

# How the world should invest in **energy efficiency**

*A program that targets cost-effective opportunities in energy productivity could halve the growth in energy demand, cut emissions of greenhouse gases, and generate attractive returns.*

**Diana Farrell and Jaana K. Remes**

**Article  
at a  
glance**

Boosting energy efficiency will help stretch energy resources and slow down the increase in carbon emissions. It will also create opportunities for businesses and consumers to invest \$170 billion a year from now until 2020, at a 17 percent average internal rate of return.

However, a wide range of information gaps, market failures, and policy imperfections could slow the pace of investment.

Public- and private-sector leaders can encourage higher energy productivity by setting efficiency standards for appliances and equipment, financing energy efficiency upgrades, raising corporate standards for energy efficiency, and collaborating with energy intermediaries.



One hundred and seventy billion dollars a year invested in efforts to boost energy efficiency from now until 2020 could halve the projected growth in global energy demand. What's more, these investments could also deliver up to half of the emission abatement required to cap the long-term concentration of atmospheric greenhouse gases at 450 parts per million, the level experts suggest will be needed to prevent the global mean temperature from rising by more than two degrees centigrade.

The key to achieving these results will be carefully targeting cost-effective opportunities to boost energy productivity—the level of output achieved from the energy consumed. In previously published work, the McKinsey Global Institute (MGI) and McKinsey's global energy and materials practice have described the possibilities for improving the efficiency of lighting, cooling, and heating systems, and of other technologies like vehicles and factory machinery.<sup>1</sup> Concerted action could reduce global energy consumption in 2020 by 135 quadrillion British thermal units (QBTU) a year, the equivalent of roughly 64 million barrels of petroleum a day.

We arrived at the figure of \$170 billion by estimating the market price of all the large and small investments needed to realize the energy productivity opportunities identified in our previous work.<sup>2</sup> The average internal rate of return (IRR) of these investments would be 17 percent, and each of them would generate an IRR of at least 10 percent.<sup>3</sup> The total annual energy savings would come to roughly \$900 billion by 2020.<sup>4</sup> All of the investments, representing just 0.4 percent of current global GDP a year, involve existing technologies—and none require compromising the consumer's comfort or convenience.

Nevertheless, real obstacles stand in the way of these investments and the energy savings they could generate. One is a set of market and policy imperfections. To name just a few, consumers don't have enough information about energy-efficient options, fuel subsidies discourage efficient energy use, and landlords and tenants alike resist energy-efficient investments they believe would mostly benefit the other party. A second challenge is that two-thirds of the investment opportunity lies in developing countries, where consumers and businesses face a variety of competing demands for their scarce investment dollars. China alone would need to account for 16 percent of the annual investment that our analysis suggests is needed.

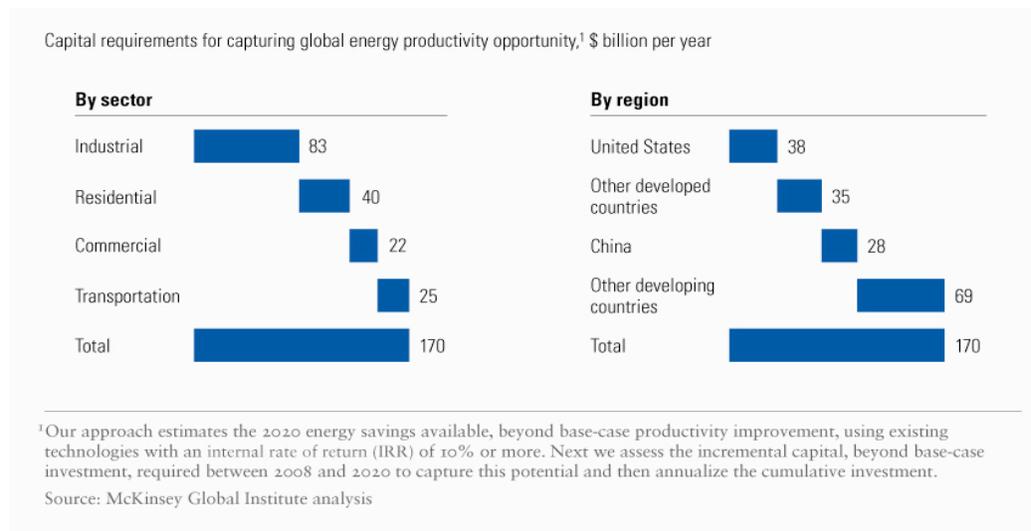
The public and private sectors can do much to overcome these obstacles and facilitate the necessary investments, however. Policy priorities include setting energy efficiency standards for appliances and equipment, as well as removing subsidies and tax breaks for energy consumption. Businesses can raise their efficiency standards and innovate to overcome the information and agency barriers that keep both them and consumers from making economically and environmentally sound choices. In this way, the leaders will capture the significant financial benefits of efficiency and perhaps even create entirely new markets.

## How to invest \$170 billion a year

The energy productivity investment opportunity varies dramatically by sector and region. Industrial sectors around the world could remuneratively deploy just under half of the \$170 billion a year, residential sectors about a quarter. The commercial and transportation sectors would absorb the remaining investment, in roughly equal proportions (Exhibit 1). About two-thirds of the \$170 billion would go to developing economies, where the cost of abating a unit of energy demand is about 35 percent lower than it is in the developed world, because these economies are growing rapidly, consume energy in a relatively inefficient way, and have large supplies of cheap labor.<sup>5</sup>

### EXHIBIT 1

#### The \$170 billion opportunity



#### The industrial sector

By 2020, \$83 billion a year, properly invested, would allow the world's industrial sectors to abate 53 QBTU of energy demand, equivalent to about 25 million barrels of petroleum a day—40 percent of the world's energy productivity opportunity. The money would boost energy productivity in hundreds of small ways, including cross-sector moves, such as generating heat and power at the same time and increasing the efficiency of motor-driven systems. Sector-specific opportunities, such as enhanced liquid-membrane separation in chemicals, abound as well.

In emerging markets, where much of the industrial investment must take place, the economics of raising energy productivity are particularly attractive. In China, for instance, the capital required to abate each QBTU of industrial energy in 2020 would be on average 33 percent less than it is in the United States. The capital gap is

even bigger—more than 50 percent—in some sectors, such as steel and pulp and paper. China and other developing countries have such outsize potential because energy productivity can be increased there by replacing low-efficiency legacy assets and because lower labor costs reduce the capital requirements (and therefore raise the IRRs) for many industrial initiatives.

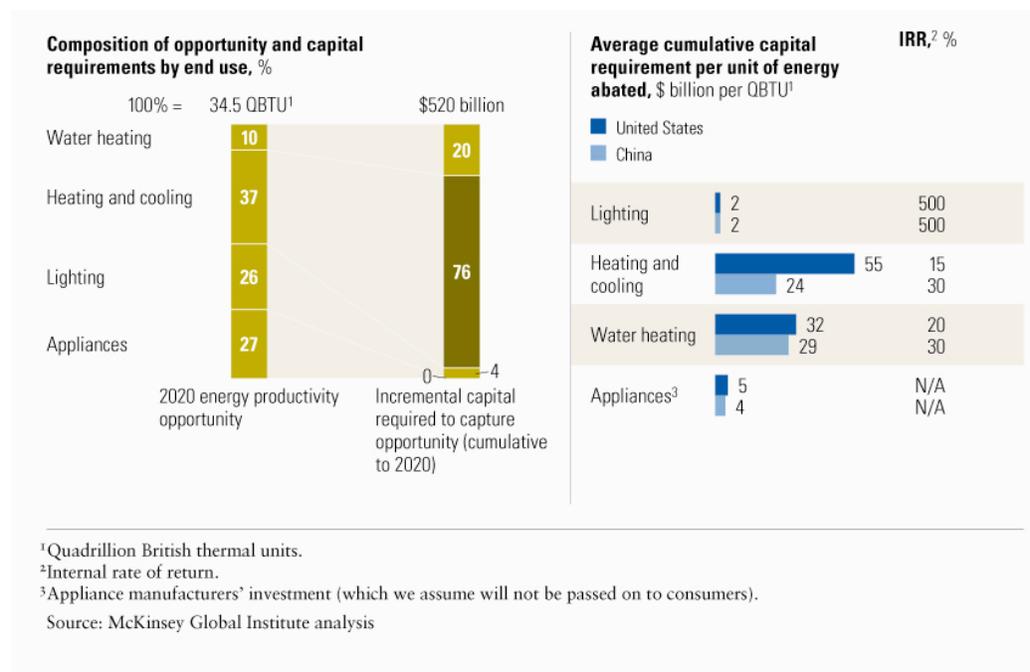
Significant numbers of energy productivity opportunities in industrial sectors around the world have an IRR of around 10 percent and are therefore sensitive to hurdle rates, which investors require for projects to proceed. Doubling the hurdle rate, to 20 percent, reduces the industrial sector’s energy productivity opportunity by 14 percent (to 46 QBTU in 2020, from 53) and the cumulative capital requirements by 27 percent (to roughly \$61 billion annually, from \$83 billion). Conversely, reducing the hurdle rate to zero percent expands the energy productivity opportunity by 14 percent (to 60 QBTU, from 53) and capital requirements by 45 percent (to \$120 billion annually, from \$83 billion).

### The residential sector

Almost 80 percent of the residential sector’s \$40 billion a year of investments would be devoted to just one opportunity: installing more efficient heating and cooling systems in new and existing homes (Exhibit 2). Yet these improvements would capture only 37 percent of the abatement opportunity in residential energy demand, which adds up to 35 QBTU, or 26 percent of the potential across all sectors.

#### EXHIBIT 2

#### The residential opportunity



The remaining 63 percent of the residential sector's abatement potential will require little more than 20 percent of the sector's \$40 billion a year in capital. One major low-capital opportunity is more efficient lighting—expanding the use of compact fluorescent lightbulbs (CFLs) and light-emitting diodes (LEDs)—which will account for only about 4 percent of the sector's capital requirements but for 26 percent of the opportunity to abate residential energy demand in 2020.

Another low-capital opportunity, representing 27 percent of the residential energy productivity opportunity, lies in boosting the efficiency of appliances. The capital cost to end users could be close to zero. In the past, the consumer price of more efficient appliances declined after new standards expanded production volumes and reduced unit production costs. Our research suggests that a major shift to more efficient appliances in the future would again create large-scale economies that would ensure limited—or even no—additional cost to end users. The remaining investment and abatement potential will be captured through more efficient water heating and some smaller opportunities.

China and the United States represent more than 40 percent of the global energy-abatement opportunity in the residential sector; by 2020, China could reduce the sector's demand by 7.3 QBTU, the United States by 7.1. The cost to abate each QBTU of growth in the sector's demand for energy is nearly 30 and 23 percent higher in Europe and the United States, respectively, than in China and other developing regions. An important reason is the lower cost of installing labor-intensive building-shell features such as insulation.

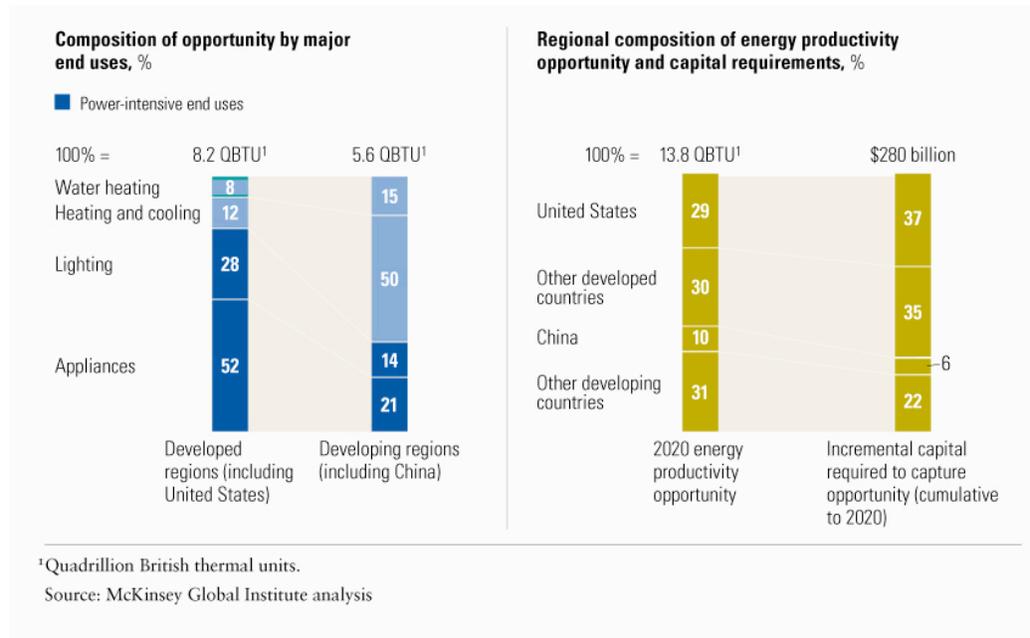
#### The commercial sector

In the commercial sector—which includes hospitals, hotels, offices, restaurants, retail buildings, and schools—the opportunity is much smaller than it is in the industrial and residential sectors. Investing \$22 billion a year, 13 percent of the total \$170 billion, would generate energy savings of roughly 13 QBTU, 10 percent of the energy productivity opportunity across all sectors.

Furthermore, the regional distribution of investment opportunities is quite different from what it is in the industrial and residential sectors (Exhibit 3). In the commercial sector, developed countries have about 60 percent of the energy-abatement potential and would absorb more than 70 percent of the capital required to achieve it, because the sector's importance typically increases along with a country's income. Similarly, the energy that office equipment and many other appliances consume increases as well.

EXHIBIT 3

**The commercial opportunity**



The scale of the investments needed to realize efficiency opportunities differs spectacularly between the commercial sector and the residential sector. In the United States, for example, to abate each QBTU of energy demand from lighting and appliances, the commercial sector would need to invest a total of roughly \$27 billion and \$25 billion, respectively, from now until 2020. In the US residential sector, the cumulative capital required for each of these purposes is less than \$3 billion.

For lighting, the huge difference is due primarily to the fact that lighting in the commercial sector is already more efficient and therefore requires upgrades more expensive than CFLs. Replacing halogen lamps with LEDs cuts demand by 50 percent, for instance, but the incremental cost of LEDs is much higher than that of CFLs. For appliances, the major difference is that in the commercial sector, the mix is dramatically more diverse and fragmented than it is in the residential one. As a result, fewer economies of scale for upgrading are available within each category, prices are less likely to fall, and end users will foot the bill.

**The transportation sector**

Fully one-third—4.5 QBTU—of the transportation sector’s energy-saving opportunity requires no additional capital. These gains would come from removing fuel subsidies in oil-exporting regions such as the Middle East and Venezuela, thereby reducing their overconsumption of transportation fuel.

The remaining two-thirds of the sector's total opportunity—13 QBTU, 10 percent of the savings potential across all sectors—is relatively capital intensive.

Opportunities to reduce the weight and size of vehicles by redesigning them and substituting new materials, for example, can be expensive. (Lightweight materials such as aluminum and high-performance composites cost significantly more than iron and steel do.) In all, the capital requirements in transportation are larger than those for the other sectors.

### **Three priorities for action**

In many cases, the energy-investment opportunities we have described are not being seized. Why not? The main reason is a wide range of market failures, including fuel subsidies that directly discourage productive energy use, a lack of information for consumers about the energy efficiencies available to them, and the misaligned balance of incentives among builders, landlords, and tenants.<sup>6</sup> There are no easy ways around these obstacles, but policy makers and business leaders can make significant progress by focusing on three priorities. Although a few leaders have already begun to act, many more will be needed.

#### *Set energy efficiency standards for appliances and equipment*

The investment requirements are relatively modest in appliances, lighting, equipment, and the like. Efficiency standards can play a critical role in coordinating the transition of production volumes from less efficient products to more efficient ones, thus boosting their market penetration by generating large unit cost reductions.<sup>7</sup> In the United States, for example, the steady growth of demanding standards boosted the efficiency of refrigerators by 4.4 percent a year from 1970 to 1985.

Some governments have chosen to base standards on specific technologies (as Australia has done by mandating the use of CFLs). A more effective approach is to set overall performance standards that can be reached in a variety of ways. South Korea, for example, has a one-watt standby power requirement,<sup>8</sup> and California is phasing out incandescent lights by 2012 but allowing consumers to replace them with any of several more efficient options. There is a strong case for adopting similar standards for other household appliances, as well as for business equipment sold in high volumes, and for applying existing local standards to larger regions.

Meanwhile, private-sector companies can create voluntary industry standards for energy efficiency. In the United States, the Consumer Electronics Association, for example, has defined the maximum energy consumption for the sleep mode of basic digital TV set-top boxes. The voluntary disclosure of information can help as well. In 2007, for instance, the UK's Bathroom Manufacturers Association announced a voluntary industry-led labeling scheme for more efficient bathroom products.

#### Finance energy efficiency upgrades in new buildings and in remodels

Incorporating energy efficiency features in new houses and other structures is much cheaper than retrofitting them later on; for instance, the cost of installing double-pane windows in new buildings is a great deal lower than the cost of replacing existing single windows with new double ones. Likewise, if households or companies tear down walls when they have buildings remodeled, it pays to install more insulation.

Yet capital constraints prevent many households from seizing these opportunities. Even in developed economies with established mortgage markets, people who have preapproved mortgages for defined amounts often face trade-offs—for example, between buying a marble kitchen countertop or energy-efficient double-pane windows. In most private commercial buildings, the main challenge is to overcome agency issues between landlords and tenants and rapid turnover of commercial businesses that lead to very high discount rates.

For all these reasons, the public and private sectors should help provide capital to finance upfront investments in energy-efficient construction. Some private- and public-sector players already offer energy efficiency loans: Citigroup and Bank of America, for instance, have announced \$50 billion and \$18 billion funds, respectively, for green investments, including preferential loans for energy-efficient homes.<sup>9</sup> China has set aside \$1 billion (financed by the sale of carbon credits) for energy-efficient products such as new lightbulbs.

There is much room for further innovation—for instance, by aggregating the energy savings from a number of households and companies and securitizing them into tradable energy-efficient mortgages, “white certificates” (tradable documents indicating energy efficiency gains), or emission permits. In addition, mortgage players can find innovative ways of collaborating with utilities and energy intermediaries to link future energy savings directly to the terms of mortgages.

Public–private partnerships often expand the investment pie and tap into specialized expertise effectively. Under the Clinton Climate Initiative, for example, the US federal government has teamed up with building-control companies and financial institutions to increase the energy efficiency of urban structures through retrofitting. Some \$5 billion of loans from five major financial institutions are available to facilitate economically practical efficiency solutions.

International financial institutions and development agencies, as well as nongovernmental organizations (NGOs), play a critical role in expanding financial support for energy efficiency in rapidly growing developing regions. The World Bank’s investments in energy efficiency and renewable energy, for example, have grown by 67 percent, to \$1.4 billion, during the last fiscal year. The Renewable

Energy and Energy Efficiency Partnership (REEEP)—a global public–private undertaking backed by more than 200 governments, businesses, development banks, and NGOs—specializes in the innovative financing of energy efficiency investments. One of the beneficiaries, the E+Co West Africa Modern Energy Fund, aims to mobilize \$120 million of third-party capital to finance energy efficiency projects in the region.

#### Raise corporate standards for energy efficiency

Why does so much of the potential energy productivity opportunity in the industrial and commercial sectors remain untapped? One important reason is that many companies around the globe continue to be government owned (for instance, those that control much of China’s industrial capacity) or enjoy high levels of regulatory protection that shields them from competition (such as steel, until recently, in the United States and many other countries). Improving performance is hard work for managers. Without market pressure to do so, many companies just will not take advantage of all the available opportunities to boost their energy productivity.

Institutional investors and other shareholders can help create incentives to pursue fragmented energy productivity opportunities—for instance, by asking public companies for information about their energy efficiency and greenhouse gas emissions and by encouraging their managers to run energy-lean operations. Developing energy efficiency metrics and generating information is a critical piece of the puzzle. In December 2007, a group of London investment banks advanced the cause by producing the London Accord, a new open-source research resource for investors interested in climate change solutions and energy efficiency.<sup>10</sup>

In state-owned enterprises and other nonmarket institutions, including energy productivity, considerations in a manager’s performance evaluation is another option, which we already see in China. Private-equity firms can implement significant change too. In the United States, some of them (and utilities as well) are already tapping into the large combined-heat-and-power opportunity in industrial companies; capturing heat to generate electricity on-site can increase the efficiency of power generation to 80 percent, from 40.

#### **The role of energy intermediaries**

Despite the favorable economics of energy productivity investments, and even if government and business leaders focus on the right ones, some opportunities will probably remain on the table as a result of information gaps, high discount rates for energy investments, and uncertainty about future savings, as well as the disinclination of landlords to make investments that benefit their tenants and vice

versa. A range of intermediaries, such as utilities and energy service companies (ESCOs), will therefore have opportunities to finance, enable, and profit from energy efficiency investments.

Utilities can play a critical role—as long as their incentives are aligned with higher energy productivity. Traditionally, the revenues of utilities have been tied to the volume of electricity delivered, encouraging growth in electricity consumption rather than energy efficiency. Instead, regulators can reward utilities for promoting energy efficiency and reducing energy consumption among their customers. For instance, the state of California has an incentive program that rewards and penalizes the state's privately owned utilities by up to about \$450 million, depending on their energy efficiency performance.

With the right incentives, utilities' demand-side-management (DSM) programs could have a large impact on household energy consumption. For example, advanced metering, which allows utilities to communicate more effectively with customers about the precise cost of their current usage patterns, would help them keep down peak-period energy consumption. Once utility bills can disaggregate time-of-use patterns, attractive financing options become practical. Some utilities are already experimenting with market-based programs that allow energy service companies to aggregate and bid on opportunities to reduce demand as an alternative to building new power generation capacity.

Energy service companies combine the engineering expertise needed to reduce energy consumption with financial services that help municipalities, universities, schools, and hospitals—which account for 25 percent of all commercial energy demand and typically operate under strong capital constraints—to bridge the gap between current financial resources and future energy savings. They make money by providing funds for upfront investments in energy savings in exchange for a share of the cash flows these savings generate. According to a trade group, US energy service companies invested \$2.5 billion in 2006. In South Africa, the state-owned electricity company Eskom has evaluated and registered more than 100 energy service companies as part of its drive to boost energy efficiency.

Creative partnerships are starting to emerge. The Washington, DC, financial-services firm Hannon Armstrong, for instance, has teamed up with Pepco Energy Services in a \$500 million project to raise the energy efficiency of private and government buildings in the US capital. Pepco will conduct an energy audit of buildings; retrofit them with higher-efficiency lighting, heating, and cooling systems; and guarantee energy savings that Hannon Armstrong will use to finance the project, which has a payback period of five to ten years.

To capture the full energy productivity prize, energy intermediaries must go on finding innovative ways to overcome information and agency barriers. Subtle changes in the way users receive information and learn about their choices—say, by offering energy efficient solutions by default, with the option to opt out—can change their behavior. These choices have direct pecuniary implications and can encourage consumers to take advantage of the savings available to them.<sup>1</sup>

The economic case for energy productivity investments has never been stronger. One hundred and seventy billion dollars a year in capital is a sum well within reach, and the prize—halving the growth in energy demand while earning attractive returns—is significant. 

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#### Notes

<sup>1</sup>For more on this earlier research, see Diana Farrell, Scott S. Nyquist, and Matthew C. Rogers, “Making the most of the world’s energy resources,” *mckinseyquarterly.com*, February 2007.

<sup>2</sup>The \$170 billion in annual investments would be aimed at all the end-use sectors (industrial, residential, commercial, and transportation), which together represent about 85 percent of the global energy productivity opportunity. Because of the end-use focus, we excluded from our capital analysis the investments required to boost the efficiency of generating and refining energy—the remaining 15 percent of the energy productivity opportunity that MGI identified. For more details on the capital analysis, see *The case for investing in energy productivity*, available free of charge on [www.mckinsey.com/mgi](http://www.mckinsey.com/mgi).

<sup>3</sup>All internal rate of return (IRR) calculations assume that oil costs \$50 a barrel—far less than today’s prices, which would generate higher returns.

<sup>4</sup>At the same time, making these investments would avoid having to invest in generating capacity and other forms of energy infrastructure that would otherwise be necessary to keep pace with accelerating demand. The International Energy Agency (IEA) estimates that, on average, \$1 spent on more efficient electrical equipment, appliances, and buildings avoids more than \$2 of investment in electricity supply (*World Energy Outlook 2006*, International Energy Agency, 2006).

<sup>5</sup>Lower labor costs reduce capital requirements both directly (for example, through labor-intensive factory construction or equipment installation) and indirectly (through the lower cost of locally produced inputs, such as commodity materials and equipment in the industrial sector, as well as local buildings).

<sup>6</sup>For a more detailed description of the market failures in different energy-consuming segments, see “Policies to capture the energy productivity opportunity,” in *Curbing Global Energy Demand Growth, The Energy Productivity Opportunity*, available free of charge on [www.mckinsey.com/mgi](http://www.mckinsey.com/mgi).

<sup>7</sup>By contrast, standards for buildings have less favorable economics. The economies of scale are lower for efficient housing shells than for appliances and equipment, and the capital constraints in financing them are higher. For these reasons, the rate of compliance with standards for buildings is much lower than it is for appliances, particularly in the more credit-constrained developing economies.

<sup>8</sup>Standby electricity use is the energy consumed by electrical appliances when they are turned off, or not in use.

<sup>9</sup>These allow households that buy energy-efficient homes to qualify for higher mortgages by adding future utility bill savings to their qualifying incomes and to pay for any efficiency improvements over the lifetime of the mortgage. To compensate consumers for the time and cost of third-party certification, the two banks now take \$1,000 off closing costs.

<sup>10</sup>For details of the London Accord collaboration among investment banks, research houses, academics, and NGOs, see [www.london-accord.co.uk](http://www.london-accord.co.uk).

<sup>11</sup>See the examples in Richard H. Thaler and Cass R. Sunstein, *Nudge: Improving Decisions About Health, Wealth, and Happiness*, New Haven and London: Yale University Press, 2008.

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