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# Buildings Energy Efficiency in China, Germany, and the United States


Climate Policy Initiative

Hermann Amecke
Jeff Deason
Andrew Hobbs
Aleksandra Novikova
Yang Xiu
Zhang Shengyuan



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## Descriptors

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| Contact | Jeff Deason jeff@cpisf.org |

## About CPI

Climate Policy Initiative (CPI) is a policy effectiveness analysis and advisory organization whose mission is to assess, diagnose, and support the efforts of key governments around the world to achieve low-carbon growth.

CPI is headquartered in San Francisco and has offices around the world, which are affiliated with distinguished research institutions. Offices include: CPI Beijing affiliated with the School of Public Policy and Management at Tsinghua University; CPI Berlin; CPI Hyderabad, affiliated with the Indian School of Business; CPI Rio, affiliated with Pontifical Catholic University of Rio (PUC-Rio); and CPI Venice, affiliated with Fondazione Eni Enrico Mattei (FEEM). CPI is an independent, not-for-profit organization supported by a grant from the Open Society Foundations.

# EXECUTIVE SUMMARY

This report compares energy efficiency policy in buildings in China, Germany, and the United States, providing the context for, and describing, policies in these three countries in order to lay the groundwork for future review of policy effectiveness.

As a lens for our analysis, we identify four opportunities for policy to impact energy use in buildings: new construction, building retrofit, equipment, and operations. Each of these categories presents distinct challenges and opportunities:

- Integration of efficiency principles during the **new construction** phase provides an opportunity for a building to achieve substantial energy savings at low cost given current technology. Policies that encourage or require efficiency at the time of construction are therefore crucial to a successful policy portfolio where construction rates are high.
- **Building retrofit** represents the post-construction opportunity to achieve deep improvements in the building envelope. Old buildings that lack current technology or may have deteriorated over time must be addressed through policy that encourages and deepens retrofit.
- Throughout the lifetime of a building, **equipment** such as appliances, lighting, and electronics is replaced or upgraded. Each time this occurs represents an opportunity for policy to maximize efficiency improvements by providing incentives, setting standards, and labeling.
- Finally, energy consumption in buildings continually depends upon the behavior of their inhabitants, which we term **operations**. Government can provide information and incentives to help encourage building users to operate buildings efficiently and choose low-consumption behaviors.

All of these categories are targeted by energy efficiency policies in all three countries. The policy instruments used are broadly similar, though they differ in their degree of reliance on markets (China is more likely to regulate through mandates than the other countries) and in the level of government that implements them (the U.S. devolves more policy to the state and local levels than the others, while in Germany most regulation is set at the national level but important parts are decided at the European Union and state level). However, differences in underlying conditions in the three countries motivate very different points of emphasis for policy.

**China**'s building stock is characterized by rapid new construction and demolition of older buildings, large scale urban expansion, and a broad range of climatic conditions. China is developing and modernizing its technologies. Accordingly, China's foremost building energy efficiency priorities are ensuring that new buildings are built to high standards and improving the efficiency of equipment. Northern China is heated mostly with district heat, and improving incentives for conservation in district-heated buildings could achieve considerable energy savings. Additionally, China faces the challenge of balancing its development-driven increase in building services demand with the preservation of current efficient behaviors such as part-time, part-space heating/cooling and natural ventilation.

**Germany** has a relatively old building stock, a low construction rate, and long building lifetimes. Therefore, policy emphasizes building retrofit, encouraging demand for retrofits and further encouraging these retrofits to attain deep energy savings. Germany also seeks to tighten building standards for new buildings and to control rising electricity use for appliances, electronics, lighting, and other devices. Germany has set ambitious energy reduction goals for its buildings sector (e.g. an 80% reduction in primary energy use in buildings by 2050), the only one of the three countries studied to do so; it is also the only country studied whose population and total building sector energy usage have stabilized and are not expected to rise in the future.

In the **United States**, aging buildings and new construction both provide policy challenges. Moreover, energy demand for equipment use consumes a higher share of building energy use in the U.S. than in China or Germany. Thus, while new build is the clear emphasis in China and retrofits in Germany, there is no comparable single point of policy focus in the U.S. A portfolio of policies targets new buildings to lock in efficiency at minimum costs, encourages efficiency through retrofit in older buildings, and works to moderate demand from devices and improve their efficiency. Historical factors have led to high energy use (per capita or per unit of floor area) relative to other developed countries such as Germany. Low energy prices and high incomes mean that incentives for efficiency are relatively weak.

CPI's buildings sector research focuses on assessing the effectiveness of key policies in the countries studied. CPI Beijing has estimated energy savings due to China's various buildings energy efficiency policies, and has focused deeper analysis on energy standards for new buildings and on improving the efficiency of district heating systems. CPI Berlin has issued a series of studies on policies that encourage retrofitting, including information tools and incentives. CPI San Francisco evaluated the energy-saving impact of building energy codes in new U.S. residential buildings. Please reference CPI's website, www.climatepolicyinitiative.org, to view completed studies.

# Contents

# 1. Introduction

Policy has been targeting improved energy efficiency in buildings for at least 35 years. Despite policy success stories,[1] energy use in buildings continues to grow. In 2010, energy services delivered in residential and commercial[2] buildings accounted for about one third of worldwide final energy demand (IEA, 2011) and carbon dioxide ($CO_2$) emissions (IEA, 2008). Cost-effective opportunities for energy efficiency in buildings remain widespread. While there is no recent review of the worldwide potential for energy efficiency improvement, analysts suggest that as much as 29% of global baseline buildings $CO_2$ emissions in 2020 could be eliminated with investments that pay for themselves through reduced energy costs (Levine et al., 2007). The largest part of this $CO_2$ emission reduction is associated with installation of energy efficiency technologies.

The fact that such opportunities endure today is testament to the difficulties of achieving apparently cost-effective energy efficiency improvements. As discussed further in Section 2 (see Box 2), a series of barriers prevent uptake of these measures. These barriers have been widely recognized for thirty years or more. While policy has made some progress in encouraging energy efficiency, there is a broad consensus that much more is necessary to meet worldwide goals for mitigation of climate change. Critical evaluation of where and how energy efficiency policy has in fact had an impact may prove vital to unlocking its potential.

## CPI Buildings Policy Framework

In this paper, we explain CPI's framework for addressing energy efficiency policy in buildings. In particular we will discuss four major factors that affect the design and effectiveness of policy:

- **The point of policy intervention.** This is the central organizing principle of Section 2, and Figure 1 splits buildings energy use into four separate categories that are generally accessed separately by policy: new buildings, retrofits, equipment, and operations.
- **The barriers or inefficiencies** the policy is designed to overcome. These barriers are discussed in Box 2 and as they arise in the discussion of policy in Section 2.
- **The energy end uses or services** to which the policy applies. End uses are discussed throughout, and amounts and trends of energy use are presented in graphics in Section 3.
- **The geography and economic environment** into which the policy is applied. These issues are discussed country by country in Section 3.

## Scope of Policy Considered

The focus of this discussion paper is energy efficiency policies in buildings. We also touch on other policies and factors that may affect $CO_2$ emissions from buildings.

Energy use in residential and commercial buildings is a function of the size of the building stock itself and the intensity of energy use in those buildings. $CO_2$ emissions from buildings are dependent on these factors as well as the emissions intensities of the fuels used to generate energy. See Box 1 for more.

Policy influences each of these factors; for example, land use and urban planning policy has substantial impact on the size of the building stock and the types of buildings constructed. However, this paper focuses more narrowly on buildings energy efficiency issues and related policy (column 2 in the box above). Buildings energy efficiency covers the energy performance of building envelopes and of equipment inside buildings (such as HVAC units and appliances), and also touches on building use, customs, and energy pricing to some limited extent.

1 For example, a recent CPI analysis (Deason and Hobbs 2011) shows that U.S. residential building energy codes have successfully reduced energy use in buildings

2 Throughout this document, "commercial" refers to private commercial buildings, government buildings, and institutional buildings such as hospitals and schools.

## Buildings Energy Use and Policy in Three Studied Countries

The body of this paper identifies and contrasts the most significant issues for buildings energy efficiency policy in three key countries: China, Germany, and the United States. From the overview presented here, it is evident that the issues to be addressed in each country are somewhat different. Moreover, to be effective, policy must fit not only the physical character of the country's building stock but also the institutional setting in which it is located.

Section 2 provides an overview of how China, Germany, and the United States consume energy and how policy can be shaped to respond to varying energy use profiles. Section 3 explores the climatic, economic, and cultural factors that make each country unique and provides a brief overview of the key questions and policy challenges being faced.

Section 4 discusses CPI's research to date on energy efficiency in buildings, linking completed and ongoing projects to the challenges and trends identified in the previous section. Little work has been done to evaluate which buildings energy efficiency policies are working well and which are not. CPI seeks to expand the evidence base on policy performance by assessing the effectiveness of these policies, and by diagnosing the reasons for their success or failure. Better understanding the outcomes of these policies and the reasons that they succeed or fail is critical to support the efforts of policymakers in designing future measures that can effectively tap the potential for cost-effective energy savings and $CO_2$ emissions reductions in buildings worldwide.

**Box 1: $CO_2$ Emissions from Buildings**

The following equation summarizes $CO_2$ emissions in buildings:

$$\text{Building } CO_2 \text{ Emissions} = \text{Building Stock} \times \frac{\text{Energy}}{\text{Building}} \times \frac{CO_2 \text{ Emissions}}{\text{Energy}}$$

Each term in this equation is itself the product of many underlying factors:

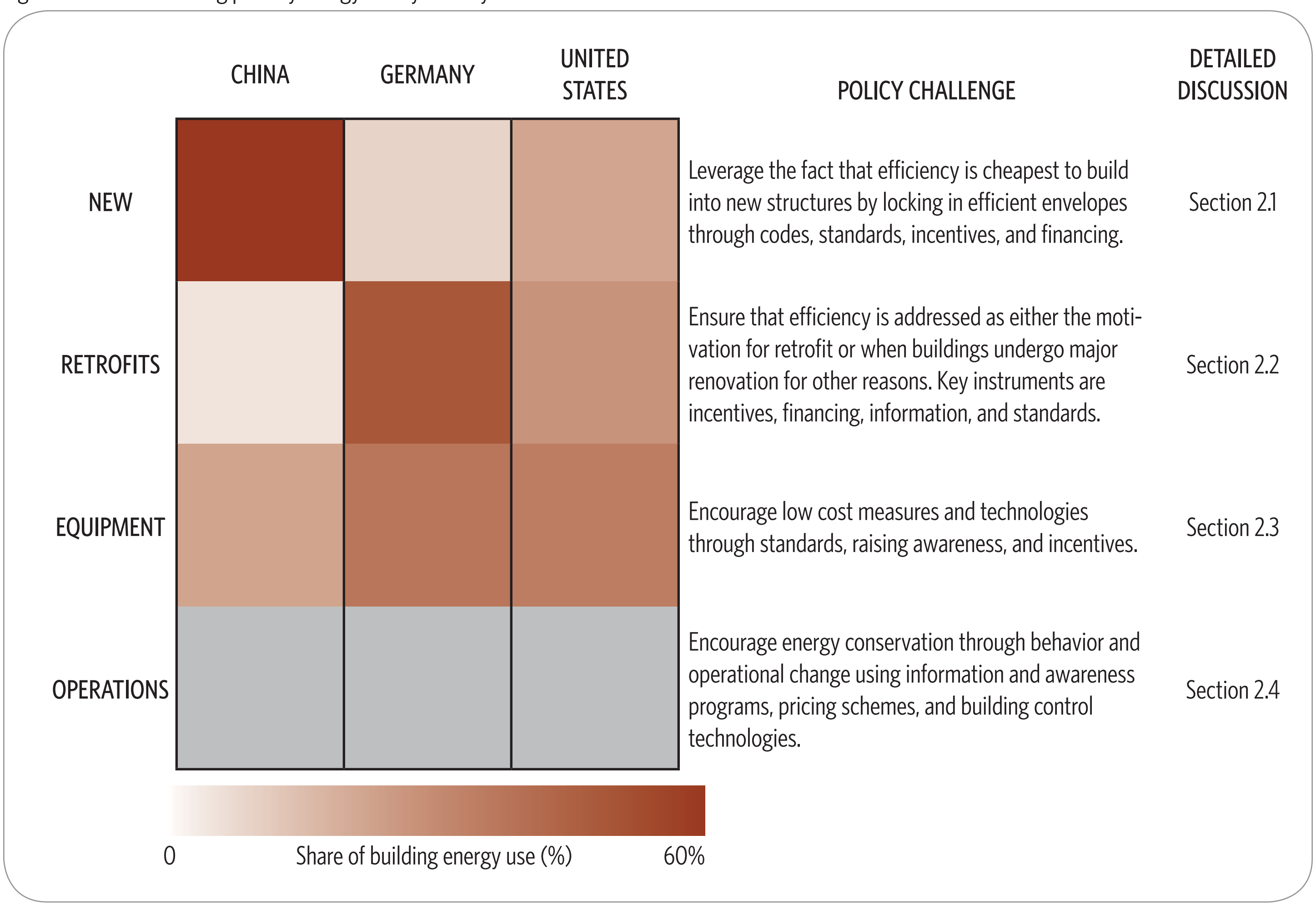
| FACTORS INFLUENCING SIZE OF BUILDING STOCK | FACTORS INFLUENCING ENERGY INTENSITY OF BUILDING STOCK | FACTORS INFLUENCING EMISSIONS PER UNIT OF ENERGY USE |
|---|---|---|
| · Population size<br>· Level of economic development<br>· Types of economic activity (particularly for commercial buildings)<br>· Custom<br>· Policies on building construction and use | · Number of people per building<br>· Climate (a critical determinant of demand for heating, ventilation, and air conditioning (HVAC))<br>· Economic development and activities inside buildings<br>· Efficiency of building envelopes<br>· Type, usage, and efficiency of equipment (especially HVAC equipment but also water heating, appliances, electronics, lighting, etc.)<br>· Energy use customs<br>· Economics of energy use (which depends on both energy prices and incomes) | · Fuel mix for energy generation, itself a function of resource availability and economics<br>· Energy conversion efficiency of fuel processing activities inside and outside buildings (notably including power plant efficiencies)<br>· Policy support for various energy sources and for emissions controls |

## 2. Energy consumption patterns and challenges

We break down buildings energy efficiency policy analysis into four categories to reflect how and when consumers make decisions about energy efficiency:

1. **New buildings -** A building is built once, and many of the decisions that impact energy use - such as heating and cooling system choices, ventilation paths, insulation levels and building use - are either locked in at construction, or become expensive to change.
2. **Building retrofit-** Retrofits provide an opportunity to upgrade and improve many of the components of space heating/cooling during a building's life. The highest levels of performance may not be possible for retrofitted buildings, and the cost may be higher (with large variations between buildings), but the overall opportunity is large. The cost of retrofitting to improve energy use is lower when combined with building renovations motivated by other purposes. Thus, policy can affect both whether a retrofit is made and the level of the retrofit.
3. **Energy consuming equipment (appliances, lighting, electronics) -** Equipment decisions are much more frequent—appliances are changed out several times over the life of a building, electronics and lighting even more often. Each discrete equipment decision has less energy impact than a retrofit, but in aggregate the impact of these decisions is of comparable importance.
4. **Building operations –** Improving energy efficiency through operations and behaviors addresses a series of small decisions; for instance, how to

Figure 1: Shares of building primary energy use by country




Data sources: Zhang et al. 2010; Building Energy Research Center 2011; Annual Energy Development Report, Beijing 2011; US Energy Information Administration 2010; Olgyay and Seruto 2010; Enerdata 2011 set a thermostat, whether to turn on a device, whether to open a window, and so on. Each of these moment-by-moment impacts is small, but changes in operational and behavioral patterns and norms can have large aggregate impacts.

Each of these categories is responsible for a substantial amount of energy consumption in each country, and each country appropriately has adopted policy to encourage efficiency in each category. However, the amount of energy use affected by these four decision points, and by implication the energy and carbon savings possible, varies among countries. For example, slower growth and an older building stock in Germany elevates the importance of retrofits there compared to China. Figure 1 presents simple estimates of the share of primary[3] energy in each studied country's buildings sector that is associated with the given category.[4] We do not estimate the share of energy due to operations, which is difficult to isolate; however, the impact of operations is certainly significant, and in fact may be as large as the impact of the other categories combined (Ürge-Vorsatz et al., 2009).

Effective policy will focus where potential reductions are greatest and where they are cheapest, and it is important to note that high energy consumption in a particular category does not necessarily indicate large or cost effective abatement potential. However, the evidence suggests that significant abatement potential exists in all categories. Moreover, cost-effective abatement potential estimates from McKinsey (2007) generate a very similar figure to Figure 1 when broken down among the same categories, indicating that our energy use data correlate well with potential measures.

Observers[5] of the buildings sector identify many efficiency measures that could pay for themselves through the energy savings they generate, yet are not being pursued. A set of perplexing barriers prevent building owners and dwellers from pursuing cost-effective energy-saving measures. The literature recognizes that multiple barriers must often be overcome to catalyze greater investment in energy efficiency (Box 2). Most of these barriers affect most of the four energy use categories, but we highlight particularly relevant barriers in each section.

## 2.1 New Buildings

Designing policy to ensure a high standard of efficiency in new buildings is important in all three countries. The U.S. and China are both building significant amounts of new residential and commercial floor space; Germany's commercial build rate is negligible, but there is some residential construction.

The potential for improving energy efficiency in a new building is very high, for several reasons. Installing upgrades at the time of construction is generally much less expensive than implementing these measures through retrofit of an existing building. Furthermore, as new buildings generally go through a permitting process, they are easier to regulate than renovations.[6] Finally, while efficiency improvements in existing buildings may disrupt building operations, building in efficiency during construction is not intrusive.

A number of issues confront energy efficiency efforts in new buildings. High efficiency design can require more expensive equipment and demands greater coordination and expertise among a *fragmented* set of professionals. These demands raise the *up-front costs* associated with building a high efficiency structure. Moreover, the long term value of efficiency improvements is not fully observable to the builder, and even less so to the homebuyer. The builder's incentive to maximize home efficiency is therefore limited by the knowledge of the buyer, as buyers will not be willing to pay extra for features of whose benefits they are *unaware*. Where the buyers will not operate the buildings themselves but will rent them, *split incentive* issues further complicate the problem, particularly for multifamily and commercial buildings.

In many countries, building energy codes are a key policy governing the efficiency of new build. These codes set various requirements for the efficiency of building envelopes and, to a lesser extent, HVAC devices. They

3 Primary energy figures include energy consumed by the generation and distribution of electricity prior to arrival at the building, as well as the energy consumed (electrical and otherwise) at the building itself. They therefore reflect the full energy and climate impact of building energy consumption better than "final energy" figures that only count energy consumed on site. One should note that primary energy figures are dependent on the efficiency of a country's generation, transmission, and distribution systems, factors on which building design, construction, operations, and policy have little if any effect.

4 For details on the calculations behind this figure, please see the Appendix.

5 See, for example, Golove & Eto 1996; UNEP 2007; and Levine et al. 2007

6 Large renovations often require permitting as well, but compliance with permitting requirements for renovations is generally understood to be considerably weaker.

**Box 2. Barriers to Energy Efficiency**

***Fragmented markets***. Many different professions and actors influence building energy use through designing, constructing, and operating buildings. Often none of the professionals at work on a given project are experts in energy efficiency, and the responsibility for achieving efficiency is diffused among them, presenting a coordination challenge.

***Upfront costs and high hurdle rates***. Building owners are often only willing to undertake improvements that pay for themselves in a very short time period (e.g. a year or two). More generally, making buildings more energy efficient, whether through new build or retrofit, imposes upfront costs while the benefits accrue gradually over time. People are often unwilling to make these kinds of investments, even where the benefits outweigh costs in the long run.

***Lack of information and awareness***. Energy use is difficult to observe in most cases. Building owners and occupants often have very little sense of the impacts of their actions on energy use. Builders and contractors may understand these issues somewhat better, but as their jobs encompass much more than energy efficiency, their understanding is imperfect as well. Lack of information on the part of builders and contractors can lead to ineffective installation practices that prevent the full potential of energy-saving measures from being realized. Apart from trained energy efficiency professionals, none of the actors in the buildings space are likely to be aware of the full suite of potential cost-effective actions that could be taken to improve a building's energy efficiency. Further, the value of energy efficiency measures is largely unobservable to potential buyers when a building is sold.

***Split or misplaced incentives***. Incentive problems occur when the person who would pay the cost of energy efficient upgrades would not receive the full benefit of them. Incentives problems often arise between landlords and tenants; between current and future building owners; and between building developers and buyers.

***Financing difficulties***. In many cases building owners will not have sufficient capital to finance their own efficiency improvements. Interest rates offered by financiers may be too high to be attractive based on one or more factors: a belief that the returns from energy efficiency investment are risky, the fact that real estate prices may not fully reflect the value of energy efficiency improvements, and the existence of other debt that may be senior to debt taken out for efficiency measures.

***"Hidden" costs, including search and transactions costs and amenity losses***. In some cases, measures that seem to be cost-effective may not be when considering the full cost of pursuing them. A building owner must generally either spend time researching energy efficiency measures or spend money to hire someone else to do so. Installing the measure also takes time and money, and may disrupt normal activities in an existing building. Moreover, in some cases the energy efficient approach may provide different amenities than the default. Simple comparisons that ignore these costs may systematically overstate the range of cost-effective energy efficient measures, helping to explain why they often go unadopted.

***Mispricing***. Regulated energy rates, subsidies, and unpriced externalities of energy use contribute to energy prices that vary widely in different countries. These prices generally do not accurately reflect the social cost of energy consumption. Where energy prices are significantly below social cost, many socially beneficial energy efficiency improvements will fail a cost-effectiveness test.

***Lack of attention and materiality***. Energy efficiency is only one of many considerations a builder, buyer, or owner faces when making decisions about the building. Moreover, in some cases the incremental savings from a specific potential efficiency measure are quite small. Even if fully aware, these actors will often not feel that potential energy efficiency benefits are material enough to attend to in the face of numerous other concerns.

leverage the fact that, in most countries, buildings must go through an approval process before being built, during which they are subject to numerous requirements including other codes governing building safety. This review process provides an easy point of regulation for new build that is more difficult to achieve in existing buildings. Other policies that promote heating and cooling efficiency in new buildings include incentives for energy-efficient design, materials, and HVAC equipment, training and outreach to architects and contractors, and standards for HVAC equipment. Further, building labeling programs and energy efficiency disclosure rules provide buyers with important information on the value of efficiency measures.

## 2.2 Building Retrofit

Encouraging energy efficiency retrofits in existing buildings is a key issue for Germany and the U.S., where building lifetimes are long and renovations are relatively common. These measures generally target the building envelope and/or HVAC units to improve performance. While these measures are generally more expensive in existing buildings than in new buildings, most studies indicate that they are cost-effective when pursued as part of a more general building renovation (Neuhoff et al. 2011a). One can divide the need to encourage retrofit into two stages: raising the rate of energy-efficiency retrofits and "deepening" the retrofits so that each achieves a greater level of energy savings. Different policies may be most effective for these two different objectives (e.g., informational and awareness tools for raising the rate; audits and targeted financial support for deepening the retrofit).

Retrofit policy faces a wide array of challenges. Building retrofit is often held up by *high up-front costs* and difficulties raising *finance* since savings accrue in the future. Where properties are rented, or where ownership is likely to change soon after a renovation, *split incentive* issues arise. (This is especially relevant for Germany, which has a large share of rented buildings in its residential stock.) *Awareness* of the energy savings that can be achieved from thermal retrofit is generally low among building owners and among contractors who are not specifically trained to assess such savings. *Search and transactions costs* can be high: the building owner must find appropriate contractors, define the actions to be taken, and potentially tolerate additional disruptions to normal building activities. While incentives may help realize a cost-effective retrofit, owners must be aware of them (or be made aware by contractors) to benefit from them.

Efficiency retrofits in residential and commercial buildings pose somewhat different challenges. Residential building owners are somewhat less likely to view building operations as a business expense to be managed, and information and awareness problems are likely to be large. Search and transactions costs are also likely to be large in relation to potential savings. Commercial (and large residential) building owners may be somewhat more likely to identify cost-saving measures, and the transaction costs may be less likely to rival potential energy savings. On the other hand, capital may be scarce and required outlays significant, emphasizing hurdle rate and financing barriers.

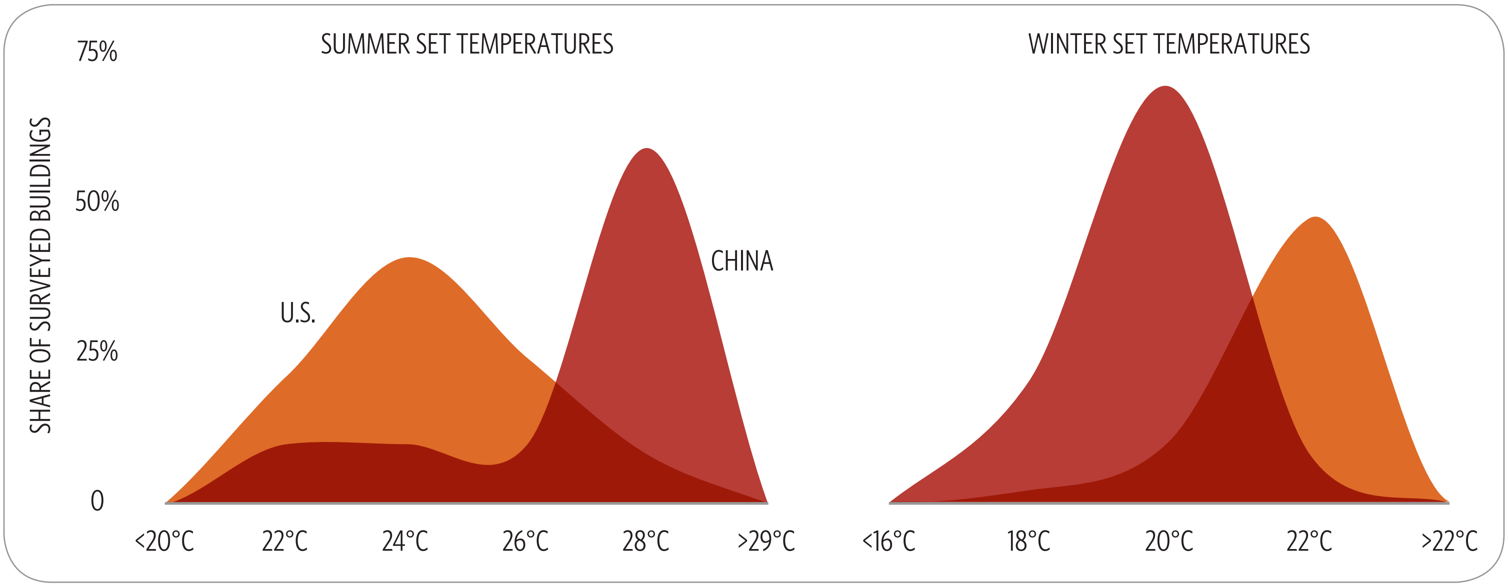
The multiple barriers at play here motivate a suite of policies. Informational and public awareness campaigns raise visibility and (hopefully) uptake of retrofits. Training programs raise awareness among contractors, and contractor certification schemes help reduce search and transaction costs for building owners. A variety of incentives and low-interest financing programs mitigate the first cost and hurdle rate barriers.

## 2.3 Equipment

Water heating, appliances, electronics, and lighting together consume a large share of energy in all the studied countries. While water heating demand is relatively stable in the U.S. and Germany, it is growing in China. Electrical appliances and electronics are of particular concern because they are large primary energy consumers and their energy use is growing rapidly. The share of building energy consumption represented by electronics and electric appliances is rising in all three countries. In recent years, the number of home appliances has increased rather dramatically in all three countries due mostly to rising demand for communication, information, and entertainment technologies. On the other hand, common large appliances such as refrigerators, clothes washers, and dishwashers have become more efficient in recent years. Lighting consumes a significant amount of energy in all countries, particularly in commercial buildings.

Water heaters, appliances, electronics, and light bulbs have short life spans relative to buildings, and therefore policy focuses on encouraging efficiency in new devices. In many cases, efficient devices pay for their increased *up-front cost* very quickly with energy savings; in the case

Figure 2: Seasonal Set Temperatures, U.S. and China




Data Sources: U.S. Energy Information Administration 2009; Building Energy Research Center at Tsinghua University 2010

of lighting, most efficient bulbs have high upfront costs and very low operating costs, making payback period a critical concern. *Information and awareness* barriers are significant here, as many cost-effective opportunities for savings exist. *Amenity loss* from differences in light bulb spectrum is a concern, and R&D on this issue may prove important for market acceptance of efficient lighting technologies.

Standards that set minimum energy efficiency performance levels for devices offered for sale are an important equipment policy. Like building codes, these standards leverage an easily available point of regulation: the sale of the appliance. Other key measures include labeling for outstanding efficiency and incentives to encourage the purchase of more efficient equipment. Public and cooperative procurement arrangements can help efficient appliances secure market share. Many countries have phased out inefficient lighting technologies by tightening efficiency standards. Building codes can also place requirements on insulation of pipes and water heaters and on lighting fixtures and control systems to encourage efficiency. Financing support to help offset first cost barriers is also potentially important.

## 2.4 Operations and Behaviors

The way buildings are used has a substantial impact on building energy consumption. Choices about temperature setting, frequency of appliance use, amount and type of ventilation, and the like can lead to very different energy usage in similar buildings with similar equipment. Particularly in larger buildings, automated controls on lighting and HVAC can deliver large savings.

Operations and behaviors vary greatly across the studied countries. For example, survey data show that Chinese residential buildings are kept colder in the winter and warmer in the summer than those in the U.S. (Figure 2). Equivalent data are unavailable for Germany, but one study (Thermco, 2009) indicates a preference for temperatures between 21.5° and 24°C in the summer and 22° and 25°C in the winter, suggesting that German preferences are similar to those in the U.S. (although in practice German residences use very little space cooling).

The ratio of energy pricing to per capita income helps explain national differences in energy consumption (see Figure 3). The United States has very low electricity prices relative to income; electricity prices relative to income have remained relatively low and roughly constant for the last decade. In China, the ratio of price to income has been falling steadily due to income growth. In Germany, growth in per capita GNP has largely offset the rise in retail electricity prices since 2000.[7] The price-to-per-capita-GNP ratio is relatively constant, but more than twice that of the U.S.

If these trends continue, Chinese households can be

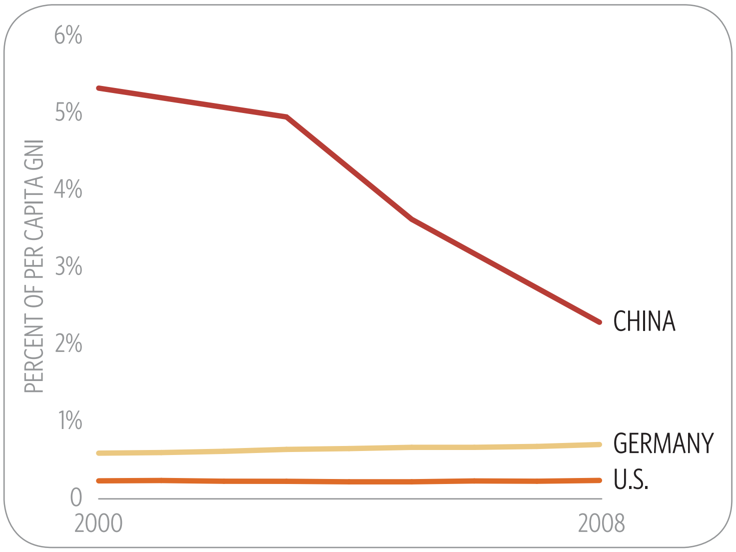
7 Prices and income in the U.S. also rose somewhat during this period, but less so than in Germany in both cases.

expected to consume more energy in decades to come as incomes rise.[8] Diffusion of central heating and air conditioning, mechanical ventilation, and narrower set temperature ranges could all increase energy consumption. However, policy encouraging certain building occupant behaviors could mitigate some of this effect. China is making efforts to avoid a shift to energy-intensive building use practices more typical of the developed world. For Chinese policymakers, the challenge is therefore to balance the development-driven increase in building services demand with the preservation of low-consumption behaviors where appropriate. The U.S. and Germany, on the other hand, made this transition several decades ago. Their challenge is to unwind current energy-intensive behaviors by encouraging energy conservation through energy *pricing*, public *awareness* campaigns, and promoting building designs that encourage more efficient energy use. Attracting *attention* to energy savings opportunities is also critical.

The potential for energy savings through operations is not well understood (recall Figure 1). We do not have enough information to develop estimates that are differentiated by country, even though we know the conditions and challenges are quite different. The impact of policy on operations and behaviors is also not well understood. Policies that we would expect to be important include information and awareness campaigns, incentives (most notably energy prices), dissemination of best practices (particularly in commercial buildings), energy audits, and energy feedback devices and tools.

As more thorough understanding of households' and businesses' motivations for pursuing energy improvements may improve our ability to encourage energy efficiency through policy measures. Reduction of energy use through behavior change is a quickly growing field of study, and many interventions are currently being piloted by governments, companies, and researchers.[9] For example, research shows that detailed billing programs that invoke social norms by provide rich comparative information have been successful in reducing residential energy use.[10] Also, an emerging finding from studies of home retrofitting decisions is that thermal comfort is often a greater motivation than energy savings[11]; this

Figure 3: Price of one megawatt hour of electricity as a fraction of per capita income




understanding may help retrofitting programs and contractors make effective pitches to homeowners.

8 It is generally accepted that higher income leads to increased energy consumption. See for example Ritchie et al. (1981).

9 See, for example, Abrahamse et al. (2005); Darby (2006).

10 See Allcott (2011); Allcott and Mullinaithan (2010).

11 See Fuller et al. (2010); Neuhoff et al. (2011).

# 3. Country Conditions, Policies, and Outlook

## 3.1 China

**Summary**

China's greatest potential for energy savings is in ensuring high energy efficiency standards for new construction (Figure 4). Much of Northern China relies on district heating, making it difficult to incentivize conservation using prices. Current lifestyle practices are not energy-intensive, but energy demand is growing rapidly; China seeks to balance low-energy traditions with improvements in comfort and services. Rapid building construction and growth in equipment use means that energy use will continue to increase, and also that potential savings from energy efficiency are large.

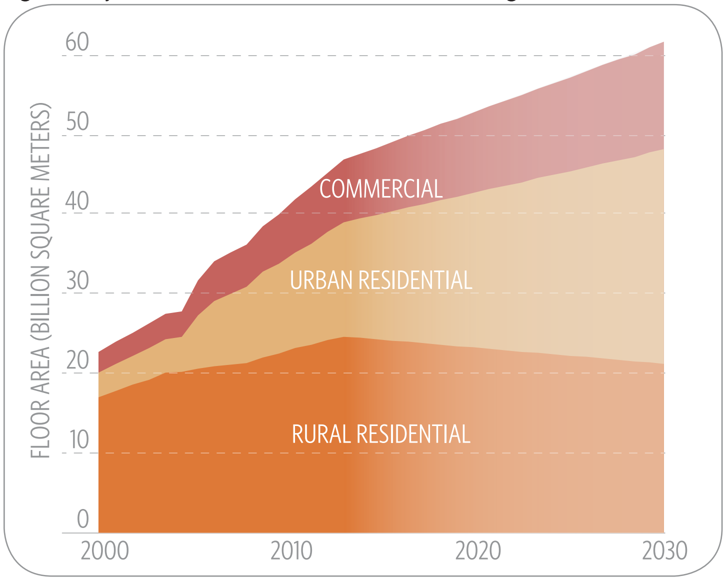
### 3.1.1 Building Stock

Due to rapid economic growth and urbanization, China's building stock is expanding rapidly. This growth has been particularly concentrated in urban areas, where both residential and commercial floor space more than doubled from 2000 to 2008. Most buildings in northern China are heated by district heating systems. Large commercial buildings tend to use mechanical whole-building HVAC (heating, ventilation, and air conditioning) systems and therefore consume much more energy per unit of floor area than other buildings in China. The floor space of these buildings more than tripled from 2000 to 2008.

### 3.1.2 Climate and Energy Economics

China's climate includes a wide spectrum of heat and cold, as well as varying humidity levels. As mentioned previously, Northern China is heated largely by district heating systems. Southern China, on the other hand, requires very little heat. Rural areas rely largely on traditional methods for climate control and cooking. Each of these distinct energy consumption profiles must be addressed by Chinese policymakers.

Figure 4: Dynamics of the floor area of Chinese building stock, 2000-2030




While Chinese energy prices are lower than in U.S. and Germany in absolute terms, they are much higher relative to per capita income (recall Figure 3). For this reason, energy prices may provide a stronger incentive for energy conservation than in the other two countries. However, energy prices as a fraction of per capita income are rapidly decreasing due to rapid economic growth, which may lead to reduced incentives for energy conservation.

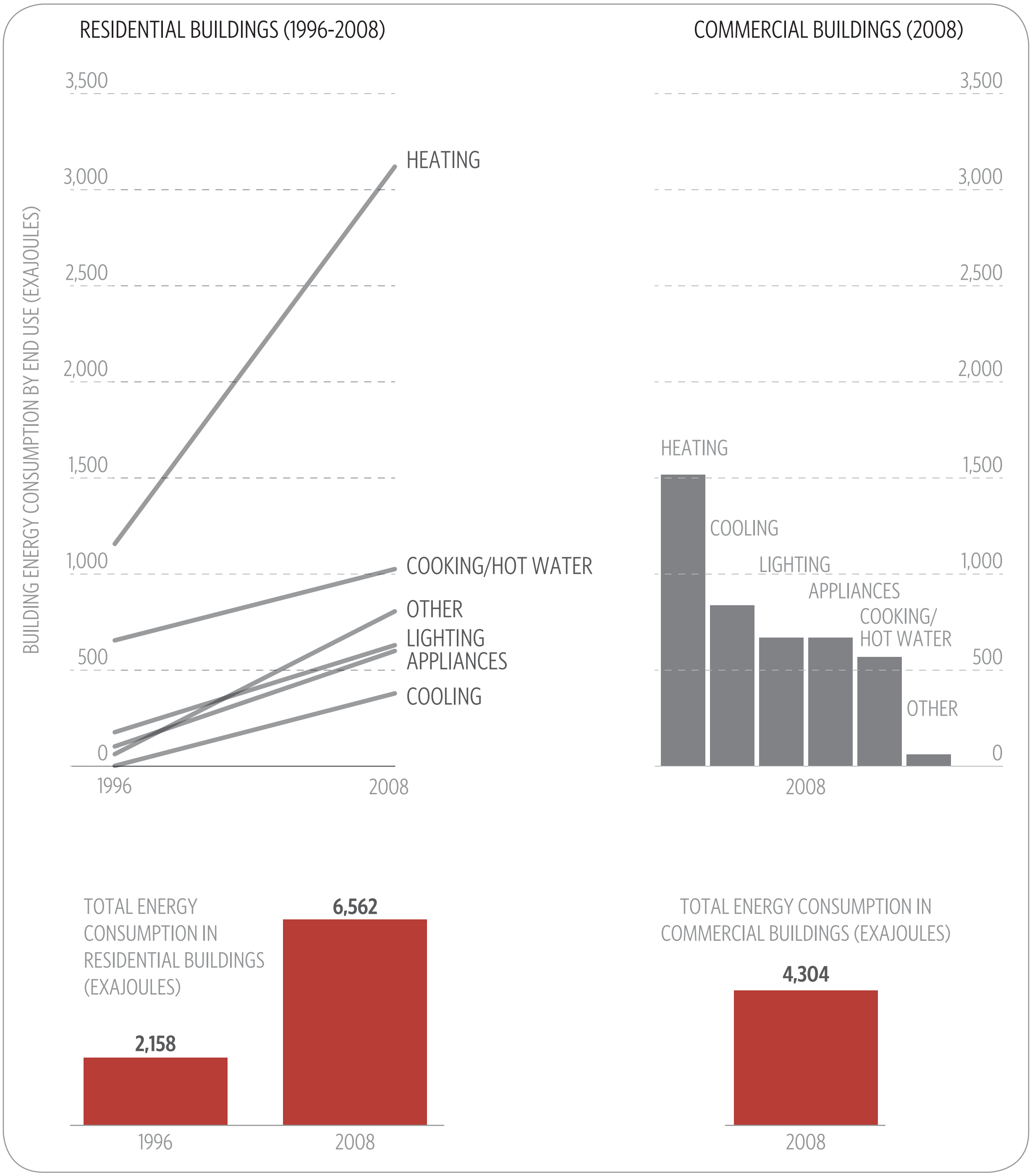
Energy pricing in district heating systems is a major challenge for China, as measurement of actual heat consumption in individual buildings is not currently possible. While heat metering is a commonly suggested solution, technical and economic factors currently preclude the widespread adoption of metering, forcing China to search for other pricing methods that can at least partially reflect actual energy consumption.

### 3.1.3 Energy and Emissions

As shown in Figure 5, residential urban energy consumption in China tripled between 1996 and 2008. Energy consumption in rural buildings (not included in the figure) has also increased significantly over this time, though not as rapidly as urban consumption. While these trends are likely to continue with further economic development, policy can play an important role in maximizing improvements in living standards while minimizing increases in energy consumption.

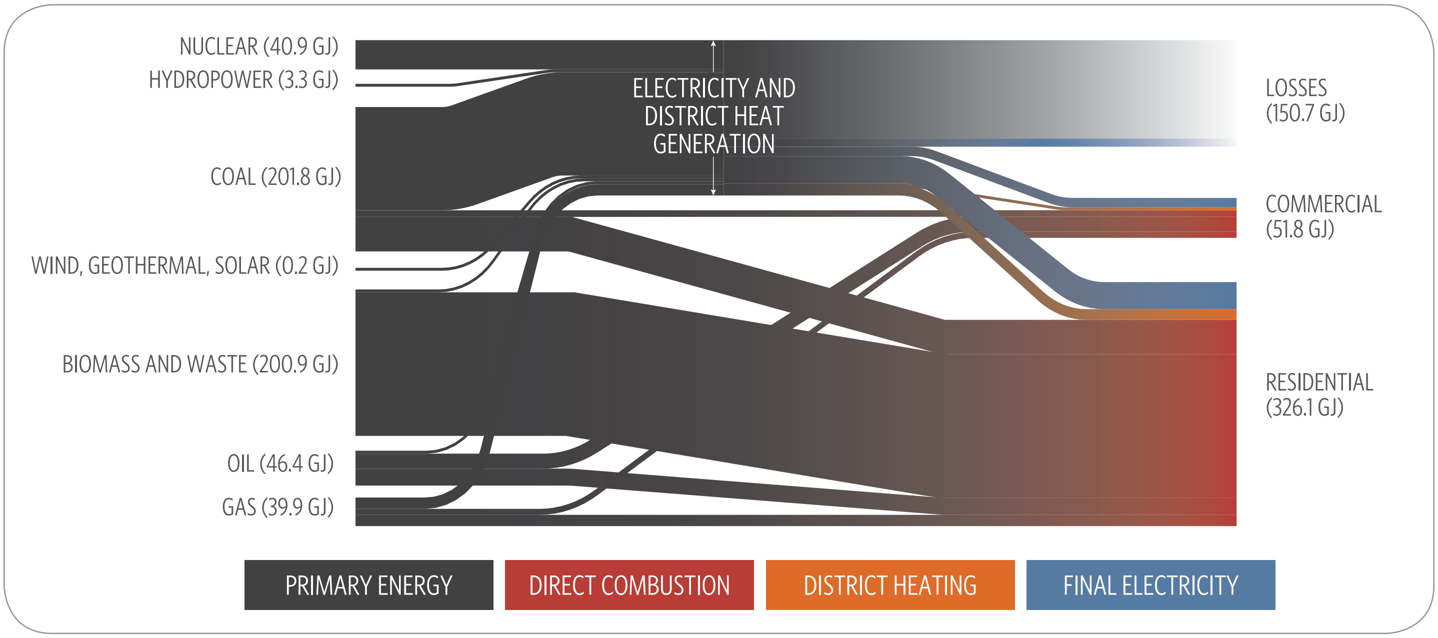
As shown in Figure 6, the residential sector in China currently consumes more than 1.5 times the energy

Figure 5: Chinese Urban Building Energy Consumption by End Use




Historic commercial consumption data by end use were unavailable. Sources: Building Energy Research Center of Tsinghua University (2011) and Zhang S Y, et al. (2010)

Figure 6: Energy and Emissions in China's Buildings Sector




This graphic, as well as its equivalents in the Germany and United States sections, are based on data from the International Energy Agency. In China's case, these data differ from those used elsewhere in this report in a number of important respects. First, urban are rural residential data are presented in a single category. The considerable biomass burned by rural residences in China accounts for the large flow of biomass and waste, and is not reflected in the other graphics in this report, which focus on urban data. Second, much of the heat generated in China comes from combined heat and power stations, leading to challenges in disaggregation. As a result, the heating flows in the diagram are probably underestimates of the actual energy consumed. Finally, the considerable amount of direct oil consumption in the commercial sector is probably due to transportation.

consumed by the commercial sector. Rural China generates substantial energy from the combustion of biomass (such as straw and fuelwood) in the residential sector, largely in rural areas.

### 3.1.4 Key Challenges

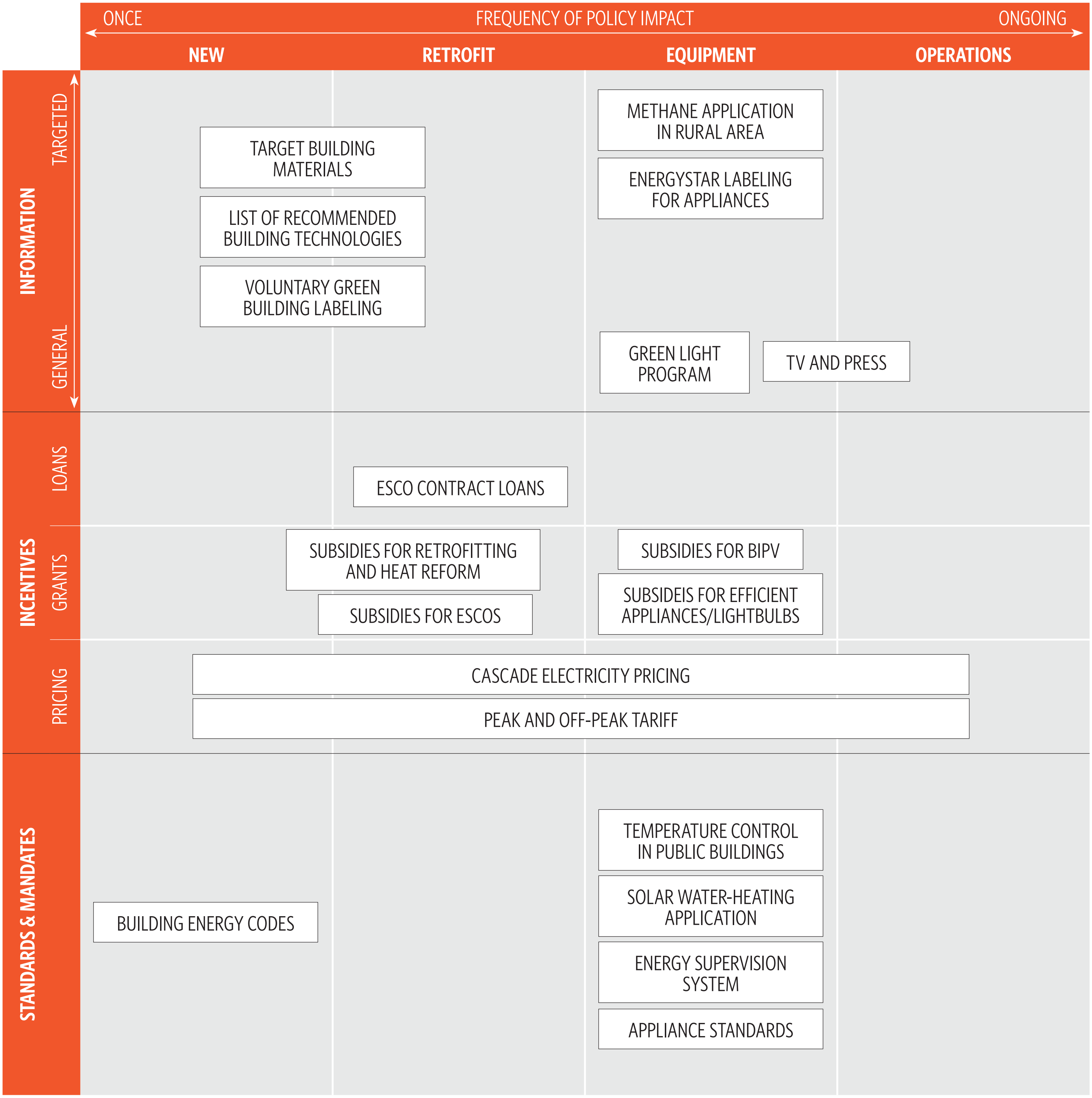
- Ensure that new buildings are built to high standards to lock in energy efficiency at a low cost. This is of paramount importance given the very high rate of new build in China.
- Improve the efficiency of new technologies in all sectors.
- Provide incentives for energy conservation in district heated buildings.
- Where appropriate, maintain traditional low-energy practices such as natural ventilation and part-space, part-time space heating and cooling as energy becomes more affordable.

### 3.1.5 Policies

China's energy efficiency policy is largely defined and supervised at the federal level, though implementation is often conducted by provinces and municipalities. The policy system consists of laws and regulations; major national plans (most notably the Five Year Plans); and policies (e.g., standards, administrative measures, economic incentives) based on these laws and plans. The Eleventh Five-Year Plan, covering 2006-2010, set a national goal of reducing energy intensity by 20% and motivated considerable strengthening of energy efficiency policy.

China has made an effort to increase compliance with energy standards to govern envelopes and HVAC systems in new buildings. Mandatory minimum standards for many appliances (including a growing number of electronic devices and lighting technologies) exist, and are also receiving heightened enforcement attention. China promotes a voluntary appliance energy efficiency labeling program similar to Energy Star in the United States, and mandates labeling adapted from the EU for a few appliances. Corporate income tax incentives promote the uptake of energy efficient technologies and measures. Administrative measures promote efficiency of equipment and energy management in large commercial and public buildings, and various levels of government provide financial support for actions required by these measures.

Figure 7: Key policy clusters for China's building energy efficiency



### 3.1.6 Current Policy Questions and Issues

- Given the extraordinary pace of new construction, how should building energy codes for new buildings be improved to achieve cost-effective energy efficiency, accounting for
  - » differences in building types, including traditional vs. modern buildings and large commercial vs. small commercial buildings?
  - » differences in climate?
  - » rapidly rising incomes and potential changes in building use practices?
- How can heating reform policy improve incentives for energy efficiency in district heated buildings where actual energy use per unit is not currently measured?
- How can policy best balance the development-driven increase in building services demand with the preservation of low-consumption behaviors (part-time, part-space conditioning, natural ventilation, building temperatures that are cool in winter and warm in summer)?
- How can energy intensity for large commercial buildings, which tend to use whole building HVAC systems, be reduced?
- How can appliance standards be best advanced to reach international best practice standards?

## 3.2 Germany

**Summary**

Germany's long-lived building stock and declining population imply that the efficiency of existing buildings is of central importance (recall Figure 1). As in other countries, additional reduction potential lies in improving equipment efficiency and promoting energy conservation behaviors. Germany's building energy use is already decreasing, and it has set significant sector-specific energy reduction targets.

### 3.2.1 Building stock

The German population has been declining since 2003, so construction rates are low. What little demand exists for new dwellings with different characteristics is driven by smaller sizes of households, aging population, and internal migration. The commercial and public floor area is expected to shrink as the working age share of the population declines. Figure 8 below illustrates expected development of the German buildings stock to 2030. Unlike the U.S., China, and most European countries, the majority of German residences are rented.

### 3.2.2 Climate and energy economics

Germany is located in a temperate region with cool and wet winters and warm summers. To address demand for thermal comfort, a significant share of building energy is spent on space heating (Figure 9). Due to the cool climate and cultural preference for natural ventilation, demand for mechanical space cooling is very low.

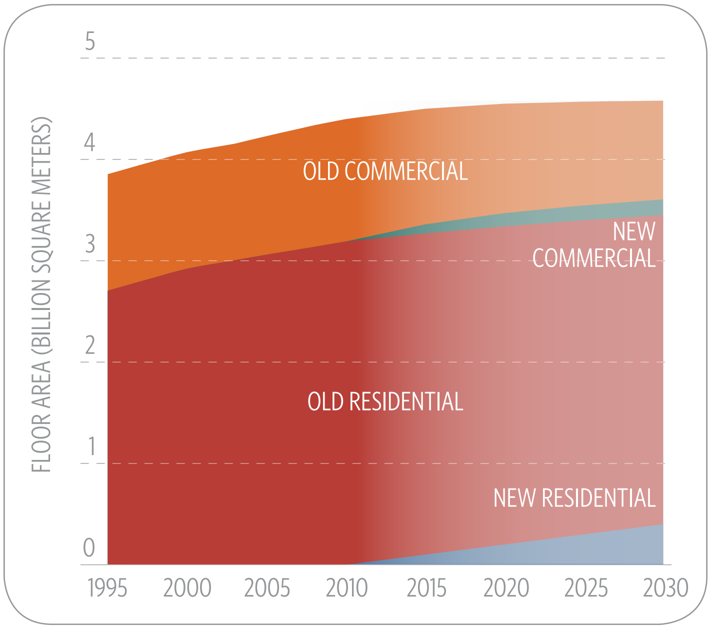
German energy prices are higher than those in the United States. Therefore, more energy efficiency measures are cost-effective in Germany than in the U.S.

### 3.2.3 Energy and Emissions

As Figure 9 shows, total energy use in Germany fell between 1996 and 2008. Primary energy consumption for space heating has decreased significantly; its share of primary energy has also fallen. This is due to several factors: demolition of stock in East Germany with poor thermal performance; retrofit of thermal envelopes and replacement of heating systems in existing buildings; demographic and behavioral changes (Schlomann et al. 2009); and growth in the use of electricity for amenities and other non-heating purposes. Energy efficiency of major electrical appliances and equipment has improved dramatically over this period and electricity prices have risen. However, increases in demand for electrical services have more than offset these savings, particularly in commercial buildings.

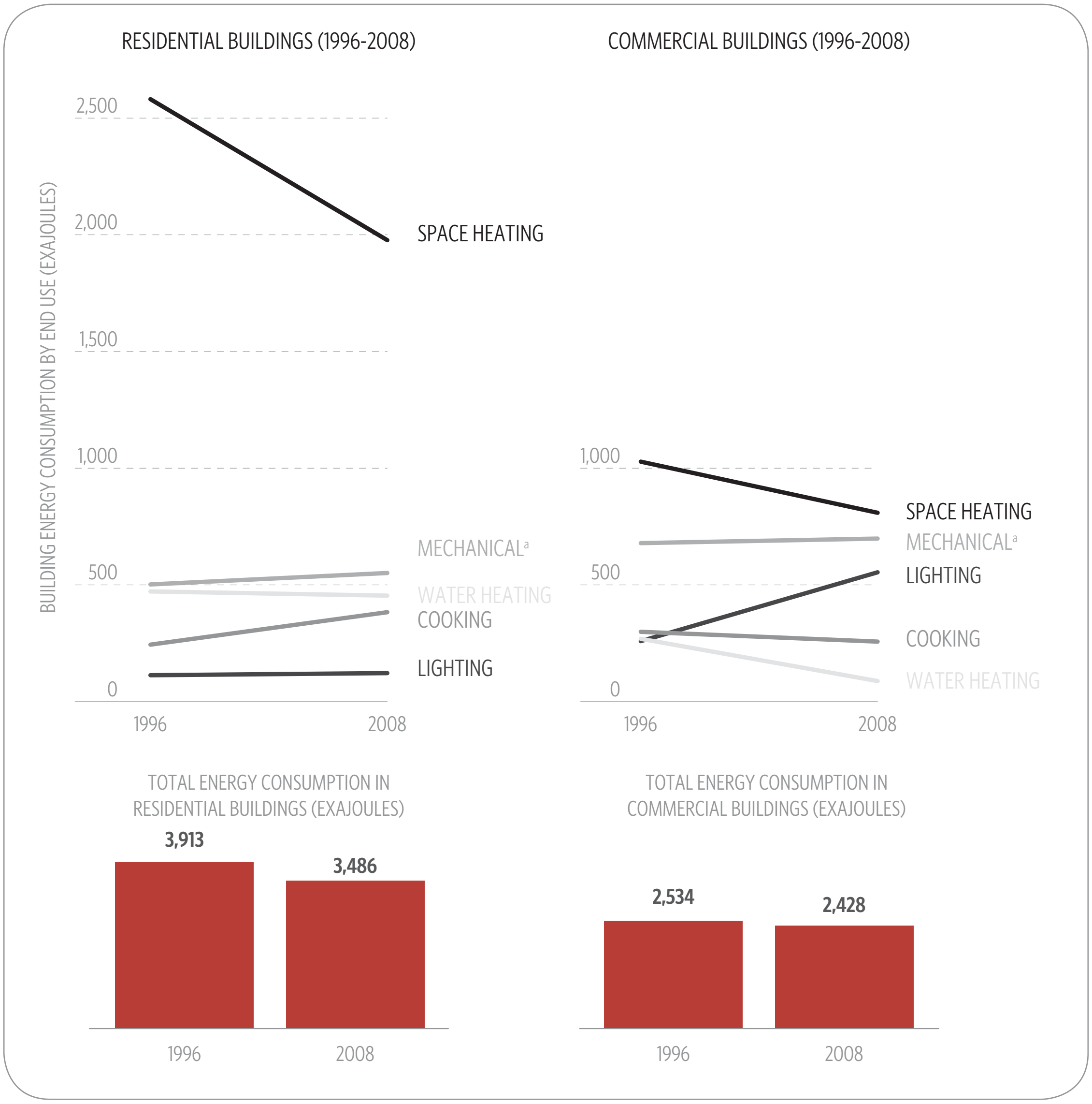
In Germany, the bulk of residential and about half of commercial energy consumption stems from direct combustion of oil and gas. Coal accounts for a smaller share of electric power generation than in either the U.S. or China. District heating is responsible for a small but noteworthy fraction of energy consumption in both the residential and commercial sectors. Indirect emissions from electricity generation constitute more than half of total emissions from building energy use.

Figure 8: Dynamics of the floor area of the German building stock, 2005 – 2030




Source: EWI, GWS, Prognos (2010)

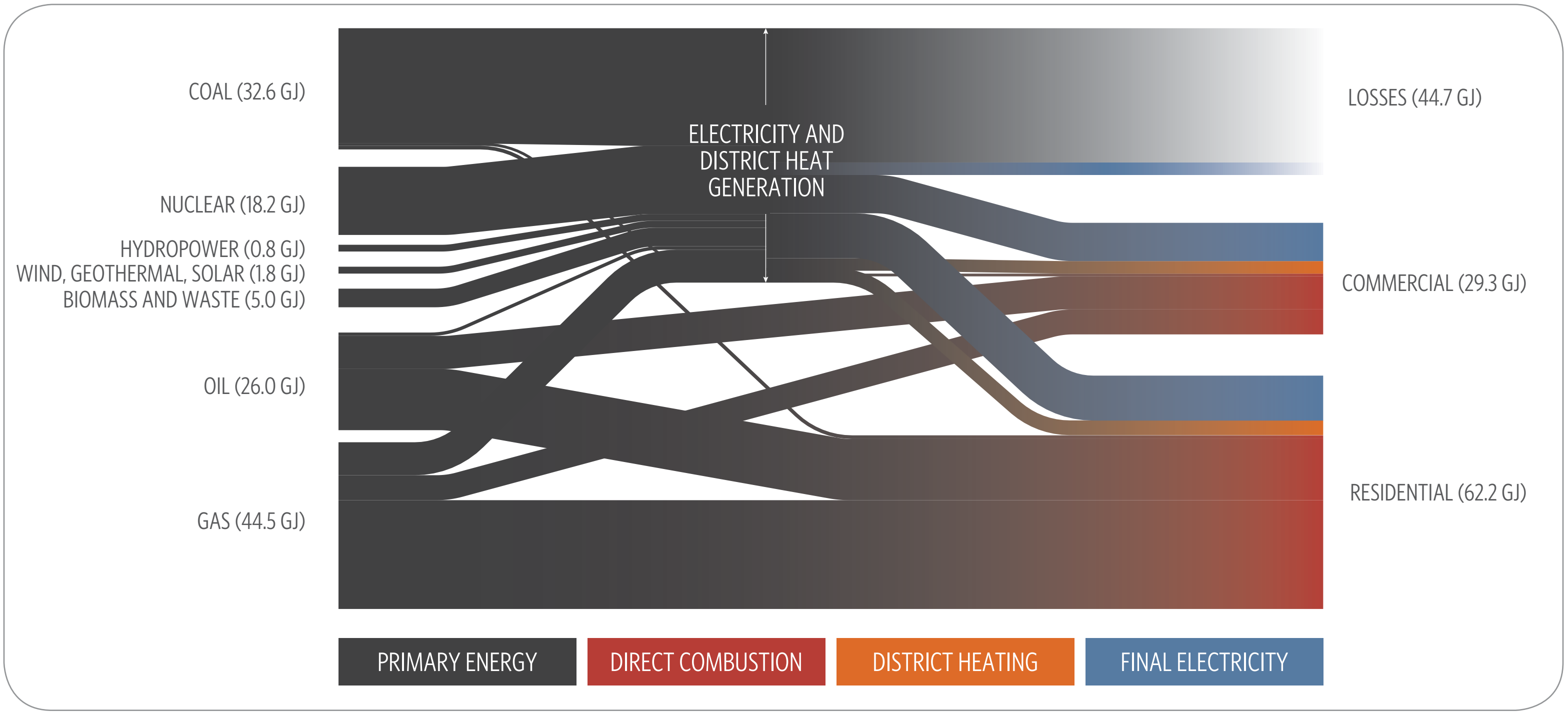
Figure 9: German Building Energy Consumption by End Use




Source: BMWi (2011)

[a] Space cooling, refrigeration, information and communication technologies, and other mechanical are reported in the “mechanical” category.

Figure 10: Energy and Emissions in the German Buildings Sector




### 3.2.4 Key Challenges

- Reducing thermal energy demand in existing buildings by increasing the scale and depth of building retrofit. Long building lifetimes make thermal efficiency retrofit of the existing buildings stock essential. At the current rate of retrofit[12], however, it would take more than a century to retrofit the entire stock. Further, few thermal retrofits are done in a comprehensive manner that achieves deep energy savings (Neuhoff et al., 2011).
- Constructing new buildings with thermal efficiency in mind. Despite the low construction rate, new construction gradually accumulates and will constitute a significant share of the building stock in the long term. Stronger standards for new buildings are desirable as soon as possible in order to avoid locking in more inefficient buildings.
- Reducing the rising demand for electrical services through both technological and non-technological (behavioral) approaches.
- Shifting the supply of the remaining energy demand to renewable energy.

12 The yearly thermal related retrofit rate of outer walls is 0.83%. Source: IWU/BEI (2010)

### 3.2.5 Policies

The German Energy Concept (BMWi & BMU, 2010) specifies national efficiency goals, including an 80% primary energy demand reduction goal by 2050 for the buildings sector. Mid-term goals include reducing heating demand by 20% by 2020; ensuring all new buildings are climate neutral by 2020; and increasing the thermal retrofit rate to 2%.

The Energy Efficient Renovation Program of the KfW Bank Group provides preferential loans and grants for single energy efficient components and for comprehensive retrofits. The Heating Cost Ordinance mandates metering and pricing of district heat according to actual consumption, and the Eco-tax taxes energy inputs, ensuring a fair pay-back period for retrofitting investments. The German Tenancy Law is under revision to allow landlords to capture benefits of investments currently lost due to split incentives.

A variety of information instruments have been designed to support participants of building retrofit process such as building owners, managers, residents/tenants, and construction industry professionals (Novikova et al., 2011a). Information tools are most important in early stages of the retrofit process. Energy audits – as desk advice provided by the German consumer association and on site advice provided by BAFA (Agency for Economy and Export Control) – have been shown to have large impact. (Duscha et al., 2008 and Duscha et al. 2005). Audits range from free advice from contractors under the programme "Retrofit the House and Profit" to comprehensive audits performed by an energy auditor supported by the Onsite Advice programme. Other information tools employed are Energy Performance Certificates and billing information.[13]

The key policy to reduce thermal energy demand reduction in new buildings is the energy efficiency building code introduced by the Energy Savings Ordinance. The code sets a standard for primary energy use and allows the building owner to determine a combination of insulation, heating, and ventilation systems, and potentially integrated renewable energy to achieve this objective. The trade-off between renewable heat and energy efficiency is limited, as the code also sets a requirement for maximum transmission heat losses. To help overcome high upfront costs, the Energy Efficient Construction Program of the KfW Bank Group provides preferential loans, including loans for new buildings that significantly surpass the building standard.

The country has recently introduced policies to promote integrated renewable energy in space heating. The Market Incentive Programme Renewable Energies (MAP) helps overcome up-front cost barriers with grants to support small scale installations of renewable energy heating systems. The Renewable Energies Heat Act sets a minimum standard for renewable heat production in new buildings.

The key financial, information, and regulatory policies of Germany towards energy efficient buildings stock are summarized in Figure 11.

Policy to reduce energy consumption from equipment and devices in buildings is mostly set at the EU level. This facilitates an EU-wide market in more efficient technologies. Key policies are the EU Labeling Directive,[14] which sets minimum energy efficiency standards and requires energy performance labeling for major appliances.[15]

### 3.2.6 Current Policy Questions and Issues

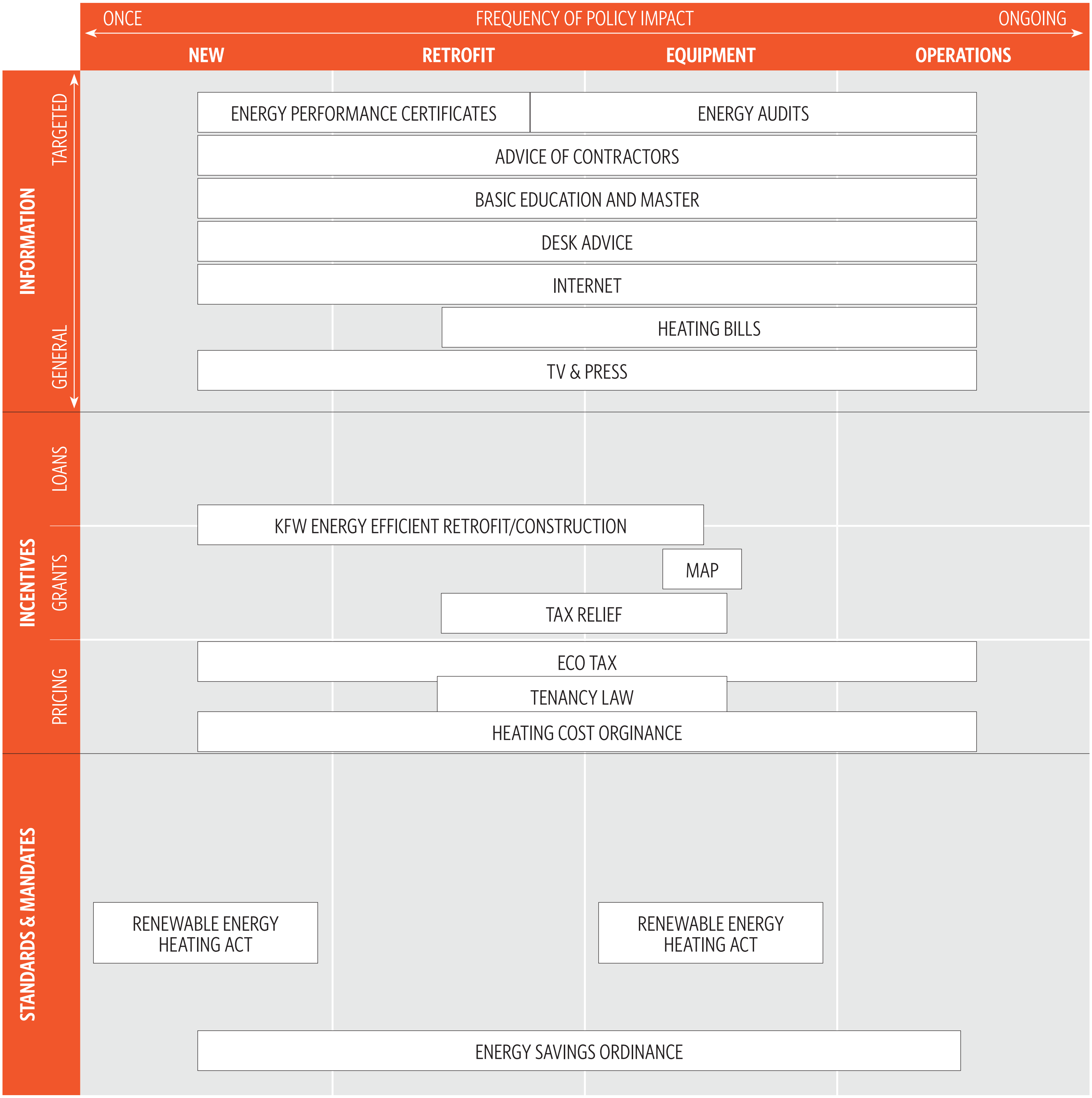
- How can policy best help achieve the goal of climate-neutral buildings by 2020 and, in particular, what is the role and trajectory of raising stringency of the building code?
- What additional and/or alternative approaches to finance building retrofit might best support and ease the burden on the existing grant and loan financial incentives provided by the state budget?
- How can policy overcome the split incentive barrier given the very high share of rented space?
- How can Germany further refine existing instruments in the policy mix? Can existing instruments be refocused or complemented with additional policy?
- What policy options exist in order to improve efficiency of electricity use?

13 See footnote 23 & Amecke (2011)

14 Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances and recast (in action at present): Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products. Official Journal of the European Union, L153 of 18.06.2010. p. p. 1-12.

15 Cold appliances, clothes washers and dryers, dishwashers, household lamps, water heaters, air-conditioners, and electric ovens.

Figure 11: German policies and programs supporting thermal energy demand reductions




Source: Amecke & Neuhoff (2011)

## 3.3 United States

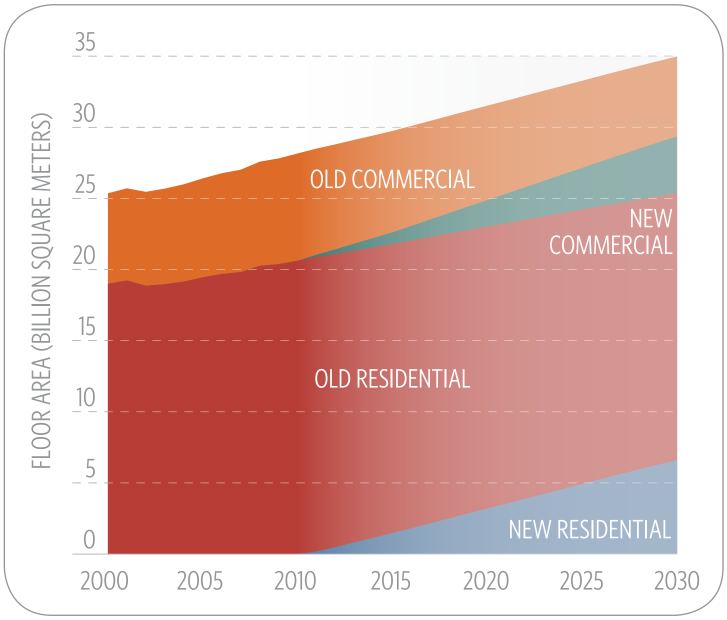
**Summary**

The United States faces the twin challenges of substantial new construction and a long-lived building stock. Historically low energy prices have contributed to building occupants having relatively energy intensive behaviors. Equipment consumes a large share of energy in the United States.

### 3.3.1 Building Stock

U.S. buildings are relatively long-lived. The typical lifetime of a U.S. building is 55-60 years. Residential units in the U.S. are large relative to China and Germany. Commercial floor space per capita is also high, and commercial buildings compose a large share of total U.S. buildings floor space relative to the other two countries. Both the residential and commercial building stock are growing, partially due to the fact that the U.S. population is growing more quickly than China's or Germany's. As a result, despite the recent crisis in the housing sector, significant new construction is expected in the medium and long term (see Figure 12).

Figure 12: Dynamics of floor area of United States building stock, 2000-2030




Data Source: Buildings Energy Data Book

### 3.3.2 Climate and Energy Economics

Climatic conditions vary considerably across the U.S., ranging from very cold to quite warm. Most areas of the country have substantial heating demand in the winter and substantial cooling demand in the summer. Energy prices in the U.S. are low, particularly relative to income levels. Economic incentives for energy efficiency are therefore relatively low absent policy intervention. Even so, studies consistently find cost-effective energy efficiency opportunities in the U.S.

### 3.3.3 Energy and Emissions

As shown in Figure 13, recent increases in energy consumption for space cooling, lighting, and residential electronics have been key factors in the increase in energy consumption since 1998. These three end uses are all powered by electricity in almost all cases.

Figure 14 shows energy and greenhouse gas emissions flows in the U.S. buildings sector. Relative to the other countries studied here, the U.S. derives a smaller share of its buildings energy from direct combustion of fossil fuels and biomass and a greater share from electricity. The U.S. uses very little district heat. These factors, combined with the current U.S. electricity generation mix, mean that indirect emissions from electricity generation account for the majority of building sector emissions—much more so than in the other countries studied.

### 3.3.4 Key Challenges

- With substantial new construction expected, efficiency of new build is important.
- Given the long-lived building stock, efficiency improvements through retrofit are also important.
- Policy must address growth in electricity consumption for electronics and other appliances given the emissions impact of electricity use.
- U.S. commercial buildings use very high amounts of energy per unit of floor space; this suggests substantial opportunities for energy savings.

### 3.3.5 Policies

The U.S. uses codes and standards primarily to govern the efficiency of new products, including buildings themselves (building energy codes) and appliances (appliance standards). Most appliance standards are adopted at

Figure 13: U.S. Energy Consumption by End Use

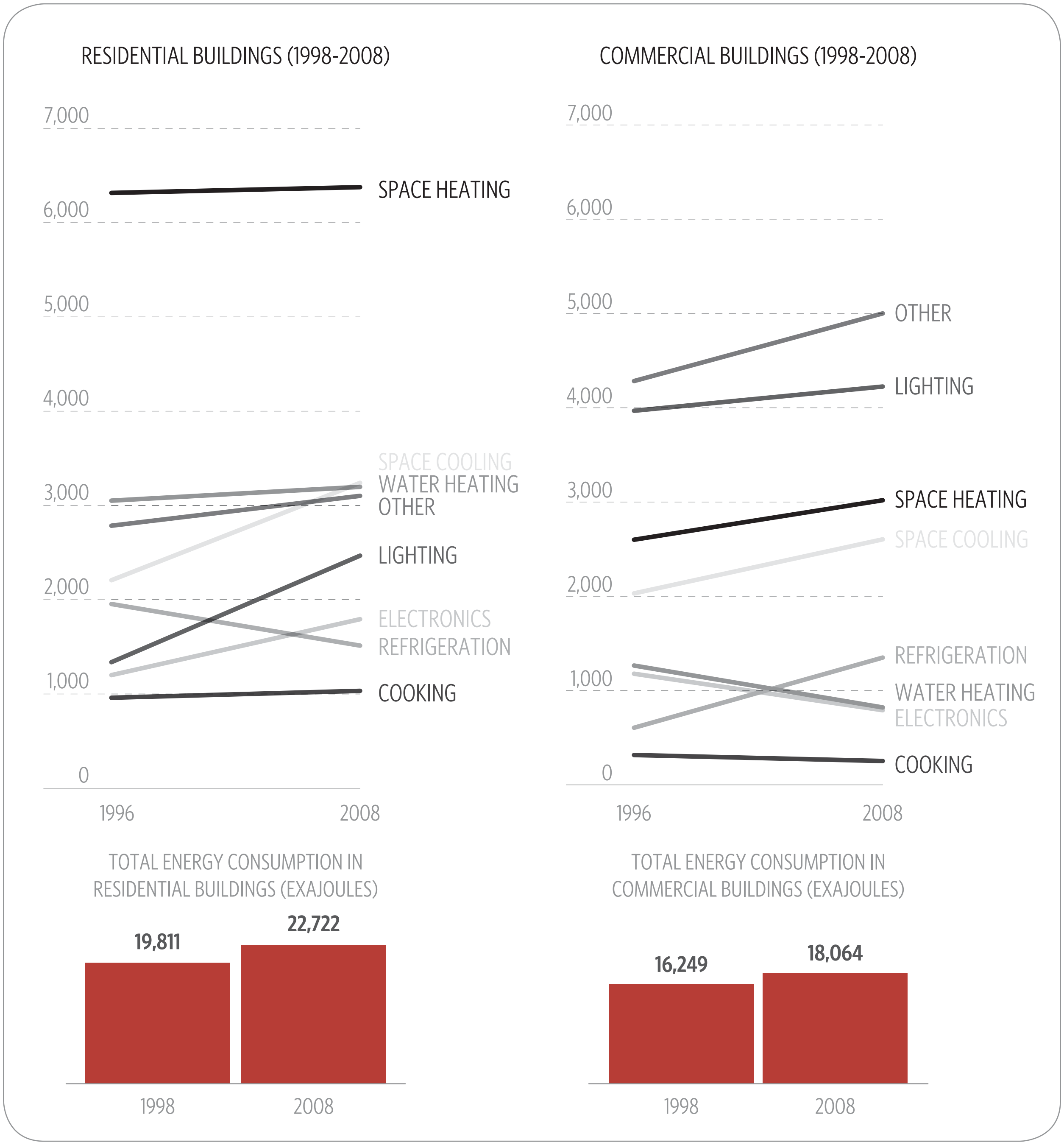
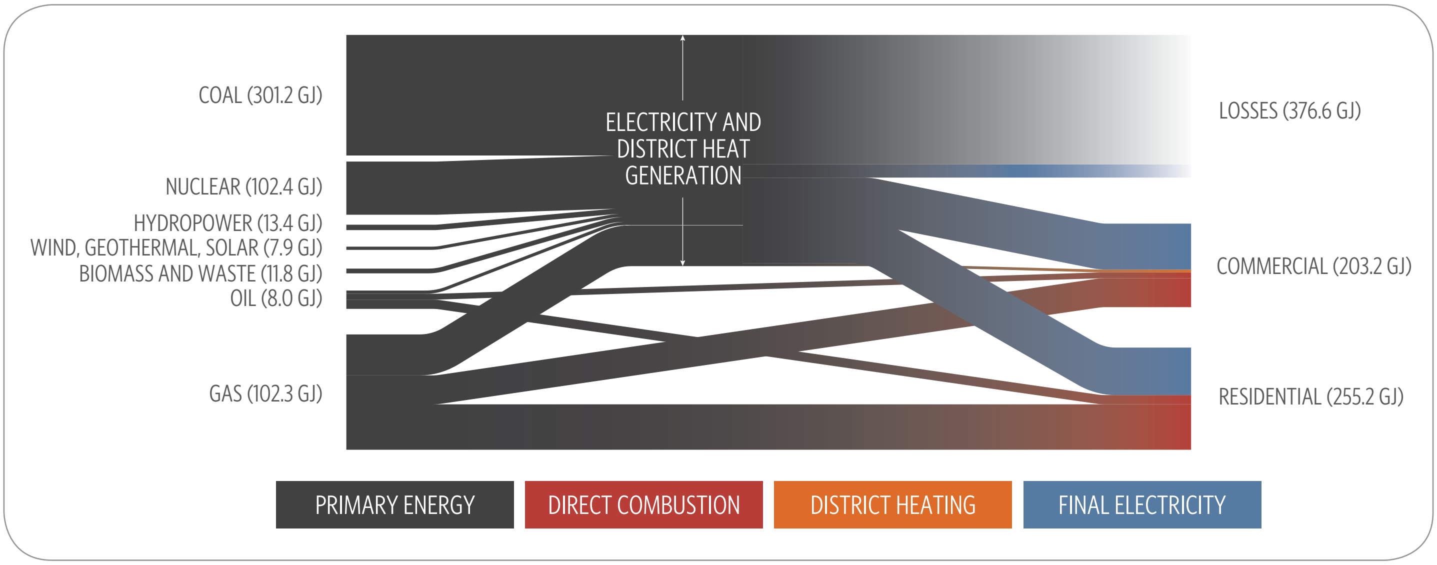


Figure 14: Energy and Emissions in the U.S. Buildings Sector




Source: IEA 2008.

the federal level, while building codes are adopted by individual states. This arrangement parallels the EU case, where equipment is regulated at a common market level while construction is regulated at a member state and local level. Beyond this point, policy focuses on providing incentives, information, and training to encourage individuals and firms to overcome barriers and make efficient choices.

Different states have adopted different building energy codes. These codes primarily regulate building envelopes, though many of them bear on the efficiency of heating, cooling, water heating, and lighting devices as well. Most if not all state codes also regulate significant building renovations. A handful of states have not adopted building energy codes, while some local governments adopt codes that are more stringent than the code in their state. Codes are enforced at the local level. Some state and local governments offer support for "stretch" codes, such as green building codes or independent building performance certifications, that go beyond the required codes.

Appliance standards govern the energy efficiency of heating, cooling, and water heating equipment, major appliances, lamps and lighting systems, and other miscellaneous equipment. A few states, most notably California, regulate additional devices not currently covered by federal standards.

Federal policy requires energy performance labeling of appliances and other energy-using devices, and the voluntary but widely-adopted EnergyStar label certifies high-performing options. Use of building energy labeling schemes is growing—the Home Energy Rating System (HERS) score is required to qualify for an energy efficient mortgage or the EnergyStar Homes certification, and California is piloting its own label--but such labels are not currently required for all buildings. Information, awareness, and outreach programs to promote energy efficiency are common, and are most often offered by utilities through DSM programs or through state programs funded by federal grants. Some utilities are adopting information-delivery formats (through billing or associated reports) that attempt to leverage behavioral science findings to make consumers' energy usage more salient and actionable. Other state programs, often with federal grant support, provide contractor education and training.

Many incentives (including rebates and preferential loans for purchase of efficient measures) are offered by regulated utilities through required demand-side management (DSM) programs supervised by state public utility commissions. Tax incentives (including income, property, and sales tax reductions) are also offered at the federal, state, and sometimes local levels. Most incentives (whether DSM or tax-related) relate to uptake of individual efficiency measures or equipment, though some are tied to attainment of a green building standard. Tracking and harmonizing this profusion of individual incentive measures is a challenge. Lack of awareness and search and transaction costs brought on by this somewhat disorganized landscape may limit the effectiveness of individual measures. In addition, potential policy redundancy raises the possibility of "double dipping" and as a result diminished cost-effectiveness.

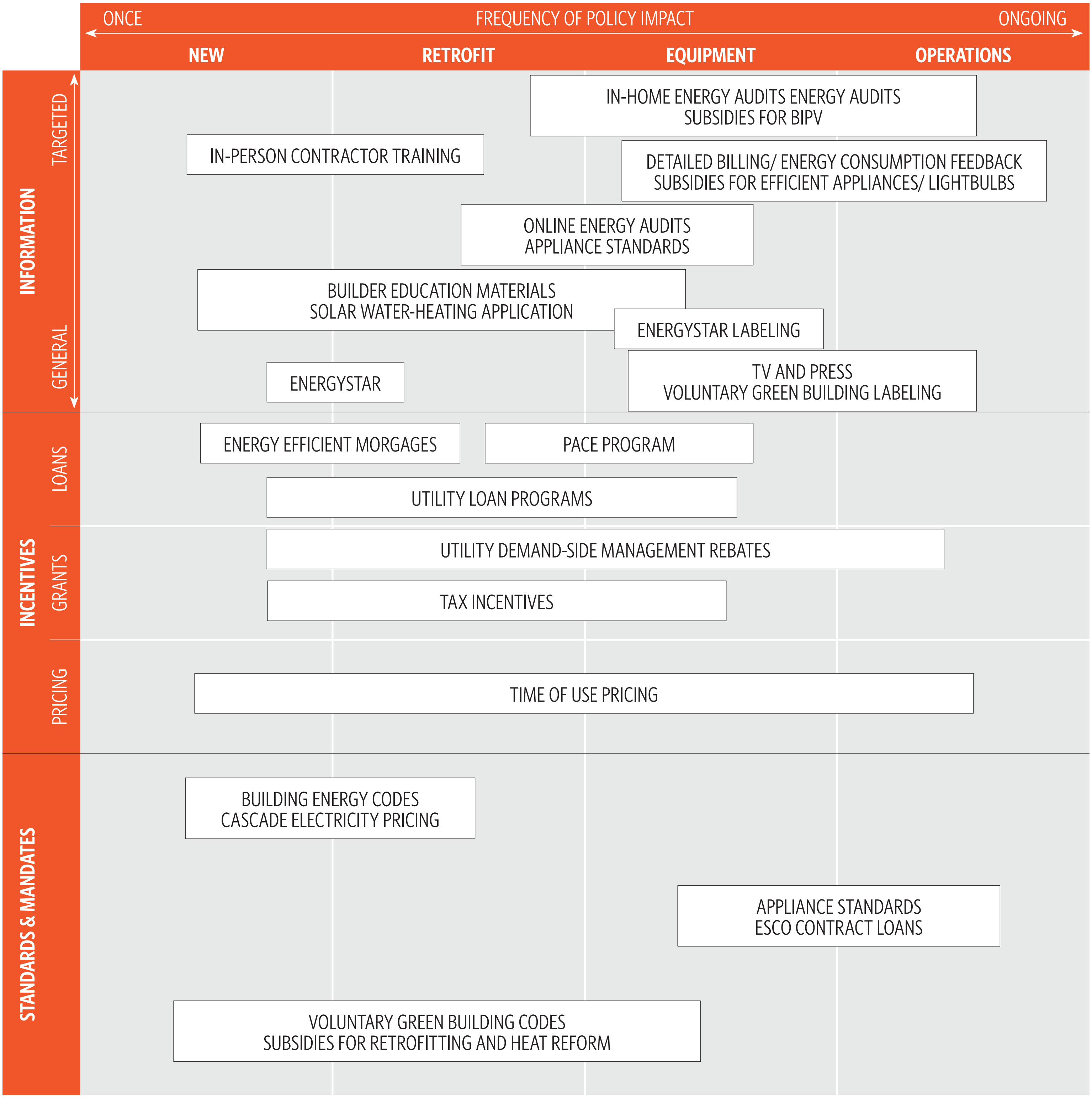
The U.S. has also experimented with policies to aid in financing of energy efficiency measures, including energy efficient mortgages (which roll costs of efficiency measures into a new home mortgage or refinance), utility-sponsored on-bill financing, and property-assessed clean energy (PACE, which finances efficiency measures through a new lien that remains with the building, similar to a property tax increase). For various reasons, uptake of these financing measures has been limited to date.

The U.S. devotes significant resources to research and development on efficient technologies and control systems for buildings. In 2011 the Obama administration prioritized commercial buildings and pledged to make them 20% more efficient by 2020, though the precise definition of this target is unclear. An executive order states a goal to design all new federal buildings to achieve net zero energy starting in 2020. Other goals are to reduce energy use in residential homes by 30-50% relative to 2009 efficiencies for new build and relative to current energy use levels for existing build; no target dates are specified for these goals. These targets are specified for a typical building, and as such, they relate to the achievable performance of a correctly-designed building more so than to the performance of the sector taken as a whole. The U.S. has not established federal sector-wide targets for energy use, emissions, or floor space control.

### 3.3.6 Current Policy Questions and Issues

- What policies can best overcome barriers to participation in retrofitting activities?
- How can policy best improve energy efficiency in new buildings, particularly moving towards zero net energy and with a particular focus on R&D/commercialization of new technologies?
- How should policy adjust to address the rising use of electrical devices? What types of tools (standards, pricing, informational campaigns) will be most effective?
- How can the U.S. improve coordination between local, utility, state, and federal buildings policy, and between the many different instruments employed?
- How can policy support the diffusion of best practices to achieve energy savings, particularly for commercial buildings?

Figure 15: US policies and programs supporting thermal energy demand reductions



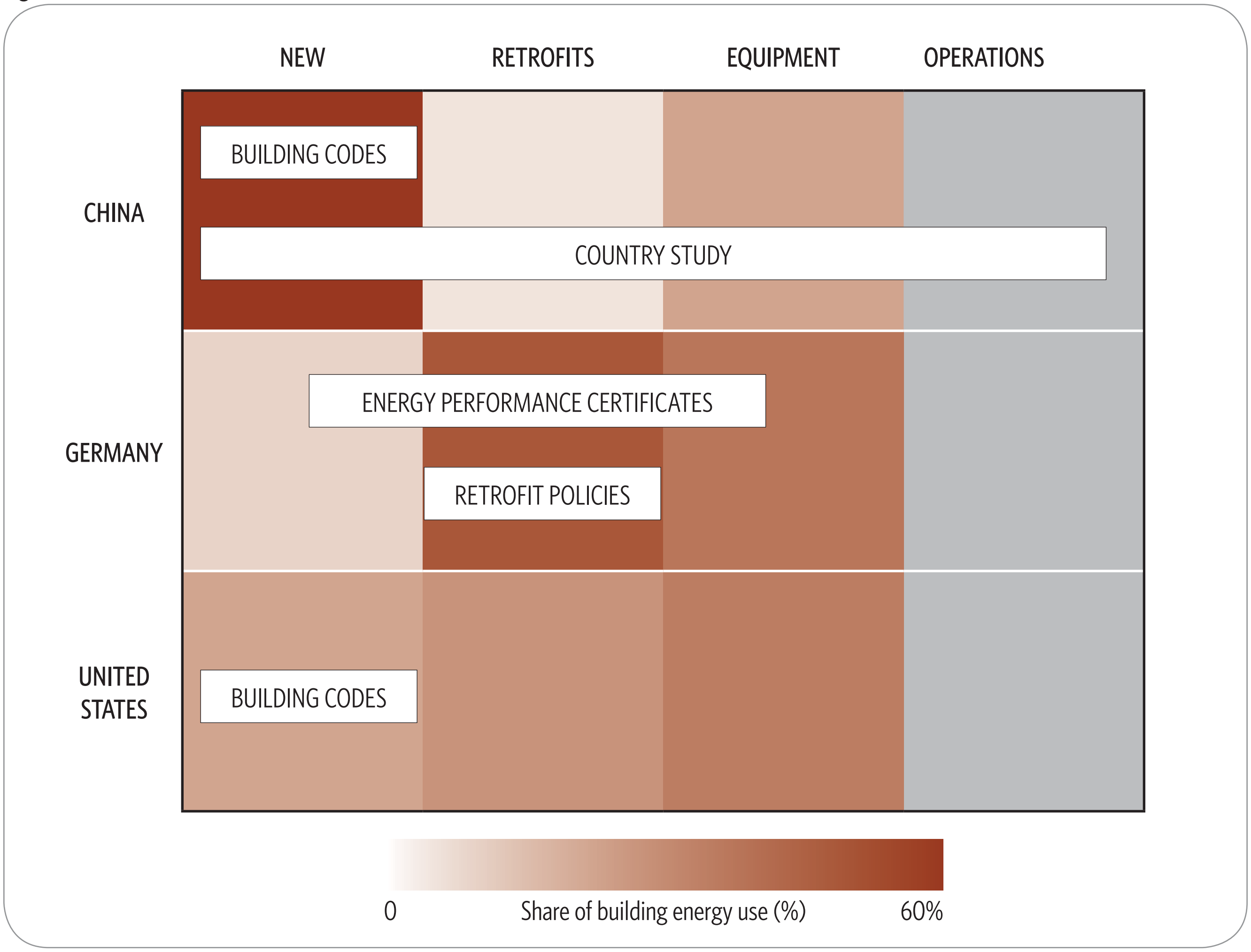
# 4. CPI Research on Buildings Energy Efficiency

CPI's buildings energy efficiency research explores the performance of building energy efficiency policies within and across our countries of focus. Our topics of analysis flow from the key buildings sector challenges and policy questions identified in Section 3. CPI research assesses the effectiveness of the studied policies and derives insights that help policymakers design and implement more effective policy moving forward. Figure 16 below locates current CPI research on the categories of energy consumption discussed in Section 2. Completed projects can be found at www.climatepolicyinitiative.org/publications.

Due to the importance of new buildings in China, work led by CPI Beijing examines the relative stringency of building energy codes in these three countries, and critically evaluates the requirements of the Chinese codes and their relationship to traditional building practices and lifestyles in China. CPI Beijing is currently conducting research on policy to encourage energy efficiency in district-heated buildings in northern China, an issue with large efficiency improvement potential. Finally, as part of its China Country Study (CPI, 2011), CPI Beijing estimates the energy-saving impact of each key Chinese buildings energy efficiency policy in the Eleventh Five Year Plan (covering the period 2006-2010).

Given the continuing importance of new construction in the U.S., CPI San Francisco analyzed the impact of residential building energy codes on energy use and emissions in the U.S. (Deason & Hobbs, 2011). Our results suggest that codes have had a modest impact on energy use, in line with (and perhaps slightly greater than) engineering model projections. The codes have

Figure 16: Current and former areas of CPI research.



also encouraged modest substitution towards natural gas as a heating and water heating fuel in new homes. Since natural gas is relatively low emissions compared to other fuel sources, this substitution means that building energy codes deliver slightly greater reductions in emissions than in energy use.

Due to the buildings sector energy reduction objectives in the German Energy Concept and the relatively high priority of thermal efficiency upgrades of the existing building stock in Germany, CPI Berlin has focused on analysis of tools which encourage more and deeper building renovation in six recent reports and briefs. Even if Germany achieves the target 2% thermal retrofit per year, each building will likely only be retrofitted once between now and 2050. Therefore, in order to reach the overall 80% savings target, each building retrofit has to be deep. By compiling and standardizing existing studies, CPI Berlin found that deep thermal retrofit is cost-effective if included in a general retrofit project (Neuhoff et al., 2011a). Due to numerous barriers, financial support is necessary; its careful design can contribute to deep retrofits (Neuhoff et al., 2011b). Non-financial support to buildings efficiency retrofits is equally important. When house owners are not actively searching for building retrofit information, they need to be directly addressed (Novikova et al., 2011a); a CPI survey found that some policies are more effective for generating interest in thermal efficiency retrofits while other policies are more effective for assisting already interested house owners in selecting retrofit options (Novikova et al., 2011b). CPI's survey found that contractors are regarded as an important information source for the implementation of retrofit measures by 61% of households. Therefore, policies and programs to improve the competence of contractors and their accessibility for households are crucial for reaching the target.

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# 6. Appendix

To produce Figure 1, we first split current energy use in each country into space heating, cooling, and ventilation (Category A) and water heating, appliances, electronics, and lighting (Category B). The energy use attributed to the new buildings category is the Category A share multiplied by the share of current floor space that was built in the last ten years, on the theory that the past ten years of construction activity are a reasonable proxy for activity in the immediate future. Energy use in the retrofit category is the Category A share multiplied by the share of floor space built before 1980, which we take as a rough indication of the need for retrofit. Energy use for equipment is calculated by assuming that 80% of non-lighting Category B energy and 90% of lighting energy will be due for replacement in the next ten years as an estimate of how much of this energy can be reached through equipment replacement in the near future. As noted in the text, we do not perform an explicit calculation for the operations values.

These calculations involve a number of simplifications and assumptions. For example, part of energy use for Category A is more logically associated with equipment concerns (furnaces, air conditioners, etc.), while water heating energy consumption, assigned to Category B, is also affected by choices that arise in new construction and retrofitting. Some buildings built before 1980 have already been retrofit; however, some buildings built more recently than 1980 already require retrofit, and we simply assume that these two effects cancel each other out. Also, there is no common determination for which buildings require retrofit. We are not asserting that buildings built after 1980 will not require retrofitting in the future; for example, Germany's 2050 energy savings target is stringent enough that almost all current buildings will need to be retrofit by then to achieve it. We simply use a common definition in all three countries as of today to arrive at a comparable value.