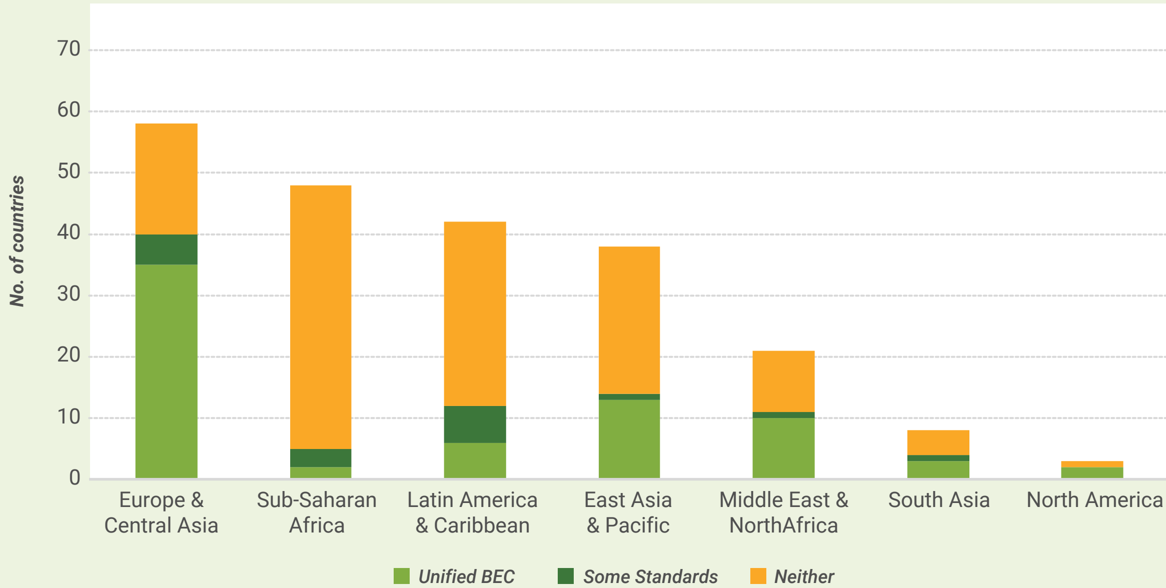
Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

Of the 88 countries covered in the dataset, 71 have adopted and made mandatory a building energy code or building energy efficiency standards in at least one major city. The remaining 17 countries have some standards but lack a comprehensive BEC. Of the total, 47 countries are classified by the World Bank as high-income, 22 are upper-middle-income, 17 are lower-middle-income, and one is classified as low- income.[3] Only one low-income country, Rwanda, has been identified as having a unified BEC. In terms of regions, nearly all of the 40 countries in Europe and Central Asia (ECA) covered by the dataset have adopted a unified BEC (the few exceptions include Albania, Iceland, Kazakhstan, Moldova, and Uzbekistan). Of the 11 countries in the Middle East and North Africa (MENA) region covered by the dataset, 10 have introduced a BEC, as have three of the four South Asian countries covered. The regions that lag furthest behind are Latin America and the Caribbean (LAC) and Sub-Saharan Africa (SSA). In LAC, of the 12 countries covered by the dataset, six have a unified BEC. In SSA, five countries from the dataset have a mandatory BEC or standards in force: Kenya, Ghana, Nigeria, Rwanda and South Africa. Of these five, only Nigeria and Rwanda have comprehensive BECs; while Kenya is currently in the process of implementing a new one.

Figure 3 // Building Energy Codes and Standards – Prevalence varies by income group

Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

Figure 4 // Building Energy Codes and Standards – Prevalence varies by region

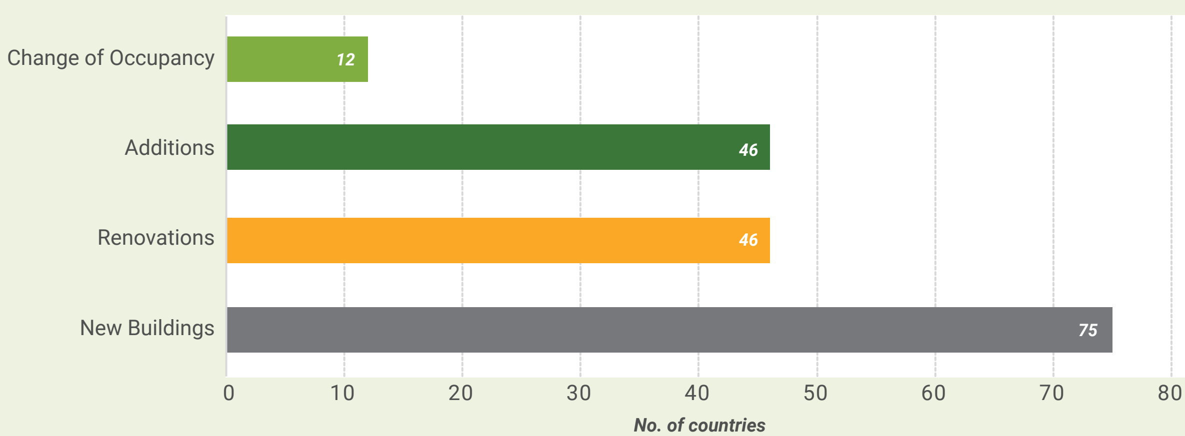


Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

2.2 WHAT TYPES OF BUILDINGS ARE COVERED IN THE BUILDING ENERGY CODES AND STANDARDS?

Building energy codes also vary widely in terms of the types of buildings covered. Overall, 75 countries impose requirements for entirely new buildings. Most of them also have requirements for other types of construction project, such as renovations, addition of floors, or change of occupancy. Codes in 21 countries are also exclusively geared toward commercial buildings and exempt residential buildings. Some countries, such as India, Malaysia and Mexico, include some categories of residential buildings, such as multistory apartment buildings, but exclude single family homes and dwellings. Nearly all codes cover office buildings; similarly, public buildings are usually one of the first categories targeted for coverage.

Figure 5 // BECs and standards – type of construction covered



Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

2.3 COMPREHENSIVE BUILDING ENERGY CODES:

Detailed standards are usually necessary to guide the construction industry toward more energy-efficient designs in emerging markets that are still unfamiliar with considerations of energy efficiency. Countries that introduce minimum standards for energy efficiency are able to prepare their construction community to comply with ever more stringent standards later. Once the industry has adapted to green building practices, codes often shift toward more performance-based approaches where tradeoffs are allowed and where the overall energy performance of a building is evaluated rather than each of its component parts. The data collected reveals that countries with newer codes will tend to adopt 'low-hanging fruit' that are easier to enforce and that do not require difficult or costly adaptation. For example, the Rwanda Building Code approved in 2019 mandates that new commercial and public buildings focus on efficient building envelopes, use of natural ventilation and use of natural light, energy-efficient cooling and water heating equipment and appliances, and on-site renewable energy generation, through a simple point-based system. The revised Ghana Building Code of 2018 similarly introduces energy efficiency provisions for private buildings larger than 5,000 square meters and certain public buildings; it focused on passive cooling, natural ventilation, use of natural light and use of sustainable construction materials. Other codes raise the bar gradually—adding new elements, such as building orientation, permanent shading, glazing for windows, reflective painting on rooftops, lighting fixtures and controls, and insulation and heat trap requirements—to increase ambition without necessarily requiring the exclusive use of costly construction materials.

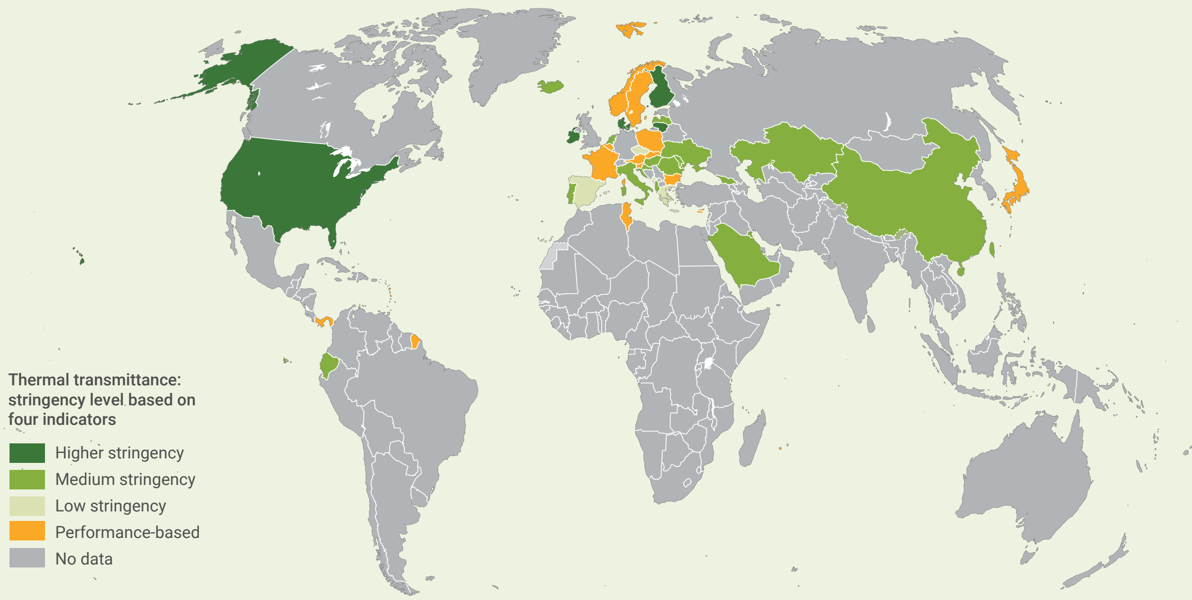
2.4 HOW STRINGENT ARE CODES AND STANDARDS?

Building codes and standards may introduce varying levels of stringency depending on the energy efficiency outcomes they intend to achieve. The dataset treats the number of building components covered in the codes or standards, as well as the overall energy performance required of the building,   as reflective of the stringency of the jurisdiction.

2.4.1 Passive design requirements

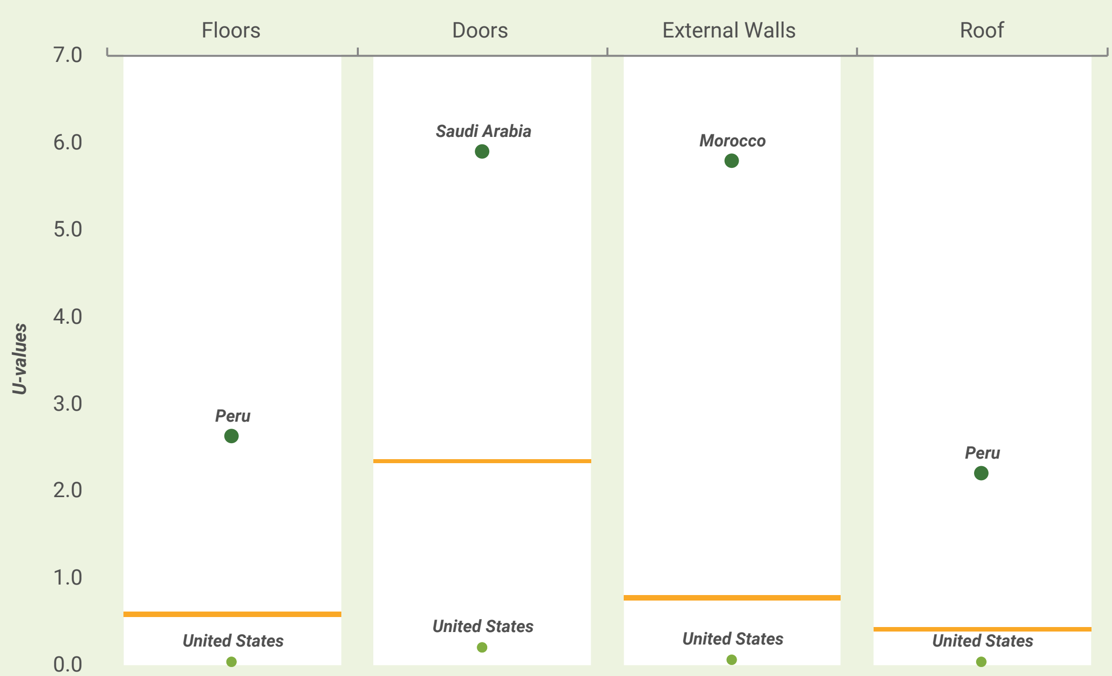
Thermal transmittance standards can be very revealing indicators of the stringency of the building energy code. Requirements to build with materials that have greater insulating properties reduce the need for mechanical heating and cooling and therefore can significantly reduce the energy consumption of buildings. Among the strictest codes in the dataset are those of Denmark, Finland and Luxembourg, if measured by U-Values. Alternatively, if the measure is maximum solar heat gain coefficients, the codes of Australia, Qatar and Saudi Arabia are among the most stringent.

Figure 6 // Building envelope – How stringent are the building codes?



Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

Figure 7 // Building Envelope – how much does the required thermal transmittance U-values vary across countries?

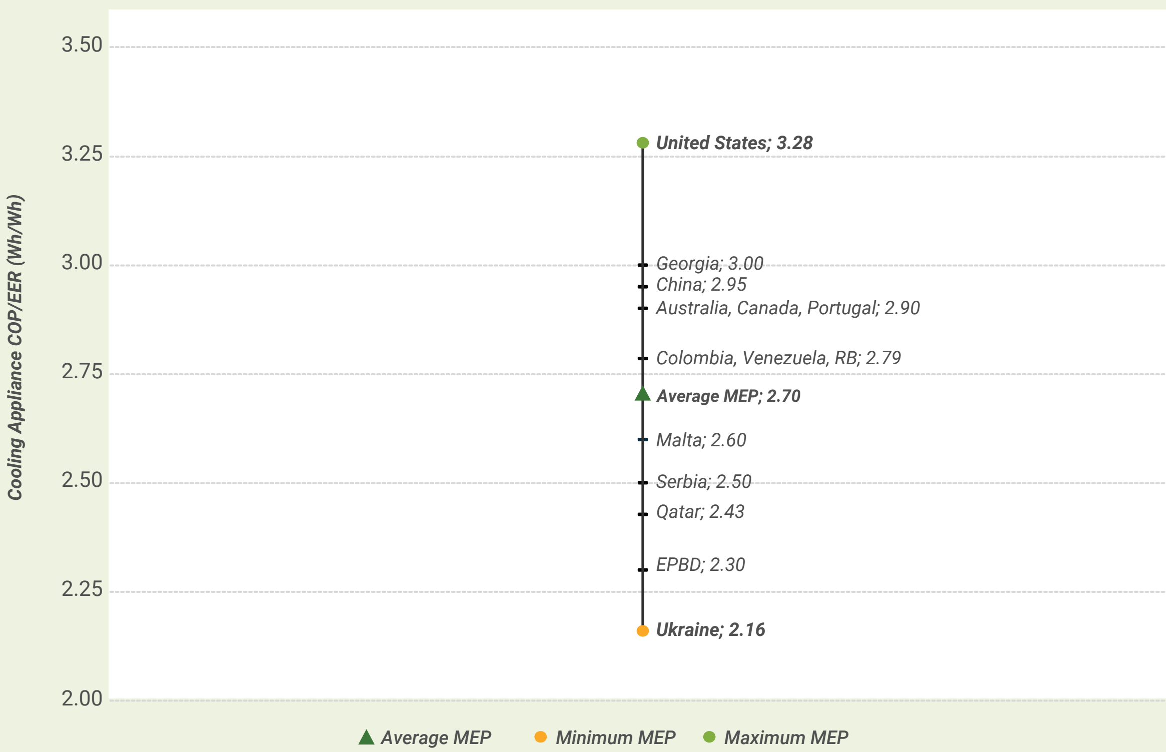


Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

2.4.2 Technology Requirements in Building Energy Codes and Standards

Beyond passive design requirements, building energy codes that are comprehensive must tackle the efficiency of heating, ventilation, and air-conditioning (HVAC) systems. In countries and cities where temperatures reach extreme heat or cold, HVAC systems can account for up to 70 percent of energy use. New technologies, however, significantly reduce energy needs and can also respond to occupancy changes and use set-points that balance thermal comfort with reduced reliance on artificial temperature control. Overall, of the 88 countries covered by the dataset, 52 have codes or standards that include efficiency of air-conditioning systems while only 36 have adopted those for heating systems. Canada, the UK and Spain have the strictest standards for the energy efficiency of fossil-fuel furnaces, while Lithuania, Finland and Portugal have introduced the most stringent standards for electrical boilers and furnaces. Heat pump technologies are covered by the building energy codes or standards of 33 countries, with China, the Netherlands, and the Slovak Republic imposing the highest performance requirements for this type of equipment.

Figure 8 // Cooling standards: Minimum energy performance standard (MEPS) for split AC systems



Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

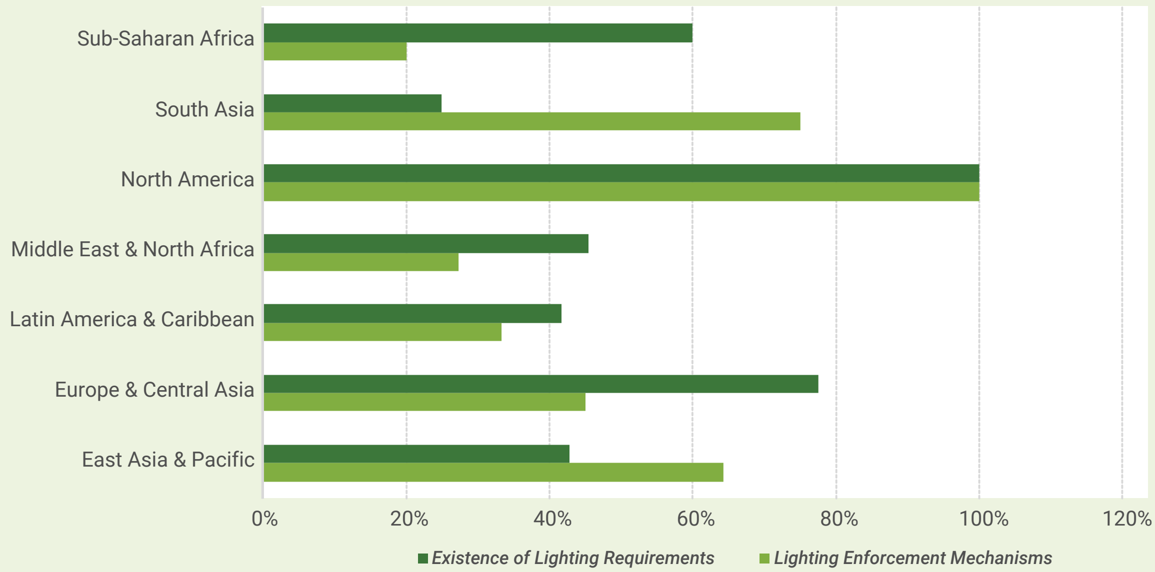
The dataset also covers two other key sources of energy use in buildings: water heating and lighting. In more temperate climates these are the predominant end use of energy consumption. A total of 45 countries mandate minimum performance standards for water heating equipment, while 53 cover lighting efficiency standards. These most commonly specify maximum wattage, or lighting allowances, and luminary efficiency standards. Some countries, including Austria, Luxembourg and the Slovak Republic, have completely phased out the use of fossil-fuel-based equipment, with several more having introduced gradual phase-outs. Other countries, including Ireland and Canada, have stringent standards for fossil-fuel equipment to encourage the adoption of electrical water heaters. Certain types of equipment with the highest abatement potential, such as heat pumps, have a high cost and are unlikely to be adopted widely in the short term. Countries therefore have focused on phasing out the worst performing equipment, such as old boilers and furnaces with electrical equipment.

Figure 9 // Heating equipment standards: Coverage

	Fuel boilers / furnaces	Electric boilers/furnaces	Heat pumps
Albania	✓	✓	✓
Australia	✓	✓	
Belgium	✓	✓	✓
Canada	✓	✓	✓
China	✓		✓
Finland	✓	✓	✓
Georgia	✓		✓
Greece	✓	✓	
Japan	✓		
Lithuania	✓	✓	✓
Malta	✓	✓	✓
Montenegro	✓	✓	✓
Netherlands	✓	✓	✓
Pakistan	✓		✓
Portugal	✓	✓	✓
Serbia	✓		
Sweden	✓	✓	✓
Ukraine	✓		
United Kingdom	✓		✓
United States	✓		
Vietnam	✓		✓

Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

Figure 10 // Lighting requirements and enforcement mechanisms in Building Energy Codes and Standards



Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

2.4.3 Retrofitting in Building Energy Codes and Standards

The most ambitious building energy codes have also introduced deep retrofitting of "brown buildings". This implies setting a timeline to phase out and replace the most inefficient thermal, water heating and mechanical systems. It can also imply installing additional insulation layers or other structural works to improve the insulation of building envelopes. These measures have only been introduced in 16 high- income countries, all with climates that demand heating for a large part of the year. Due to its high costs, this transition requires fiscal support as well as a large skilled workforce. Retrofitting for this reason remains out of reach for many economies, where the focus is commonly placed on new buildings rather than "greening" existing buildings.

2.5 EFFECTIVE ENFORCEMENT OF BUILDING ENERGY CODES:

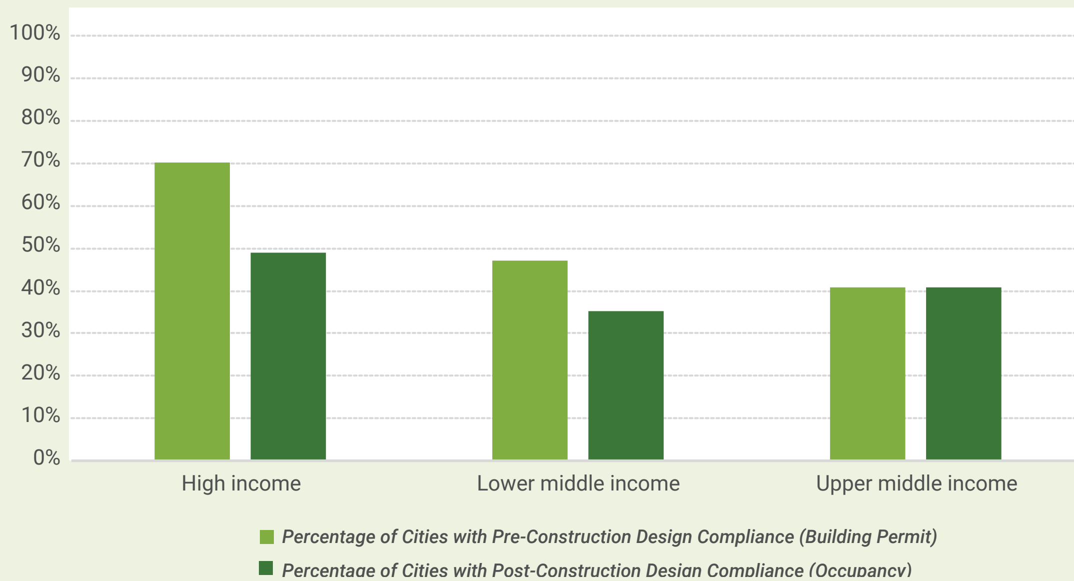
Codes and regulations establishing minimum standards and performance levels are not enough. The dataset highlights the fact that transforming the building stock requires a comprehensive approach. This will include financial incentives, disclosure and transparency requirements, and mechanisms to enforce standards and ensure high levels of compliance. Many successful cities have achieved more sustainable building stocks largely because of efforts at the local level—where implementation and enforcement take place—to a certain extent regardless of existing nationwide standards. This reflects different levels of public-sector capacity (especially the resources to ensure regulations are followed) and the degree of public–private collaboration. It also shows the degree to which the local construction industry can delegate to third parties the task of inspecting and certifying the compliance of buildings to applicable regulations.

According to local experts surveyed by the project, there are 52 countries where codes are mandatory and consistently enforced, nine countries where codes have been introduced but are lacking in formal enforcement mechanisms, and 20 where codes are enforced inconsistently or partially. A total of 51 countries have used the building permitting process to enforce building energy regulations; indeed this is the most common enforcement mechanism across all regions and income groups. Although it makes sense to complement inspections for structural integrity and fire safety with assessment of building energy efficiency compliance, this does require specialialized skills and adds to the workload of building control authorities. In the absence of private-sector parties capable of inspecting and verifying compliance, this may be the entry point for many jurisdictions seeking to enforce regulations.

There are 35 countries where regulations permit third-party enforcement of building energy code provisions. All of these are in high-income or upper-middle-income countries except for Kenya, Myanmar and Sri Lanka. Only 30 countries have developed a system for minimum professional qualifications required to register as a third-party inspector and even fewer, 25 countries, have a supervisory body to ensure third-party inspections are conducted appropriately and without conflict of interest.

The cities and countries with the most stringent standards also tend to have the most complex verification mechanisms: Melbourne, Oslo, Qatar and Singapore require the full range of design compliance components, including checklists of passive design features, energy verification worksheets, energy modeling, HVAC plans and lighting plans. A few cities, including Berlin, Helsinki, Montevideo, and Stockholm, however, have opted for a unified pre-construction verification methodology, either an energy performance model or an energy verification worksheet, to ensure compliance and streamline the process.

Figure 11 // Enforcement requirements in Building Energy Codes and Standards

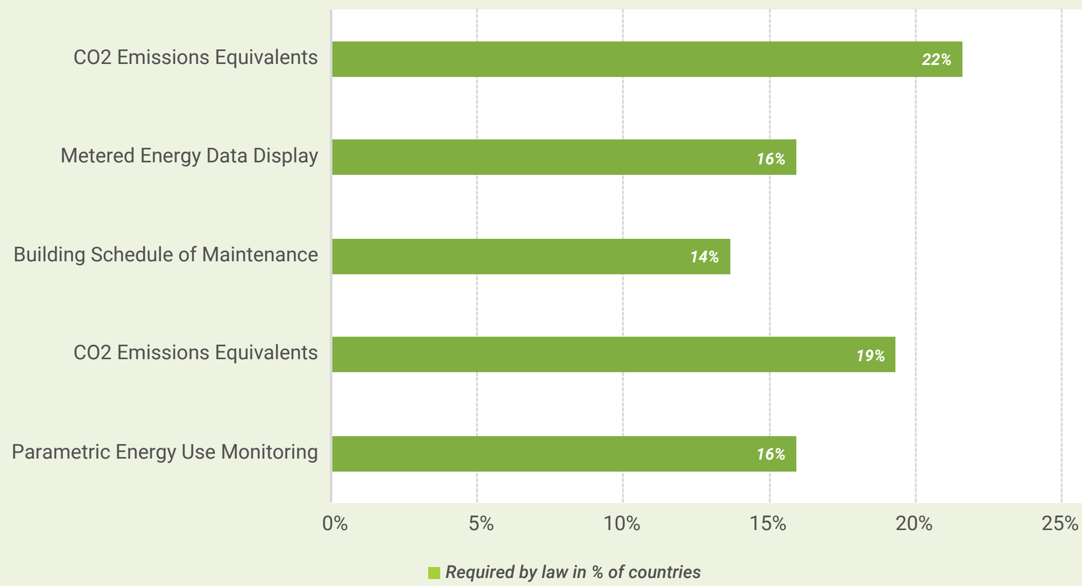


Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

Only 24 countries have introduced disclosure mechanisms for building energy performance. This is a critical component that allows the market to identify buildings that achieve higher energy efficiency; it enables stakeholders, including buyers, banks that finance housing, and investors, to account for the reduced carbon footprint and the financial benefits and energy savings expected from the building. Although the majority of these are located in Europe, cities and countries such as Almaty, Bahrain, Buenos Aires, Hong Kong SAR China, Qatar, and Santiago have at least one disclosure mechanism in place to facilitate properly pricing assets and estimating operating costs of the building.

Energy-efficient buildings also invariably require a transition away from fossil-fuel sources for thermal comfort as well as water heating. The electrification of building equipment has been mandated in several countries covered in the dataset, including Ireland starting in 2023, and the Netherlands starting in 2026. This step, however, is likely only possible for cities that have prepared over a long time span for this final transition toward fully electrical equipment.

Figure 12 // Disclosure mechanisms for building energy performance

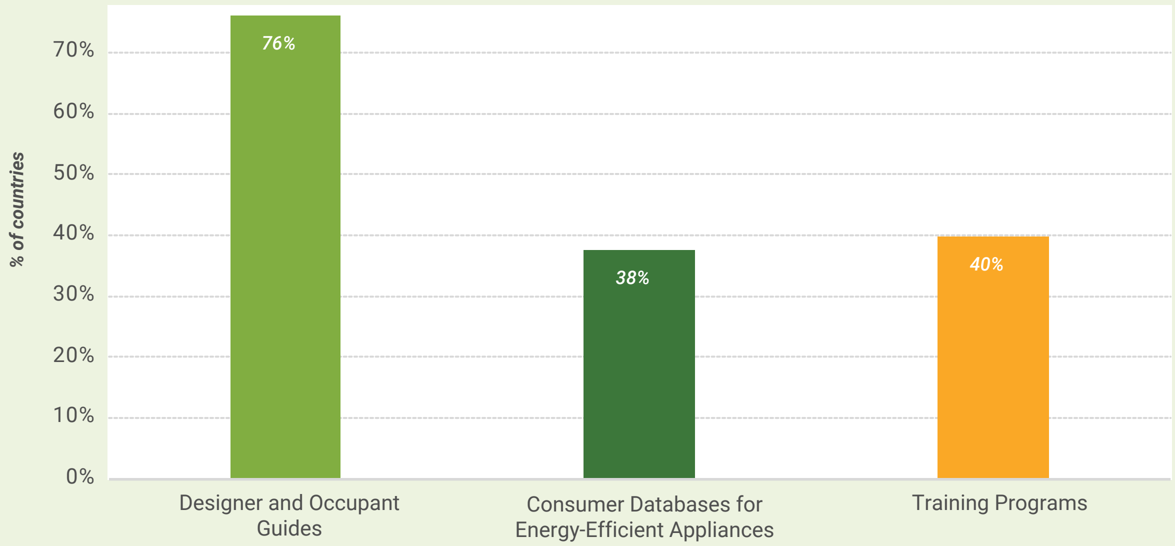


Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

2.6 AVAILABILITY OF RESOURCES AND INCENTIVES FOR PROMOTING ADOPTION OF BUILDING ENERGY EFFICIENCY MEASURES

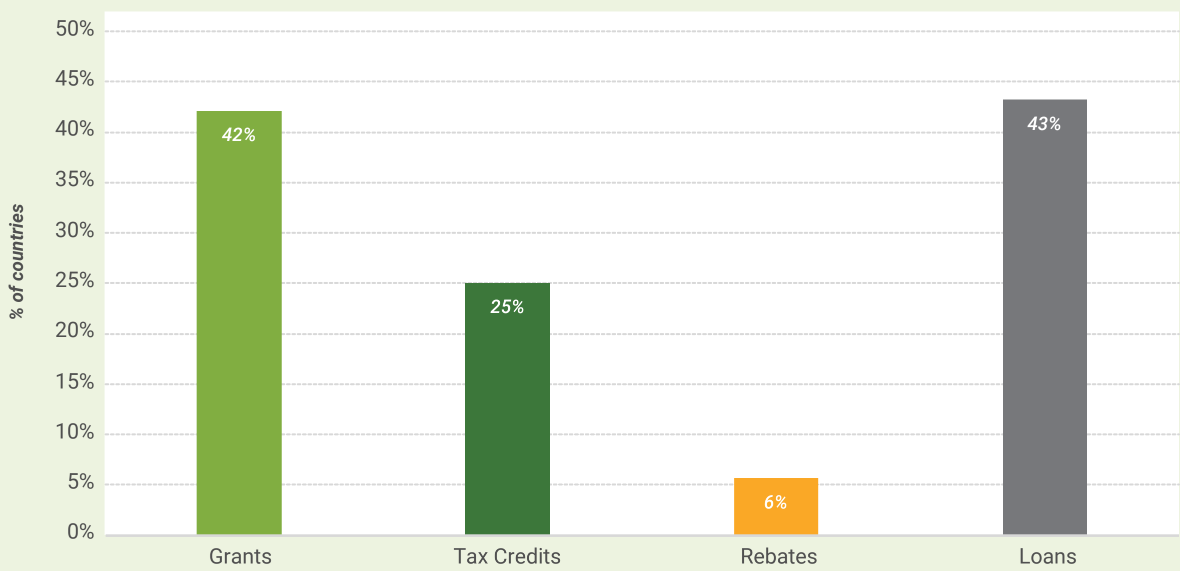
Countries that have achieved the most significant transition toward a greener building stock have done so by supporting the construction industry with incentives and resources. The challenge of changing building practices and mandating strict standards can only be met if governments are supportive and introduce well-targeted programs to encourage adoption and make a compelling case to invest in low- or zero-carbon buildings. Overall, the dataset reveals that 55 countries have some form of financial incentives, such as grants, tax credits, rebates or loans. Even more common are resources made available to facilitate energy efficiency transition, such as Designer and Occupant Guides, consumer databases for energy-efficient equipment or training programs.

Figure 13 // Resources available to facilitate compliance and improve uptake of energy efficiency technologies and designs



Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

Figure 14 // Financial Incentives to facilitate uptake of energy efficiency technologies and design



Source: DECIG Building Energy Efficiency Standards Global Dataset, 2024.

3. Using the dataset

Decarbonizing the building sector requires a multifaceted approach that addresses both new construction and the existing building stock. Introducing passive design requirements, such as optimal building orientation and natural ventilation, can significantly reduce energy demand and reliance on mechanical systems. However, these requirements must be accompanied by robust enforcement mechanisms to ensure compliance.

Benchmarking the stringency of current building energy codes is a useful exercise as it can reveal areas where requirements can be tightened or where new approaches can be introduced, such as mandatory phase-outs of obsolete cooling or heating equipment or additional passive design requirements.

Countries that have implemented building energy codes should consider integrating energy efficiency measures aimed at improving the performance of building envelopes, glazing, and building service systems to meet enhanced Minimum Energy Performance Standards (MEPS). For countries without existing codes, establishing specific standards for new construction, either separately or as part of future codes, is essential to establish minimum performance requirements for various building types. Additionally, building energy codes should outline a clear pathway toward achieving net-zero carbon emissions through a gradual tightening of regulations over time.

These small regulatory changes have the potential to yield substantial benefits, including electricity savings, emission reductions, and mitigation of energy poverty, when applied across millions of new buildings globally.

WHAT'S NEXT?

A full report will be developed to analyze global and regional trends, good practices and country examples of successful code implementation and standards driving change in the building energy efficiency sector. That report is being funded by the City Gap Fund, and will be published toward the end of 2024.

Endnotes

1 UNEP – Global Status Report for Buildings and Construction, 2024
2 IEA, Sustainable Recovery, World Energy Outlook Special Report (2020)
3 Venezuela has been temporarily unclassified as of July 2021, World Bank Country and Lending Groups, 2024