McKinsey Global Institute

The Case for Investing in Energy Productivity

February 2008

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MGI's research is conducted by a group of full-time MGI fellows based in offices in San Francisco, Washington, DC, London, and Shanghai and led by MGI's director, Diana Farrell. MGI project teams also include consultants drawn from McKinsey's offices around the world and are supported by McKinsey's network of industry and management experts and worldwide partners. In addition, MGI teams work with leading economists, including Nobel laureates and policy experts, who act as advisors to MGI projects.

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Preface

This report builds on a yearlong effort by the McKinsey Global Institute (MGI) and McKinsey's Global Energy and Materials (GEM) Practice to understand the microeconomic underpinnings of global energy demand. Our report *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity* was published in May 2007 and identified the potential to abate energy demand growth by tapping available opportunities to boost energy productivity. This latest report, *The Case for Investing in Energy Productivity*, assesses the additional investment and key actions needed to capture the productivity potential. Both reports are available without charge at the MGI website.

We are pleased to present the findings of our research at the Investor Summit on Climate Risk hosted by Ceres and the United Nations Foundation at the United Nations in New York City on February 14, 2008. The event provides a high-level forum for 450 leading institutional investors, financial-firm leaders, and corporate executives from around the world to consider the scale and urgency of climate-change risks, as well as the economic opportunities of a global transition to a clean energy future.

Jaana Remes, a senior MGI fellow based in San Francisco, worked closely with me to provide leadership to this project. The project team included Florian Bressand and Anjan Sundaram, both consultants from the San Francisco office, and Mark Laabs, a consultant from the Atlanta office. We benefited from the thoughtful input and expertise of many McKinsey colleagues around the world. We would like particularly to thank Scott Andre, Eric Beinhocker, Peter Berg, Jon Creyts, Nuri Demirdoven, Anton Derkach, Tim Fitzgibbon, Michael Graubner, Anja Hartmann, Khush Nariman, Scott Nyquist, Jeremy Oppenheim, Oliver Ramsbottom, Matt

Rogers, Jaeson Rosenfeld, Michael Wang, Allen Webb, Jonathan Woetzel, Derek Ying, and Benedikt Zeumer. We also benefited from numerous interviews with external experts and practitioners.

We are grateful for the essential research provided by Adrian Bartha, Tim Beacom, and Susan Sutherland. For their committed support throughout the project, we would like to thank Janet Bush, MGI senior editor; Rebeca Robboy, MGI's external relations manager; Deadra Henderson, MGI practice administrator; and Sara Larsen, MGI executive assistant.

This work is part of the fulfillment of MGI's mission to help global leaders understand the forces transforming the global economy, improve company performance, and work for better national and international policies. As with all MGI research, we would like to emphasize that this work is independent and has not been commissioned or sponsored in any way by any business, government, or other institution.

Diana Farrell
Director, McKinsey Global Institute
February 14, 2008
San Francisco

The Case for Investing in Energy Productivity

Unless there is a concerted shift in energy policy and consumption, global energy demand growth is set to accelerate over the next 20 years. This will not only make efforts to combat climate change even more challenging but also impose significant costs on the world economy, businesses, and consumers in an era of historically high energy prices. Yet there is a major opportunity to abate energy demand growth in a cost-effective way that offers investors attractive returns.

Recent research by the McKinsey Global Institute (MGI) and McKinsey & Company's Global Energy and Material Practice finds that we could cut projected global energy demand growth to 2020 by at least half by capturing opportunities to increase energy productivity—the level of output we achieve from the energy we consume. These opportunities use existing technologies that pay for themselves, thereby freeing up capital for investment or consumption elsewhere.[1]

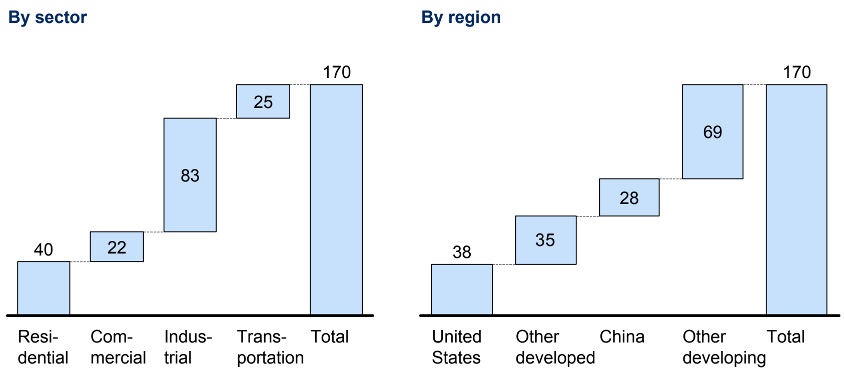
Our latest research shows that additional annual investments of $170 billion for the next 13 years would be sufficient to capture the energy productivity opportunity among all end users (Exhibit 1). Global industrial sectors need just under half of the total capital required—$83 billion a year. Residential sectors around the world need some $40 billion a year, roughly one-quarter of the total. The capital needs of commercial and transportation end-use sectors are smaller at $22 billion and $25 billion a year respectively. Breaking down capital requirements geographically, developing regions represent two-thirds of the incremental capital needed, with China alone accounting for $28 billion or 16 percent of the total $170 billion annual requirement.

1 Interested readers can download our full report *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity*, McKinsey Global Institute, May 2007 (www.mckinsey.com/mgi).

Exhibit 1

ADDITIONAL $170 BILLION A YEAR IS NEEDED TO CAPTURE GLOBAL ENERGY PRODUCTIVITY OPPORTUNITY

$ billion per annum



Note: Our approach sizes the 2020 energy savings available, beyond the base-case productivity improvement, using existing technologies that pay back with an IRR of 10 percent or more. We then assess the incremental capital required beyond base-case investment between 2008 and 2020 to capture this potential and annualize the cumulative investment.

Source: McKinsey Global Institute analysis

The economics of such investments are very attractive. With an average internal rate of return (IRR) of 17 percent, they would collectively generate annual energy savings ramping up to $900 billion annually by 2020. Energy productivity is also the most cost-effective way to reduce global emissions of greenhouse gases (GHG). Our research finds that capturing the energy productivity opportunity could deliver up to half of the abatement of global GHG required to cap the long-term concentration of GHG in the atmosphere to 450 to 550 parts per million.[2]

Moreover, we would avoid investment in energy infrastructure that we would otherwise need to keep pace with accelerating demand. The International Energy Agency (IEA) estimates that on average, an additional $1 spent on more efficient electrical equipment, appliances, and buildings avoids more than $2 in investment in electricity supply.[3] As Chevron CEO David O'Reilly recently pointed out, energy efficiency is the cheapest form of new energy we have.[4]

2 This is the range that experts suggest will be necessary to prevent the global mean temperature from increasing by more than 2° centigrade. For more on McKinsey's work on GHG abatement opportunities, see "A cost curve for greenhouse gas reduction," *The McKinsey Quarterly*, 2007 (www.mckinsey.com/clientservice/ccsi/pdf/Cost_Curve_for_Greenhouse_Gas_Reduction.pdf); "Costs and potential of greenhouse gas abatement in Germany," McKinsey & Company on behalf of BDI initiativ—Business for Climate, October 2007 (www.mckinsey.com/clientservice/ccsi/pdf/Costs_And_Potentials.pdf); "Reducing US greenhouse gas emissions: How much at what cost?" McKinsey & Company, November 2007 (www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf).

3 *World Energy Outlook 2006*, International Energy Agency, 2006.

4 "Chevron's CEO: the price of oil," *Fortune*, November 28, 2007.

If energy productivity is so attractive on several fronts, why haven't more investors taken up the opportunities that are available? The answer is that myriad policy and market imperfections stand in the way. This paper aims to provide a road map for action in two ways. First, it describes the characteristics and costs of specific energy productivity opportunities in the industrial, residential, commercial, and transportation sectors. Second, it highlights some critical priorities—setting energy efficiency standards for appliances and equipment, upgrading the energy efficiency of new buildings and remodels, raising corporate standards for energy efficiency, and investing in energy intermediaries—needed to jump-start efforts toward boosting energy productivity.

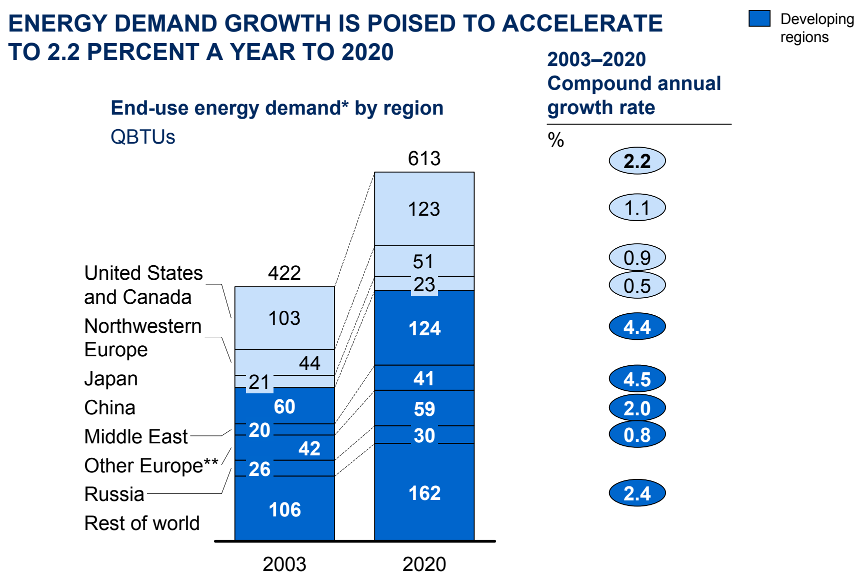
ENERGY DEMAND GROWTH IS ACCELERATING

In 2003, global energy consumption reached 422 QBTUs (quadrillion British thermal units) of energy—equivalent to 200 million barrels of oil per day. Although the world has learned how to get more from the energy we use and energy productivity grew by some 1 percent a year between 1980 and 2003 and will continue to do so, this "business-as-usual" increase in energy productivity will not be sufficient to prevent energy demand from accelerating to 2020. Indeed, MGI's base case projects that global energy demand growth will accelerate to an average of 2.2 percent a year to 2020, up from the average annual growth rate of 1.7 percent observed since 1986 (Exhibit 2). Global CO_2 emissions will grow by 2.4 percent annually to 2020—more quickly than global energy demand—because of a shift to a more CO_2-intensive fuel mix, notably, fast-growing coal-intensive power demand in developing economies.

There are two key dimensions of new demand for energy. Economic development is one. Rapidly emerging markets will account for an overwhelming 85 percent of energy demand growth to 2020, with China alone representing one-third of total growth. The second is that the world economy has shifted away from industry and toward less energy-intensive service industries. As a result, sectors that have the characteristics of consumer goods—such as residential and commercial buildings and road transportation—will drive 57 percent of energy demand growth to 2020.[5]

5 We use end-use energy demand as the basis of our analysis. This equals primary demand but allocates all generation and distribution losses to the corresponding end-use segments. This methodology enables us to focus on a single global demand number and capture the full implications of behavioral and policy factors affecting each end-use segment. We looked in detail at each of the main end-use segments in the largest economies globally, identifying the key microeconomic, behavioral, and policy relationships that explain their energy demand. We then aggregated across countries and end-user segments to produce an integrated, dynamic perspective on global energy demand and productivity.

Exhibit 2



* Transformation losses (power generation, refining) allocated to end-use segments.
** Includes Baltic/Eastern and Mediterranean Europe and North Africa.
Source: McKinsey Global Institute Global Energy Demand Model

Energy demand growth could be even more rapid if robust current rates of GDP growth around the world continue. Our research shows that energy demand growth swings substantially between low- and high-growth scenarios—from 1.7 percent a year to 2020 to 2.8 percent by 2020.[6] That is the equivalent of a 50 QBTU variation around our base-case demand forecast for 2020 of a 613 QBTU level of demand. China and the Middle East together account for 46 percent of this swing between the low- and high-growth scenarios. Energy demand is significantly more sensitive to GDP growth than to the price of oil; the swing between our low and high oil-price scenarios is only 7 QBTUs.[7]

THE ECONOMICS OF ABATING DEMAND

Public and political discourse on the world's energy challenge has for years centered on how to secure future supply. However, it is increasingly evident that simply building the infrastructure to ensure supply meets burgeoning demand is not optimal. Investments in energy productivity (see "What is energy productivity?")

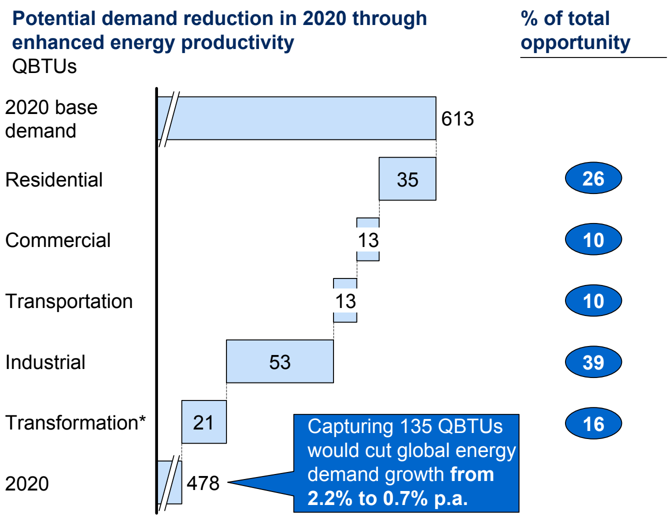
6 For China and India, our high-and low-GDP-growth scenarios assume plus or minus 2 percent; for other developing economies, plus or minus 1 percent; and for developed economies, plus or minus 0.5 percent.

7 Our base case assumes oil at $50 a barrel. Oil at $30 a barrel leaves energy demand growth unchanged, while oil at $70 per barrel decreases global energy demand by 7 QBTUs. There are two reasons for the relatively modest influence of oil prices. First, regulation, subsidies, and taxes shield many energy end users from fluctuations in the market price of energy. Second, although high prices have a direct dampening effect on fuel demand in road-transportation sectors that are free from subsidies or tax breaks, in oil-exporting countries high oil prices accelerate GDP growth and therefore energy demand.

are a far more cost-effective option, delivering a significant abatement in energy demand growth. MGI research has identified opportunities that would more than double the rate of energy productivity growth from its historic rate of 1 percent a year to 2.5 percent per annum.[8] This would reduce energy demand growth to below 1 percent, less than half the growth projected in our base case, and cut global demand in 2020 by 135 QBTUs—the equivalent of 64 million barrels of oil per day, or almost 150 percent of today's entire US energy consumption (Exhibit 3).

Exhibit 3

LARGE OPPORTUNITIES FOR IMPROVING ENERGY PRODUCTIVITY ARE AVAILABLE ACROSS SECTORS



* 20 QBTU power sector opportunity not included in capital analysis.
Source: McKinsey Global Institute analysis

The energy productivity improvements in all end-use segments would require additional capital outlays of $170 billion annually until 2020—or cumulative investment of $20 billion over the next 13 years per each QBTU abated (1 QBTU is equivalent to the annual energy consumption of 5.3 million US households or 20 million cars).[9] On average, these investments would generate an IRR of 17 percent from future energy savings. Yet there are large differences around the

8 *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity*, McKinsey Global Institute, May 2007 (www.mckinsey.com/mgi).

9 Our approach is to size the energy productivity potential in terms of energy saved annually in 2020 and to estimate the cumulative capital required between 2008 and 2020 to capture this potential—take as an example upgrading air conditioners. These capital outlays are incremental to the investments expected under MGI's business-as-usual scenario. The capital outlays are valued at market prices under a higher energy-productivity-capture scenario, and energy savings are those that accrue to end users at 2005 energy prices. We include opportunities in all end-use segments amounting to a total of 115 QBTU but we do include additional opportunities in the power sector (less than 15 percent of the global total). Our base-case scenario assumes a global GDP growth rate of 3.2 percent annually to 2020 and a $50 per barrel oil price.

What is energy productivity?

Energy productivity is a useful tool with which to analyze the public-policy aims of demand abatement and energy efficiency because it encapsulates both. By looking merely in terms of shrinking demand, we are in danger of denying opportunity to consumers—particularly those in developing economies, an increasingly dominant force in global energy demand growth. Rather than seeking explicitly to reduce end-use demand, we should focus on using the benefits of energy in the most productive way.

Like labor or capital productivity, energy productivity measures the output and quality of goods and services generated with a given set of inputs. We measure energy productivity as the ratio of value added to energy inputs, which today is $79 billion of GDP per QBTU of energy inputs globally. This is the inverse of the energy intensity of GDP, measured as a ratio of energy inputs to GDP. This currently stands at 12,600 BTUs of energy consumed per dollar of output.

When identifying opportunities for energy productivity improvements, we focus on changes that rely on currently existing technologies, have an IRR of 10 percent or more, and avoid compromising the comfort or convenience valued by consumers. Our exclusive focus on economic opportunities means that making these investments would benefit the economy by freeing up resources to increase consumption or investment elsewhere.

averages in the capital required and expected returns across different global sectors and regions. For example, capital requirements across all sectors are on average some 35 percent lower in developing countries than in developed regions. The cumulative cost of abating each QBTU of energy demand in China's residential sectors is $14 billion, considerably lower than $18 billion in the United States, for instance.[10]

Before reviewing in detail both the productivity opportunity and the capital required in different end-use sectors, it is worth considering the feasibility of energy-oriented outlays of $170 billion a year. On a macroeconomic basis, they seem eminently achievable. The necessary capital outlay of $170 billion is equivalent to some 1.6 percent of global fixed-capital investment today, or 0.4 percent of current global GDP. What's more, capital outlays of this magnitude would be less than 20 percent of the average $900 billion a year between 2006 and 2030 that

10 This largely reflects China's lower labor costs, broadly shared by other developing regions. Lower labor costs reduce capital requirements both directly, for example, in labor-intensive plant construction or the installation of equipment, as well as indirectly through lower costs of locally produced inputs such as commodity materials and equipment in the industrial sector, and in buildings.

the IEA estimates would be required to build the energy infrastructure needed to safeguard global supply in an era of strengthening energy demand.[11] And despite the difficulties in the subprime mortgage market in 2007, significant liquidity is flowing into world capital markets and will continue to do so.[12]

The industrial opportunity is large but fragmented

The broad range of global industrial sectors could abate 53 QBTUs of energy demand growth—or 39 percent of the total opportunity—in 2020 through embracing higher energy productivity. The global incremental investment required to capture this opportunity is $83 billion per annum—or a cumulative $20 billion per QBTU abated in 2020. Yet this aggregate figure consists of hundreds of smaller opportunities.

These include large cross-sector prospects such as combined heat and power (CHP) generation with cumulative investment required of $43 billion per QBTU and a payback period of one to three years; the optimization of motor-driven systems with a capital requirement of $23 billion per QBTU and a payback period of between two and four years; and more sector-specific opportunities such as liquid membrane separation in chemicals with a capital requirement of $0.8 billion and payback in less than one year (Exhibit 4).

Developing regions represent 80 percent of the opportunity in industrial sectors. This reflects both the larger scope to increase energy productivity in low-efficiency legacy assets in a number of regions (our base-case scenario assumes that new capacity in global industries is built to global standards in both developed and developing regions) and the fact that lower labor costs reduce capital requirements for many initiatives and make a broader set of actions on energy productivity economically viable. In China, the capital required for each QBTU of industrial energy abated in 2020 is a cumulative $17 billion—33 percent lower than in the United States where $26 billion per QBTU is required. This gap is in fact narrower than the difference between the capital that the two countries need for most specific opportunities. For instance, in both steel and pulp and paper the gap in capital required between China and the United States is more than 50 percent on average (Exhibit 5). This is due both to differences in industry mix—China has a larger share of high-capital-requirement steel opportunities—and the inclusion of a broader set of marginal opportunities that have higher capital requirements.

11 *World Energy Outlook 2007*, International Energy Agency, 2007.

12 For a detailed analysis, see *The New Power Brokers: How Oil, Asia, Hedge Funds, and Private Equity Are Shaping Global Capital Markets*, McKinsey Global Institute, October 2007 (www.mckinsey.com/mgi).

Exhibit 4

DESPITE A WIDE RANGE OF OPPORTUNITIES, A FEW KEY ONES DOMINATE IN EACH INDUSTRY

United States reference example

■ Top seven overall

Industry	Option	Abatement	Cumulative capital requirement	IRR
		TBTUs*	$ billion	%
Cross-industry	• CHP generation	980	43	36
Cross-industry	• Optimization of electric motors	420	23	35
Pulp and paper	• Increased use of recycled paper	109	4.10	19.1
	• Steam trap maintenance	73	0.06	88.0
	• Condebelt drying	68	1.40	35.6
	• Continuous digesters	63	2.40	10.8
Iron and steel	• Thin slab casting (secondary)	149	8.40	10.5
	• Thin slab casting (integrated)	32	1.70	11.3
	• Pulverized coal injection	23	0.30	32.6
Chemicals	• Liquid membrane separation	134	0.8	109.2
	• New catalysts for petchems	74	1.7	27.3
Refining	• Increase furnace efficiency	146	2.1	37.5
	• Improve steam efficiency	126	2.2	31.4
Cement	• Blended cement	45	0.03	781.5

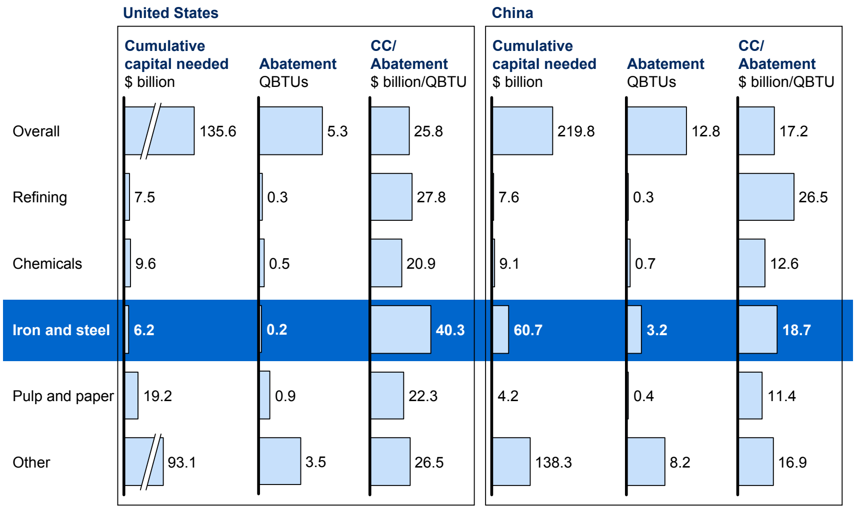
* Trillion BTUs.

Note: All opportunities are incremental to base-case technology adoption—e.g., full adoption of near-net-shape casting by 2020 in the United States.

Source: McKinsey Global Institute analysis

Exhibit 5

CHINA'S CAPITAL REQUIRED PER QBTU ABATED IS ONLY 33 PERCENT BELOW THE UNITED STATES' DUE TO LARGE STEEL OPPORTUNITY



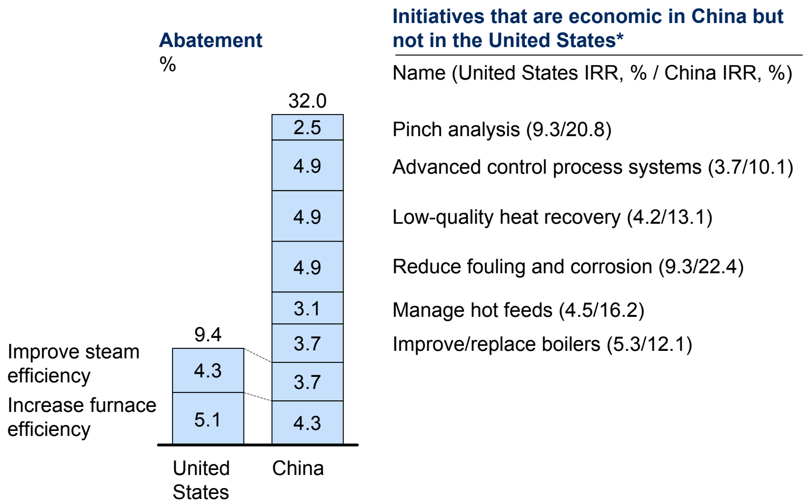
Note: Excludes cement, CHP, and electric motors.

Source: McKinsey Global Institute analysis

In refining, for example, lower capital costs in China make viable a number of opportunities that in the United States fail to meet the hurdle rate of 10 percent IRR. This triples the pool of economically viable opportunities—but also increases the average capital required across all the initiatives (Exhibit 6).

Exhibit 6

LOWER CAPITAL COSTS IN CHINA PUSH MANY REFINING INITIATIVES OVER 10 PERCENT HURDLE RATE, EXPANDING ABATEMENT POTENTIAL



* The refining energy productivity opportunity is estimated to be 28 percent on average in other developing regions.
Source: McKinsey Global Institute analysis

Because many energy productivity opportunities in global industrial sectors have an IRR of around 10 percent, they are sensitive to hurdle rates—and capital requirements even more so. Increasing hurdle rates to an IRR of 20 percent reduces the global energy productivity opportunity by 14 percent from 53 QBTUs to 46 QBTUs in 2020, and cumulative capital requirements by 27 percent from $1.1 trillion to $800 billion. This reflects the fact that opportunities with an IRR of between 10 percent and 20 percent require most capital per unit of abatement—dropping the average cost of abatement from $20 billion to $17 billion per QBTU abated. Conversely, reducing the hurdle rate to zero percent expands the energy productivity opportunity by 14 percent, from 53 QBTUs to 60 QBTUs, and capital requirements by 45 percent from $1.1 trillion to $1.6 trillion (Exhibit 7).

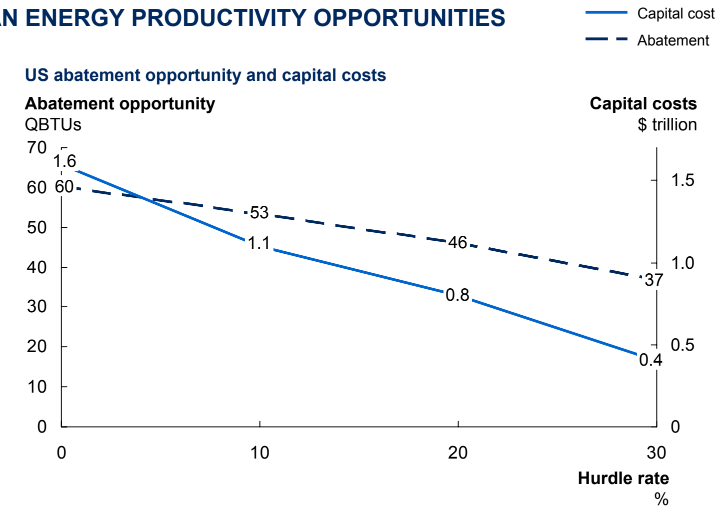
Residential sector offers opportunities with lowest investment needs

MGI estimates that the energy productivity opportunity of the global residential sector is 35 QBTUs in 2020—equivalent to 26 percent of the total potential. The United States and China represent 45 percent of the global opportunity. The

US opportunity is 7.1 QBTUs or 33 percent of projected US energy demand in 2020, while China's potential to increase energy productivity is 7.3 QBTUs or 22 percent of projected demand in 2020.

Exhibit 7

CAPITAL REQUIREMENTS ARE EVEN MORE SENSITIVE TO HURDLE RATES THAN ENERGY PRODUCTIVITY OPPORTUNITIES



Cost/unit abated $ billion/QBTU	26.8	20.2	17.0	11.3

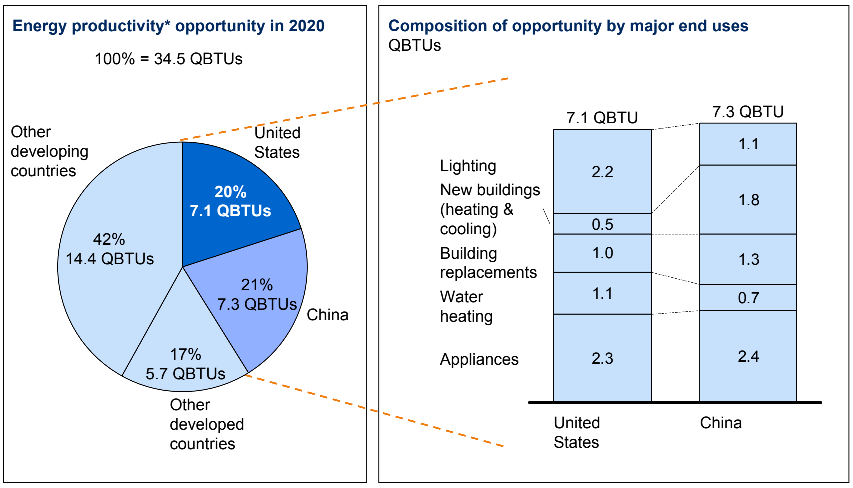
Source: McKinsey Global Institute analysis

The opportunity to boost energy productivity varies between different residential end uses—a pattern that partly reflects different stages of economic development in different regions. In the United States and other developed economies, nearly one-third of the opportunity in each country lies in efficient lighting. Another one-fifth lies in heating and cooling packages for houses (new builds and replacement upgrades). In China and other rapidly growing developing regions, the adoption of higher efficiency heating and cooling solutions (both equipment and insulation) in new houses represents one-quarter of the overall opportunity. In contrast, lighting represents only 15 percent of the total because of lower current usage and the higher penetration of compact fluorescent lighting (CFL) than in our base-case scenario (Exhibit 8).

The global incremental investment required to capture these energy productivity opportunities is in the range of $40 billion annually to 2020—or a cumulative $15 billion per QBTU abated in 2020. However, the investment needed varies between regions. The capital required is approximately 6 percent higher per QBTU abated in some developed regions, including Europe, than in the United States, and 23 percent lower in China and other developing countries (Exhibit 9).

Exhibit 8

RESIDENTIAL-SECTOR ENERGY PRODUCTIVITY OPPORTUNITY BY REGION AND MAJOR END USE

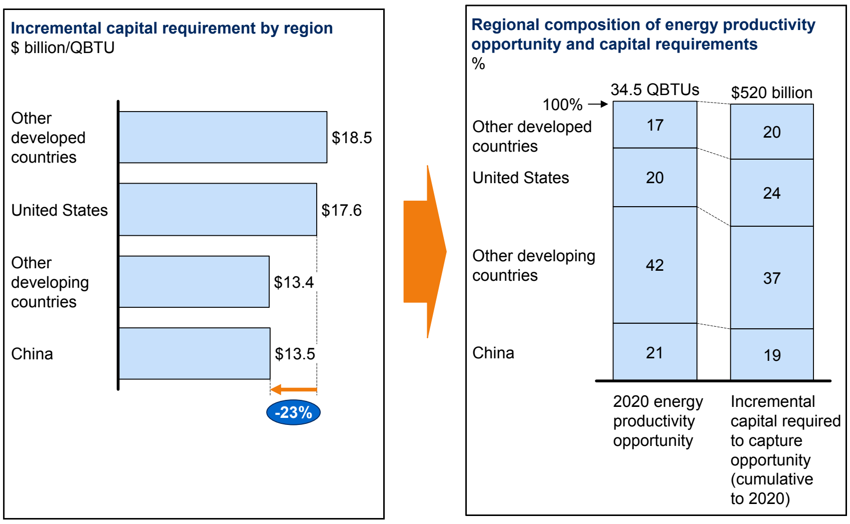


* Energy demand abatement from adopting existing technologies that pay for themselves with 10 percent IRR or more.

Source: McKinsey Global Institute

Exhibit 9

THERE ARE LARGE VARIATIONS IN CAPITAL REQUIRED BETWEEN REGIONS—RESIDENTIAL SECTOR



Source: McKinsey Global Institute analysis

The average capital requirement gap between the United States and China is not as large as in more labor-intensive end uses like heating and cooling. After adjusting for size and duration, equipment costs tend to vary much less than labor costs around the world. The extreme case is CFL, in which the incremental investment needed after adjusting for duration is very similar in the two regions. In addition, a larger share of US opportunity is in low-cost lighting and appliances, further reducing the average. Expanding the US energy productivity opportunity to include solar water heaters that today have an IRR of 9 percent (and thus just fail to meet the 10 percent IRR hurdle rate) would abate an additional 0.3 QBTU. However, achieving this would require $35 billion in incremental capital, or $116 billion per QBTU abated—an indication of the marginal capital requirement for additional abatement in the United States with current technologies.

The capital required also ranges widely between different residential end-use sectors. Expanding the use of CFL—action that we estimate could abate energy demand growth by 5 QBTUs in 2020—would require only a cumulative $2 billion per QBTU abated. Moreover, such investments would pay back within a year. If the world were to shift to more efficient appliances, this would create large economies of scale in production that should ensure that there is limited—or even no—additional cost to end users. In the past, consumer prices of higher-efficiency appliances have declined after new standards expanded production volumes. Given that higher-efficiency appliances are already on the market, we therefore assume that appliance manufacturers would absorb these costs fully (Exhibit 10).[13]

In contrast, the cost of installing more efficient heating and cooling packages (including both housing shells and equipment), which represents 37 percent of the total energy productivity potential, is more expensive at an average cumulative capital requirement of $26 billion per unit abated. This is almost 80 percent of the capital required—and also has a longer average payback period of 17 years.

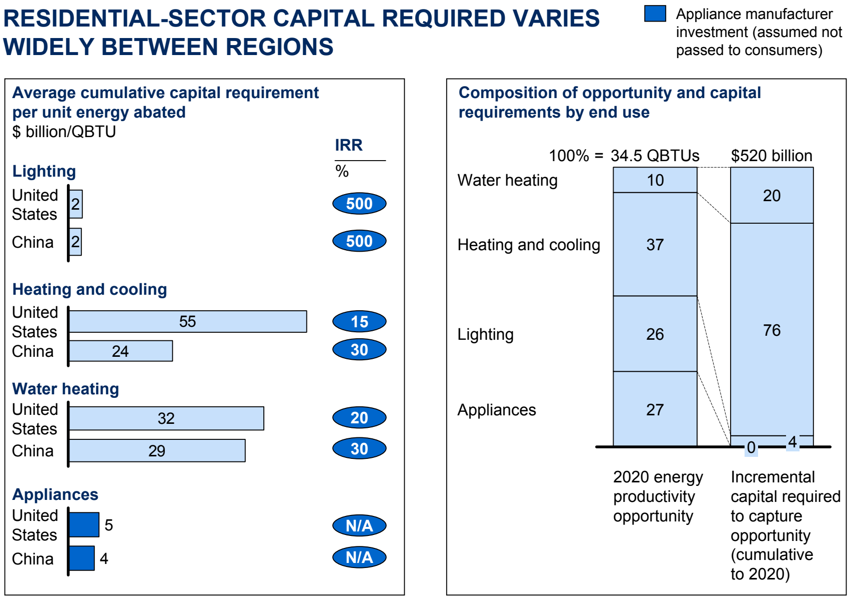
Commercial sector offers more opportunities in developed countries

Global commercial sectors account for approximately 10 percent of the total opportunity to boost energy productivity—at 13 QBTUs globally. Some 60 percent of the overall potential is in developed regions that have a higher share of services and a larger number of commercial buildings, each with many energy-consuming appliances and pieces of equipment. The mix of opportunities varies widely

13 The overall cost to Original Equipment Manufacturers (OEM) is an estimated $5 billion per QBTU. For references on past price performance, see Mark Ellis, Nigel Jollands, Lloyd Harrington, and Alain Meier, *Do Energy Efficient Appliances Cost More?,* European Council for an Energy Efficient Economy, 2007.

Exhibit 10

RESIDENTIAL-SECTOR CAPITAL REQUIRED VARIES WIDELY BETWEEN REGIONS



Source: McKinsey Global Institute analysis

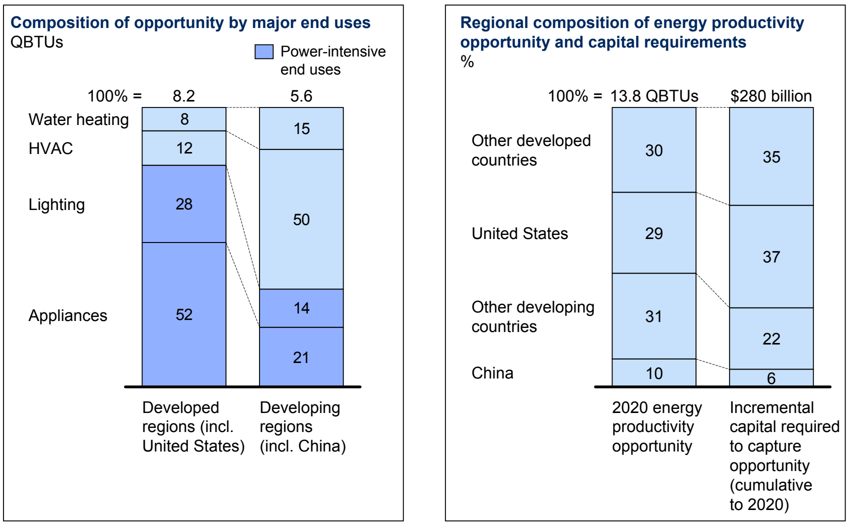
among regions—as it does in residential sectors. For instance, power-intensive end uses such as air-conditioning, lighting, and office equipment represent a large majority of energy demand and an even larger share of the abatement opportunity in developed countries. By contrast, more "basic" end uses such as space and water heating still represent a majority of demand and abatement opportunities for China and other developing regions (Exhibit 11).

On average the incremental capital requirement to abate 1 QBTU of commercial-sector energy in 2020 is a cumulative $21 billion between 2008 and 2020. As in other sectors, the cost is higher in developed regions such as the United States (a cumulative $26 billion per QBTU abated in 2020) than in developing regions such as China (a cumulative $16 billion per QBTU). The gap here is larger than in residential sectors because the opportunity in developing regions, especially in China, is more concentrated in heating and cooling where lower labor and local input-cost benefits are most substantial.

Capital requirements are relatively homogeneous across end uses within the commercial sector, but they can be spectacularly different from those in residential sectors. Lighting and appliances are examples of this. In the US commercial sector the average cumulative capital requirement to abate 1 QBTU of demand in 2020 is $27 billion for lighting and $25 billion for appliances. In the US residential sector, the capital required for each of these is less than $3 billion. In lighting, what accounts for this huge difference between the commercial and

Exhibit 11

THERE ARE LARGE VARIATIONS IN CAPITAL REQUIRED BETWEEN REGIONS—COMMERCIAL SECTOR



Source: McKinsey Global Institute analysis

residential sectors? The major reason is that, in residential sectors, the main opportunity is to replace incandescent bulbs with CFL bulbs with savings of close to 90 percent in some cases. In the commercial sector, however, lighting is already more efficient and requires more complex upgrades. While replacing halogen lamps with light emitting diodes (LEDs) saves 50 percent of demand, the incremental investment cost for LEDs is much higher than for CFL bulbs, leading to a capital requirement of $17 billion per QBTU.[14]

In appliances, the difference between the capital requirements needed in the commercial and residential sectors is that, in the latter, there is a more fragmented mix. This means that there are lower economies of scale available within each category. In addition, price is typically a less critical purchase factor, enabling higher costs to be passed on to end users. In contrast to the minimal incremental costs to consumers that we see in the residential sector, the average cumulative capital requirement in the commercial arena is $25 billion per QBTU. Consider these appliances: upgrading efficiency requires $25 billion per QBTU for vending machines, $43 billion for freezers, $41 billion for beverage coolers, and as much as $90 billion for street lighting.

14 Another example of a more capital-intensive opportunity is the introduction of lighting controls that achieve 60 percent savings with a cumulative capital requirement of $68 billion per QBTU.

Better design in transportation offers potential for higher fuel economy

Transportation accounts for 10 percent of the total energy productivity opportunity—13 QBTU in 2020, or the equivalent of 6.5 million barrels of oil per day. There are two kinds of energy productivity opportunity in road transportation.

Some two-thirds of the opportunity—8 QBTUs, or 4 million barrels of oil a day by 2020—comes from adopting additional fuel-saving technologies that, despite the fact that they meet the 10 percent IRR threshold, are not implemented in our base-case scenario. However, these opportunities represent only a 9 percent decline in fuel demand beyond the base case. The reason is that we already foresee a significant improvement in fleet fuel economy in our base case—0.8 percent annually in Europe, 0.7 percent in China, and 0.5 percent in the United States. As a result, the average fuel economy of light vehicles climbs from 25 mpg to 31.5 mpg in the United States, for example, representing a 25 percent increase by 2020. This reflects two developments. First, there is a shift in consumer choices toward smaller vehicles and more efficient engines (such as hybrids) in response to fuel prices, which, even at a $50 per barrel oil price, are significantly higher than the levels seen in previous decades. Second, auto manufacturers introduce engine fuel-saving technologies with a 10 percent or more IRR in fuel-cost savings for consumers.[15]

The opportunities that remain are in vehicle weight and size reduction through material substitution and vehicle redesign. Because consumers may associate heavier or larger vehicles with improved safety, these options to reduce fuel consumption can be perceived to bear a degree of consumer risk for OEMs and are not as likely to be implemented. Given the high cost of lightweight materials such as aluminum or high-performance composites relative to iron and steel, the incremental capital requirements are larger than in the other sectors—cumulatively close to $40 billion per QBTU of energy abated in 2020.

The remaining third of the road opportunity—an additional 4.5 QBTUs or 2.5 million barrels of oil a day—comes from the removal of market-distorting fuel subsidies in oil-exporting regions such as the Middle East or Venezuela. Removing subsidies would reduce the current overconsumption of transportation fuel in these regions without requiring additional capital outlays.[16]

15 Unlike in most other sectors, in the transportation industry fuel costs are a major share of the overall cost of operations. As a result, information about fuel efficiency is readily available and a key factor in play for both businesses and households choosing vehicles, giving OEMs a strong incentive to implement fuel-saving solutions.

16 For more detail, see “Road-transportation sector,” Chapter 5, *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity*, McKinsey Global Institute, May 2007 (www.mckinsey.com/mgi).

FOUR KEY AREAS TO GET RIGHT

The case for higher energy productivity is stronger than ever before. The expected financial returns are high because peak energy prices increase the value of future energy savings. In many regions, these savings can be a source of additional revenue from sales of white certificates (indicating energy efficiency improvements) or emission permits.[17] At the same time, lower energy consumption reduces exposure to energy-related risks. In a recent survey among the 500 largest publicly traded companies, nearly 80 percent considered climate change—including extreme weather events or a tightening of government regulations—to present a business risk.[18]

Unfortunately, a wide range of energy-market failures currently discourage consumers and businesses from embracing higher energy productivity, as well as deter investors from making the capital outlays that would help end users to overcome initial financing barriers. These market failures include fuel subsidies that directly discourage productive energy use; a lack of information available to consumers about the kind of energy productivity choices that are available to them; and agency issues in high-turnover commercial businesses (Exhibit 12).[19] To overcome these barriers, there are four priority areas for action that we need to get right.

Set energy efficiency standards for appliances and equipment

Standards play a critical coordinating role in those areas in which capital is not a major barrier. Efficiency standards tend to be the most effective in appliances, equipment, and, arguably, lighting. There are three reasons for this. First, typically the value chain already has a well-established process for coordinating technical standards, often through the leadership of a few key OEMs. Nokia's role in coordinating technology standards in GSM phones is an example. Second, and more important, moving the total volume of production to a higher level of efficiency involves large economies of scale that reduce incremental capital requirements radically. Finally, capital requirements are not typically a barrier for adoption for either suppliers or consumers.[20]

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17 Italy, France, and the United Kingdom already have a white certificate program; Connecticut introduced legislation in 2007 for a similar White Tag program.

18 *Carbon Disclosure Project Report 2007 Global FT500*, Carbon Disclosure Project, 2007.

19 For a more detailed description of the market failures behind different energy-consuming segments, see "Policies to capture the energy productivity opportunity," Chapter 2, *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity*, McKinsey Global Institute, May 2007 (www.mckinsey.com/mgi).

20 In contrast, the case for standards in buildings does not have as favorable economics. There are lower economies of scale and there are capital constraints to the financing of higher-efficiency housing shells. For these reasons, the rate of compliance with these standards is much lower than for appliances, particularly in more credit-constrained developing economies.

Exhibit 12

DISTORTING POLICIES AND MARKET IMPERFECTIONS TODAY ACT AS BARRIERS TO ENERGY PRODUCTIVITY

	Examples
Policy distortions	• Fuel subsidies for transportation (e.g., Middle East) • Energy subsidies or nonmarginal pricing to households (e.g., Russian gas distribution) • Lack of financial incentives for public industries (e.g., China steel)
Lack of information	• Households unaware of the cost of their energy choices—and often make choices based on nonfinancial factors • Fragmented energy costs often go unnoticed by companies
Agency issues	• Appliance makers don't adopt efficient materials and technologies if consumers are unwilling to pay for them • Landlords and tenants opting for lower energy productivity when benefits don't accrue to them
Other factors	• High hurdle rates in many commercial and industrial companies • Credit constraints for MUSH* and residential segments

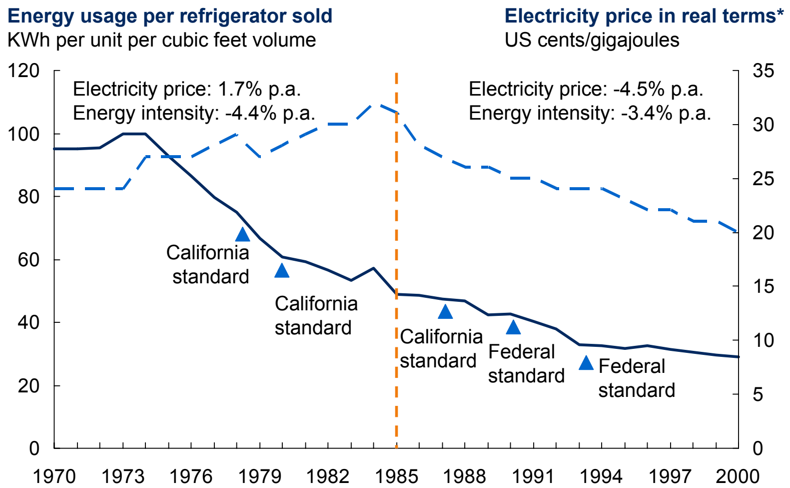
* Municipalities, universities, schools, and hospitals.
Source: McKinsey Global Institute analysis

Government efficiency standards have been shown to be an effective, low-cost way to coordinate a transition to more efficient appliances. In the United States, California spearheaded increasingly tighter performance standards for refrigerator efficiency, leading to a 4.4 percent improvement per year in 1970–1985, a trend that continued even after energy prices started to decline after 1985 (Exhibit 13). And while some governments have chosen to set standards based on specific technologies (e.g., Australia's mandate for CFL bulbs), a more neutral approach is to set performance standards reachable via alternative technical solutions. One example of this is the requirement for 1 kWh standby power mandated in Korea and elsewhere; or California's lighting performance requirements that phase out incandescent lighting by 2012 but do not mandate which of the more efficient lighting solutions should replace these.

Private-sector companies can also help create voluntary industry standards for energy efficiency. In the United States, the Consumer Electronics Association has defined a maximum for the "sleep mode" consumption of basic digital set-top boxes. Voluntary information disclosure can also contribute. In the United Kingdom, for instance, the Bathroom Manufacturers Association (BMA) announced in 2007 a voluntary, industry-led labeling scheme for water-efficient bathroom products.

Exhibit 13

STANDARDS HELPED CAPTURE REFRIGERATOR-EFFICIENCY GAINS
US refrigerator example



* Base year 1970.
Source: EIA; Lawrence Berkeley National Laboratory; McKinsey Global Institute analysis

Getting standards right is economically very attractive. The incremental capital requirements are the smallest among all the opportunities—$22 billion cumulatively over 13 years—with payback periods of less than a year in most cases. Capturing this opportunity globally in the residential sector alone would abate 16 QBTUs of 2020 energy demand—equal to the annual energy consumption of 610 typical power plants.

Finance energy efficiency upgrades in new buildings and remodels

The efficiency of facility heating and cooling is one of the largest energy productivity opportunities. And because of the long life of buildings, the energy efficiency of structures built over the next ten years—think of the rapidly growing building stock in developing regions—will impact energy productivity for many decades afterward.

It is during the construction of buildings when the economics are most attractive—it is much less expensive to incorporate higher energy efficiency features when installing new capital than to retrofit at a later stage. For instance, the additional cost of double, versus single, windows for a new building is a great deal lower than replacing existing single windows with new double ones. The same case applies to building remodels undertaken for nonenergy reasons. When households or companies are tearing down walls as part of a housing remodel, it pays to install more insulation then as well. Hence there is a very strong case for ensuring that, globally, both new construction and building remodels in the residential and commercial sector are carried out at optimal energy productivity levels.

Yet unlike the case of lighting or appliances, upgrading housing shells and equipment to higher efficiency implies significant capital outlays—ranging from $500 per household in China to $2,200 in the United States in the residential sector—with long payback periods of more than 15 years. Credit constraints and information barriers are the major factors preventing the capture of these opportunities today. The largest and most attractive opportunity is the upgrading of new houses built in China and other developing regions—yet most households face severe capital constraints that prevent them from taking advantage of this prospect. Even in developed economies with established mortgage markets, households frequently face tradeoffs—for example, between buying a desirable marble kitchen countertop or energy-efficient (and in the long term cost-saving) double-pane windows—when they have in their hands a preapproved mortgage for a defined amount. And in most private commercial buildings, the main test is to overcome agency issues and uncertainty that lead to very high discount rates.

To overcome these barriers, we need two changes. First, governments need to align policy incentives to reward investments on energy efficiency. Second, both the public and private sectors need to continue to expand the funds available and to innovate new ways to finance the incremental capital outlays from energy efficiency upgrades.

The first task for governments is to remove current disincentives to higher energy efficiency. Energy subsidies in many regions directly discourage energy efficiency by reducing the value of saved energy. We estimate that current subsidies on Russian gas alone contribute up to 2 QBTUs of higher energy consumption by 2020. In addition, tax policies in many regions erect hidden barriers—for instance, through enabling commercial sectors to write off energy costs (e.g., in the US Internal Revenue Service) and by applying a 30-year building depreciation schedule for energy efficiency investment.

Even more important, the revenues of utilities traditionally have been tied to the volume of electricity delivered, encouraging growth in electricity demand rather than in energy efficiency. Instead, regulation of utilities needs to reward promoting energy efficiency and energy-consumption patterns among their customers. For instance, the state of California has a program that rewards and penalizes privately owned utilities in the state by up to plus or minus $450 million to conduct energy efficiency efforts. Establishing white certificates to reward energy efficiency is another option that Italy, France, and the United Kingdom have already established. With the right incentives, demand side management (DSM) programs of utilities have been shown to lead to higher energy efficiency.[21]

In addition to the right incentives, the public and private sectors need to help provide capital to finance upfront investment in energy-efficient construction. Some private- and public-sector players are already offering energy efficiency loans. Among them, Citigroup and Bank of America have announced $50 billion and $18 billion funds respectively for green investment that includes preferential loans to energy-efficient residential houses.[22] China in turn has set up a $1 billion energy efficiency fund to spend on energy-efficient products such as new light bulbs, funded with resources earned from the sale of carbon credits.

But many more opportunities remain, and public-private partnerships can often be an effective way to expand the investment pie and to tap into specialized expertise. Under the Clinton Climate Initiative in the United States, the federal government has teamed up with partners in building-controls companies and financial institutions in a program to increase the energy efficiency of city buildings through retrofitting. Some $5 billion of loans from five major financial institutions are available to facilitate economically viable efficiency solutions.

There is much room for further innovation—for instance, through aggregating the energy savings from a number of individual households and companies and securitizing them into tradable energy-efficient mortgages, white certificates, or emission permits. In addition, mortgage players can find innovative ways to collaborate with utilities and energy intermediaries to link future energy savings directly to the terms of the mortgage—and thereby provide the right incentives to move to higher efficiency.

International financial institutions and development agencies and nongovernmental organizations (NGOs) have a critical role in expanding financing in the rapidly growing developing regions. For example, the World Bank's investment in

21 In the United States, a number of states have revived their energy efficiency programs in recent years by introducing Energy Efficiency Resource Standards (EERS) that set targets for reducing state electricity consumption. States typically mandate these through utilities, requiring revisions to their compensation mechanisms. Evidence from states that have introduced EERS indicates that, when utilities have an incentive to help overcome the information and agency barriers to higher productivity, they have been able to generate annual savings of around 1 percent of energy consumption.

22 These allow households that buy energy-efficient homes to qualify for higher mortgages by adding future utility-bill savings to their qualifying income, and they pay for any efficiency improvements over the lifetime of the mortgage. To compensate consumers for the time and cost of third-party certification, banks are now offering $1,000 off closing costs.

energy efficiency and renewable energy grew by 67 percent to $1.4 billion in the last fiscal year. The Renewable Energy and Energy Efficiency Partnership (REEEP), a global public-private partnership backed by more than 200 governments, businesses, development banks, and NGOs, specializes in the innovative financing of energy efficiency investments. For instance, REEEP finances the West Africa Modern Energy Fund, which aims to mobilize $120 million of third-party capital to fund energy efficiency in the region.

For the financial sector, this is a large and attractive investment opportunity of $35 billion annually, with IRRs ranging from 15 percent in the United States to 30 percent in China. These assets have relatively low risks and typically last for decades, making them particularly attractive for pension funds, life-insurance companies, and sovereign wealth funds that are looking for assets to match their long-term liabilities.

Raise corporate standards for energy efficiency

For many companies, high energy costs alone can be a competitive disadvantage in today's high-price environment and sufficient motivation to focus senior management attention on energy efficiency. Some trail-blazing companies have already demonstrated the benefits. Since the early 1990s, DuPont and Dow Chemical have achieved energy savings of $2 billion and $4 billion respectively through higher energy efficiency. In many cases, companies have not only met their savings targets but also gone beyond them—and frequently benefited from higher quality and better delivery times as well. And for many consumer companies, the brand value from being "green" is increasingly valuable among environmentally conscious consumers (see "Industrial sector opportunities vary by type of company").

Yet the very fact that there is still a large energy productivity opportunity available in the industrial and commercial sectors shows that a significant share of the potential today remains untapped. One key factor explaining why these sectors haven't gone after the opportunity is that many companies around the globe continue to be government-owned (e.g., much of Chinese industrial capacity) or enjoy high levels of regulatory protection, which shields them from competition (e.g., steel, until recently, in the United States and many other countries). Improving performance is hard work for managers, and without market pressure to do so, many companies will simply not seek to enhance their financial performance by taking advantage of all the opportunities to boost energy productivity that are available to them.

Institutional investors and other shareholders can play a key role in providing these incentives to go after fragmented energy productivity opportunities by, for instance, requesting energy efficiency and GHG information from public companies, encouraging managers to be "energy lean" in their operations—and reap the benefits in cost savings. Developing appropriate metrics and generating information is another option. In December 2007 a group of investment banks, together with the City of London, did just that by producing the London Accord, a new "open source" research resource for investors interested in climate-change solutions including energy efficiency.[23]

In state-owned enterprises and other nonmarket institutions, including energy productivity in performance evaluations is another option—an approach that we are already seeing in China. And last, private-equity firms can implement significant changes in areas where large opportunities remain. In the United States, some private-equity firms as well as utilities are already tapping into the large CHP opportunity in industrial companies, in which capturing the heat during on-site electricity generation can increase the efficiency of energy transformation from 40 percent to 80 percent.

Beyond the right incentives, there are two additional actions that can help companies identify and implement energy efficiency improvements that pay for themselves. First, energy consultants, service companies, and outsourcers can provide the necessary expertise and longer-term financing (see discussion in the next section). Second, investment guarantees and other incentives for major technology upgrades can help bring the least efficient industrial capacity up to standards. For many companies, these inefficient plants are typically the marginal ones that risk closure, and uncertainty about future production volumes can otherwise be a barrier to plant upgrades.

Collectively the industrial sector energy productivity opportunity can reduce 2020 energy demand by 53 QBTUs, achievable with $83 billion of additional investment annually until then. These savings equal more than 10 percent of total global energy consumption today, or over half of total current US energy consumption.

Invest in energy intermediaries

In all of the sectors we have discussed, some of the energy productivity opportunities will be left on the table despite the attractive returns. Consumers often

23 For details of the London Accord collaboration of investment banks, research houses, academics, and NGOs, see www.london-accord.co.uk.

Industrial sector opportunities vary by type of company

The opportunities to boost energy productivity vary among different kinds of industrial companies. In energy-intensive basic-materials industries such as chemicals and steel, the potential for increasing energy productivity typically relates closely to core-process technologies. Replacing old, inefficient plants or production lines with newer ones is often a major opportunity for improving energy efficiency, particularly in developing economies. There is an intermediation role here for both the public and private sectors. Public players can provide incentives for plant upgrades in the form of, say, guaranteed returns; the private sector can develop ways of pooling risk across multiple marginal plants in a number of regions or sectors.

Intermediate-goods manufacturers such as equipment makers or metal-casting industries typically run multiple energy-consuming processes. They therefore have large opportunities to increase efficiency through system optimization including, for example, unblocking bottlenecks and improving process flow. In addition to straightforward operational improvement programs, capturing the full potential may require specialized expertise. This opens up possibilities for energy outsourcers (such as power-island management) as well as opportunities to provide information through energy audits or consulting. For instance, a demonstration project undertaken by the US Department of Energy on the Martinez refinery in 2001 revealed the potential for a 12 percent improvement in energy efficiency with a payback time of two years or less.

Assembly operations such as automotive or consumer electronics typically have a relatively low energy share in their own processes, but they can still have a very large impact on their supply chains. OEMs can cut the overall energy intensity of their assembled products largely through their impact on suppliers by requiring these entities to report their energy consumption or carbon footprint; adopting supplier energy-certification programs and component efficiency standards; and providing consulting and funding programs for efficiency improvements. This opportunity is by no means limited to industrial companies. The Supply Chain Leadership Coalition, a group of leading global consumer-product companies such as Procter & Gamble, Unilever, Tesco, and Nestlé, has just launched its effort to press the companies' suppliers to disclose both their carbon footprint and their plans for climate-change abatement and mitigation.

For high-value-added industries—in the luxury and some high-tech segments—energy costs are typically simply not a priority. Such companies tend to seek energy efficiency improvements for "green branding" purposes alone. Even in this case, however, making information available about how much energy a product or a company consumes can make a difference.

make their choices based on nonfinancial factors and often lack the necessary information even if they wanted to make cost a bigger priority. Landlords are not inclined to make investments that benefit their tenants and vice versa. And commercial tenants typically have very high discount rates for energy-efficient investments because of the high turnover rate and uncertainty about being able to capture future savings. In the United States, 73 percent of commercial energy users require a payback within two years of their investment.[24]

In this context, there are opportunities for a range of intermediaries to find new ways to arbitrage and capture the opportunity. Energy service companies (ESCOs) are a growing segment that enables and funds energy efficiency investments. According to the National Association of Energy Companies, US ESCOs made $2.5 billion in energy efficiency investments in 2006. In South Africa, Eskom, the state-owned electricity company, has evaluated and registered more than 100 ESCOs as part of its drive to boost energy efficiency.

ESCOs have focused on the commercial sector where institutions—for example, a university or a hospital—are large enough to be attractive stand-alone investment opportunities; or where such institutions can be aggregated into larger units—i.e., all schools within a school district. The "MUSH" sector (municipalities, universities, schools, and hospitals) is particularly attractive. This sector consumes 25 percent of commercial energy demand and typically operates under stringent capital constraints. Many entities are unable to make even high-return investments because they lack sufficient capital, creating an opportunity for potential investors.[25]

Yet given that the typical time frame of ESCOs is shorter than 15 years, these entities could do much more to combine their expertise in energy-efficient solutions with longer-term capital interested in investing in opportunities with more

24 Stephen H. Wade, *Price Responsiveness in the AEO2003 NEMS Residential and Commercial Buildings Sector Models*, Energy Information Administration, 2005.

25 Government buildings provide another opportunity to improve energy efficiency. If governments lead by example by setting a standard for the rest of the society, the sheer scale of the public sector will at the same time create a significant market opportunity for companies to compete in offering energy-efficient appliances and solutions. Moreover, the lessons learned and the scale achieved from government procurement can help suppliers reduce the production costs of more energy-efficient products.

extended payback times. For example, the financial-services firm Hannon Armstrong in Washington, DC, has teamed up with Pepco Energy Services on 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 the buildings with higher-efficiency lighting and heating and cooling systems, and guarantee energy savings, while Hannon Armstrong will finance the project with payback over five to ten years through energy savings.

And there are opportunities beyond ESCOs. Utilities and energy outsourcers can offer energy supply and management services to end users ranging from housing communities and real-estate companies to industrial plants. Financial intermediaries can find ways to pool energy productivity gains across smaller players into tradable assets for white certificates or GHG-abatement credits. Energy consultants can provide energy efficiency certification services for both residential and commercial buildings. With the rewards available in today's high energy price environment, we are sure to see many new kinds of players emerge in the future.

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Governments, foundations, and other players in the social sector are becoming increasingly active in funding energy productivity, and effective public policy is important. However, today's environment means that there has never been a stronger intrinsic commercial case in favor of engaging more actively in energy productivity investments. The $170 billion in incremental capital needed annually is well within reach—and the prize of halving growth in energy demand and securing the considerable savings that this implies should be a strong incentive.

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