McKinsey Global Institute

Fueling sustainable development: The energy productivity solution

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Executive summary

Energy is a mounting policy and business concern in many developing countries today. Economic growth is boosting demand and imposing strain on existing energy-supply infrastructures, leading to brownouts and blackouts as witnessed recently in South Africa, Brazil, and Venezuela. High fuel prices are putting pressure on consumers and businesses and widening trade deficits among energy importers, causing political turbulence and economic uncertainty. Governments are struggling to find ways to secure sufficient energy supplies to meet growing demand, to finance the construction of capacity to deliver that supply, and to contain the rising cost of fuel subsidies.

The most cost-effective way to address these energy supply concerns is on the demand side: through improving energy productivity—the level of output an economy can achieve from the energy it consumes. Research by the McKinsey Global Institute (MGI) finds that by adopting existing energy-efficient technologies that pay for themselves in future energy savings, developing countries could reduce their energy demand growth by more than half—from 3.4 to 1.4 percent annually in the next 12 years—and reduce their energy consumption in 2020 by 22 percent from the projected levels. Because of its positive returns, energy efficiency is the cheapest form of new energy we have, as Chevron CEO David O'Reilly has remarked.

Higher energy productivity is a win-win for developing economies and their households and businesses. By improving demand-side efficiency, countries can cut down fuel imports and scale back the expansion of the energy-supply infrastructure that will otherwise be necessary—releasing resources to spend elsewhere. Higher efficiency would also reduce energy costs to businesses and consumers: MGI estimates that lower energy consumption would deliver cost savings that could reach $600 billion annually by 2020. The investment required to capture the energy productivity opportunity among end users would be some $90 billion annually for the next 12 years—only around half what these economies would otherwise need to spend on the energy infrastructure.

Public policy can play a vital enabling role, encouraging consumers and businesses to capture the benefits of higher energy productivity. The dismantling or reducing the influence of today's disincentives to efficient energy—fuel subsidies included—is a vital first step; putting in place effective incentives is the second. With supportive public policy, companies in developing economies have a rich opportunity to innovate and create new markets for energy-efficient goods and services—with the potential to export these into the world's rapidly growing green-solutions markets.

Time is of the essence. With many developing countries building capital stock both on a huge scale and at a rapid pace, there is a unique opportunity to ensure that this stock has an economically optimal level of energy efficiency, thereby locking in lower energy consumption for a generation. Developing countries that can pull this off will make substantial progress toward their dual aims of energy security and sustained economic growth.

Fueling sustainable development: The energy productivity solution

In many developing economies, energy is a growing concern among businesses, governments, and consumers alike. The main worry is that energy-supply infrastructure will not keep up with increasing demand, becoming a constraint to growth. The conditions in global energy markets are aggravating the situation, with high and volatile prices and supply risks—whether from weather-related shocks, political uncertainty, or evolving greenhouse gas (GHG) regulation. Governments and businesses are seeking ways to resolve the challenges they face and ensure that insufficient energy supplies will not halt sustained growth.

Improving energy productivity—the level of output we get from the energy we consume—is a way to address all of these energy-related concerns (see "What is energy productivity?").[1] By choosing more efficient cars and appliances, improving insulation in buildings, and choosing lower-energy-consuming lighting and production technologies, developing countries can cut growth in their energy demand by more than half over the next 12 years—from 3.4 to 1.4 percent per year.[2] Scaling back energy demand growth to this extent would translate into

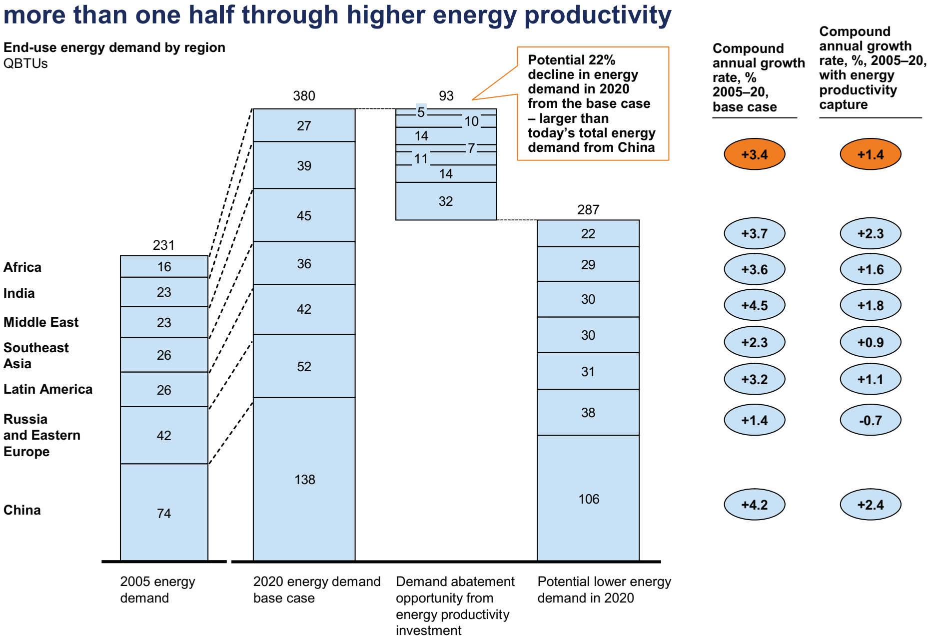
1 *Curbing global energy demand growth: The energy productivity opportunity,* McKinsey Global Institute, May 2007; and The case for investing in energy productivity, McKinsey Global Institute, February 2008 (both available for free download at www.mckinsey.com/mgi).

2 In this report, the developing countries that we analyze are China; Russia and Eastern Europe (Armenia, Azerbaijan, Belarus, Bulgaria, Georgia, Kazakhstan, Romania, Russia, Turkmenistan, Ukraine, Uzbekistan); Latin America (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela); Southeast Asia (Australia, Bangladesh, Indonesia, Malaysia, Myanmar, Nepal, New Zealand, Philippines, Singapore, Sri Lanka, Thailand, Vietnam); Middle East (Bahrain, Iraq, Iran, Kuwait, Kyrgyzstan, Oman, Pakistan, Qatar, Saudi Arabia, Syria, Tajikistan, UAE, Yemen); India; Africa (Angola, Benin, Cameroon, Congo, Côte d'Ivoire., Democratic Republic of Congo, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Mozambique, Namibia, Senegal, South Africa, Sudan, Togo, Tanzania, Zambia, and Zimbabwe).

2020 energy demand in these regions being 22 percent lower than it would otherwise have been—an abatement that would be larger than the entire energy consumption of China today (Exhibit 1).

Exhibit 1

Developing countries could cut energy demand growth by more than one half through higher energy productivity



Source: McKinsey Global Institute analysis

The economic case for improving demand-side efficiency is very strong. The solutions included in our assessment all generate an internal rate of return (IRR) of 10 percent or more in lower energy costs. So rather than costing money, investing in energy productivity generates energy savings that could ramp up to $600 billion annually by 2020 across all developing regions. And far from compromising the legitimate aspirations of consumers in developing countries for greater comfort and convenience, the more productive use of energy reduces their energy costs and leaves more money to spend elsewhere.

What is energy productivity?

Any successful program that addresses today's mounting energy-related concerns needs to be able to rein in energy consumption without limiting economic growth. Higher energy productivity is the most cost-effective way to achieve this goal.

Like labor or capital productivity, energy productivity measures the output and quality of goods and services generated with a given set of inputs. MGI measures energy productivity as the ratio of value added to energy inputs, which is $79 billion of GDP per quadrillion British thermal units (QBTU) of energy inputs globally. Energy productivity 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 globally.

Energy productivity provides an overarching framework for understanding the evolving relationships between energy demand and economic growth. Higher energy productivity can be achieved either by higher energy efficiency that reduces the energy consumed to produce the same level of energy services (e.g., a more efficient bulb produces the same light output for less energy input), or by increasing the quantity or quality of economic output produced by the same level of energy services (e.g., providing higher value-added services in the same office building).[3]

Investments in greater energy productivity would reduce the supply capacity that these countries would otherwise need to build to keep up with growing demand. And because energy efficiency improvements require less capital than new power plants or other energy-supply investments, improving energy productivity also cuts down on energy-related capital needs. The International Energy Agency (IEA) estimates that, on average, each additional $1 spent on more efficient electrical equipment, appliances, and buildings avoids more than $2 in investment in electricity supply. According to MGI analysis, developing countries could productively invest some $90 billion annually over the next 12 years on energy efficiency improvements with positive returns. The IEA analysis suggests that it would take almost twice as much investment—$2 trillion over 12 years—to expand the supply capacity for the additional 22 percent of energy consumption that we will see if developing regions fail to improve their energy

3 We use the term energy efficiency to refer specifically to the technical efficiency of translating energy inputs into energy services.

productivity.[4] Avoiding this expenditure on energy supply is particularly vital for those developing economies that face capital constraints on their growth and have a pressing need for investment in other areas such as infrastructure, health, and education.

Perhaps most importantly, a focus on improving energy productivity sets developing economies on a more sustainable growth path that will be more cost-competitive in global markets, less dependent on imported fossil fuels, and less susceptible to future energy price or supply shocks. Reducing waste in domestic energy consumption similarly benefits energy-supplying nations by directly expanding energy-export capacity. More efficient consumption of energy also reduces local pollution, an increasing challenge particularly in growing urban areas. And by cutting down on energy-related emissions of global GHGs, developing countries reduce the impact from any GHG taxes imposed on their exports and mitigate international political pressure around the issue of climate change (see “Energy productivity is the most cost-effective way to reduce carbon emissions”).

Many developing countries are already starting to make energy efficiency a part of their energy policy. China and Vietnam have included explicit energy productivity targets in their development plans; Russia and Ghana are building standard-setting capabilities; and Ecuador and India, among others, are making public buildings more energy efficient. And with higher energy costs, businesses are seeing the benefits of becoming energy-lean in their operations.

Yet much more remains to be done—and meeting the challenge is a matter of some urgency. Rapid growth in developing countries means that these economies are installing sizable volumes of new capital stock. Every new building or industrial plant built without the optimal level of energy efficiency is an opportunity lost to “leapfrog” to higher energy productivity and lock in lower energy consumption for decades to come. Also, the emerging global market for green products and services is still at an early stage. If their domestic markets encourage innovation in energy-efficient solutions, pioneering companies from lower-cost developing regions have a unique opportunity to grow into major global players before the market matures.

4 *World Energy Outlook,* IEA, 2007.

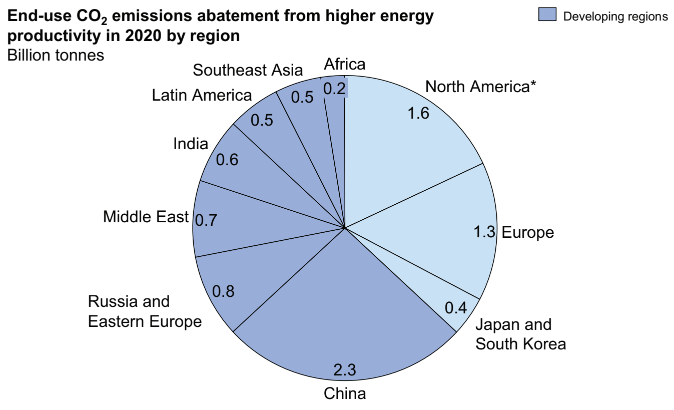
Energy productivity is the most cost-effective way to reduce carbon emissions

Increasing energy productivity is the most cost-effective way globally to reduce GHG emissions, representing roughly 70 percent of the positive-return opportunities identified in McKinsey's work on the global carbon-abatement cost curve.[5]

Developing countries account for two-thirds of the negative-cost energy productivity opportunity, for two main reasons. First, upgrading their rapidly expanding capital stock to higher energy efficiency costs less than retrofitting already existing plants or equipment. For example, increasing the efficiency of a new power plant by choosing more efficient equipment typically requires less incremental capital than replacing or retrofitting already existing equipment. And second, lower labor expenses reduce costs of installation and some other efficiency investments. As a result, boosting the energy productivity of developing countries' economies alone has the potential to reduce global CO_2 emissions by 15 percent in 2020, making it critical from the global climate-change perspective (Exhibit 2). For developing countries themselves, lower GHG

Exhibit 2

Developing regions represent 65 percent of the positive-return energy productivity opportunities to reduce greenhouse-gas emissions



* United States and Canada.
Source: McKinsey Global Institute analysis

5 See "A cost curve for greenhouse gas reduction," *The McKinsey Quarterly,* February 2007 (www.mckinseyquarterly.com); "What countries can do about cutting carbon emissions," The McKinsey Quarterly, April 2008 (www.mckinseyquarterly.com); and *The carbon productivity challenge: Curbing climate change and sustaining economic growth,* McKinsey Global Institute, July 2008 (www.mckinsey.com/mgi).

emissions will reduce their exposure to the impact of any GHG taxes imposed on their exports to other regions—an increasing concern particularly for exports of manufactured products and raw materials.

In the following pages, we present our microeconomic analyses of energy end-use segments to assess energy demand growth prospects in developing countries to 2020. We then describe the energy productivity opportunity across sectors and regions and discuss how timely action is necessary if developing countries are to capture the full potential that is available. Lastly, we examine today's barriers to higher energy productivity and suggest ways for governments, businesses, and international organizations to overcome these hurdles and to capture the attractive opportunities that are waiting to be seized.

DEVELOPING COUNTRIES ACCOUNT FOR JUST OVER HALF OF GLOBAL ENERGY DEMAND TODAY

Developing countries account for 51 percent of global energy demand today. China consumes 16 percent of the worldwide total while Russia and Eastern Europe account for another 9 percent. Latin America, Asia, Africa, and the Middle East collectively represent 26 percent. With the exception of Russia and Eastern Europe, per capita energy consumption in developing regions is significantly lower than in developed regions (Exhibit 3).

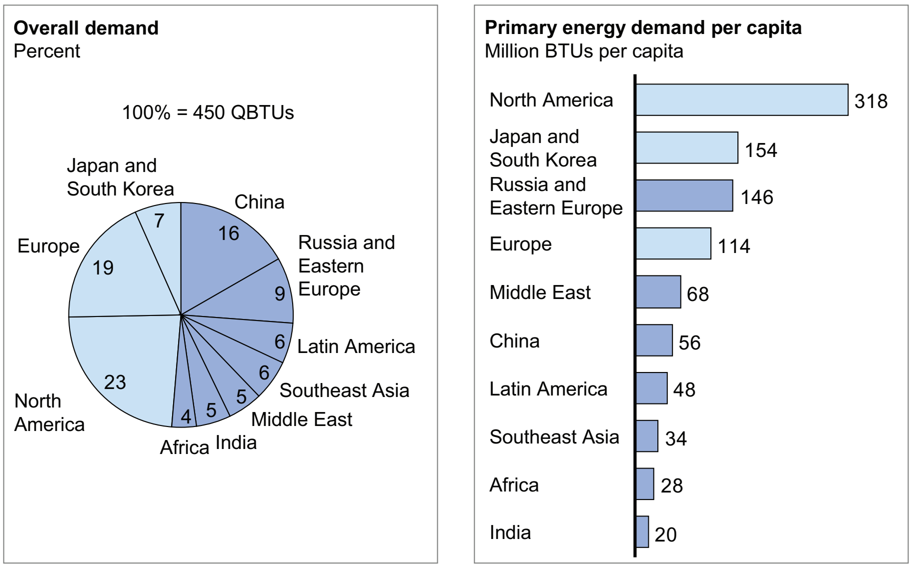
Compared with developed economies, the industrial sector consumes a higher share of energy in developing regions. This reflects a lower share of services—and thus commercial-sector energy consumption—as well as the fact that demand for household transportation fuels also tends to increase with income. Notable exceptions to the pattern are Africa and India, where low income levels limit energy consumption outside the residential sector, as well as the Middle East and Latin America where subsidized fuel prices boost transportation demand (Exhibit 4).

The fuel mix across regions varies widely, reflecting different stages of economic development as well as local energy endowments. In Africa and India, biomass—mostly wood and dung used for cooking and heating—still represents one-half and one-third respectively of overall energy consumption. In the Middle East and Latin America, local oil production and subsidized prices explain the high share

Exhibit 3

Developing countries represent just over half of global energy consumption today

Primary energy demand 2005

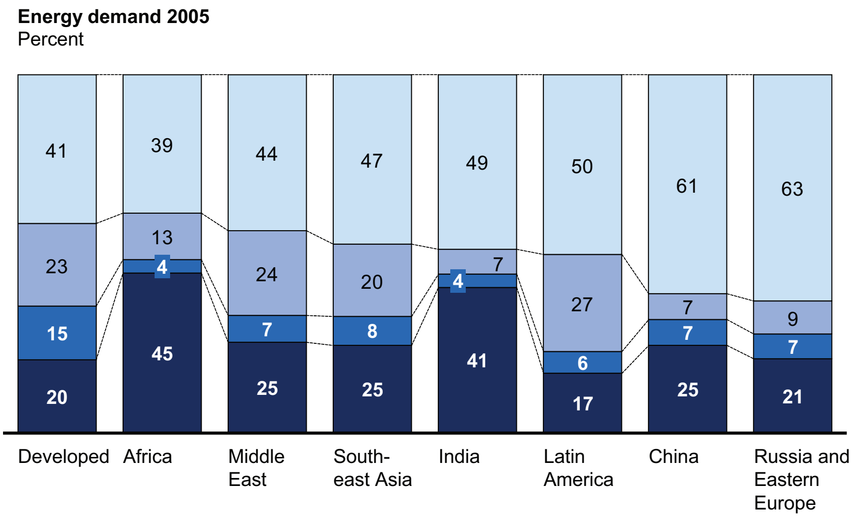


Source: International Energy Agency (IEA)

Exhibit 4

Developing countries display wide differences in fuel use

Industrial
Transport
Commercial
Residential



Source: McKinsey Global Institute analysis

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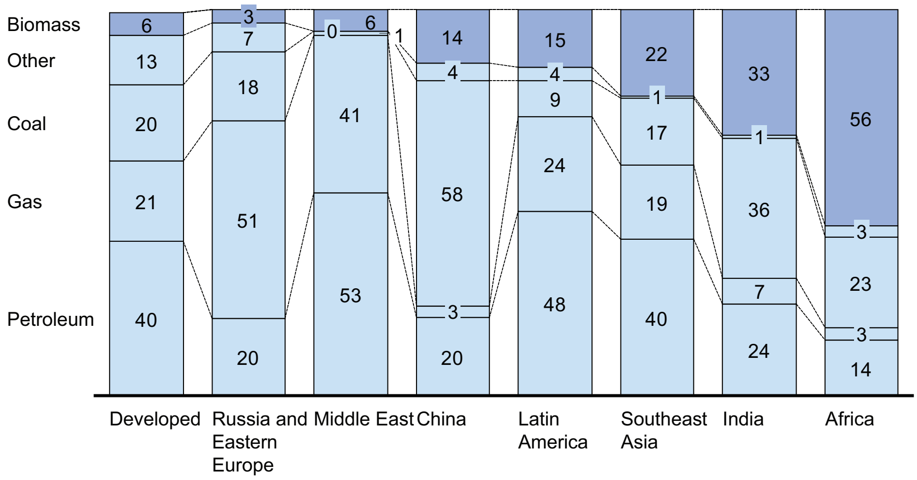
of petroleum products, reflecting higher fuel consumption and a heavier reliance on oil in the industrial sector. Energy endowments also explain the high share of natural gas in Russia and Eastern Europe and of coal in China (Exhibit 5).

Exhibit 5

Biomass remains a significant share of energy in developing regions – reducing overall efficiency

2005 primary energy demand by fuel mix
Percent



Source: McKinsey Global Institute analysis

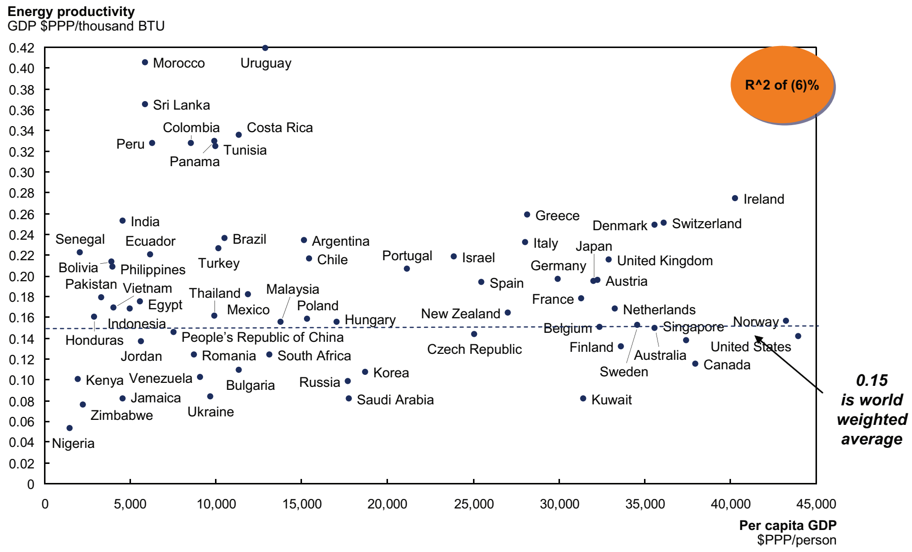
There are large differences in energy productivity among developing countries at similar levels of income (Exhibit 6). Three structural factors explain roughly half of the variation. In order of importance, these are energy policies, the structure of an economy, and the climate (Exhibit 7). Policy-related factors—subsidized or taxed fuel and electricity prices, and the level of corruption in a particular country or region—explain a quarter of the variance; energy subsidies tend to reduce energy productivity, and taxes increase it. The structure of an economy explains another 21 percent; countries with large manufacturing sectors tend to consume more energy and have lower energy productivity. Climate contributes another 13 percent; the more extreme the weather, the more heating and/or cooling is necessary, and the more energy is required per unit of GDP.

However, the fact remains that less than 50 percent of the energy productivity differences that exist are due to these structural variations.[6] This strongly

6 Some of the remaining variance reflects within-sector differences in economic activity that we are unable to detect with the two-digit SIC code sector variables included in the analysis.

Exhibit 6

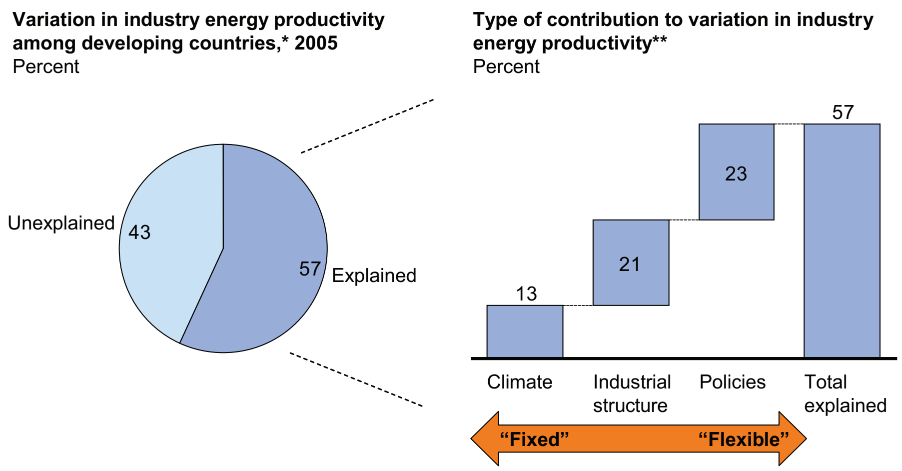
Energy productivity varies widely among countries with similar levels of economic development



Source: IEA; Global Insight; McKinsey Global Institute analysis

Exhibit 7

Policies and economic structure explain roughly half of the energy productivity variation among developing countries



* 27 developing countries (<$PPP nominal 2007 11,000/capita).

** Climate is based on hot/cold days; industrial structure reflects the manufacturing and nonmanufacturing subsectors of the economy combined with level of per capita income; policies reflect the presence of gas subsidies, gas taxes, and an index of corruption.

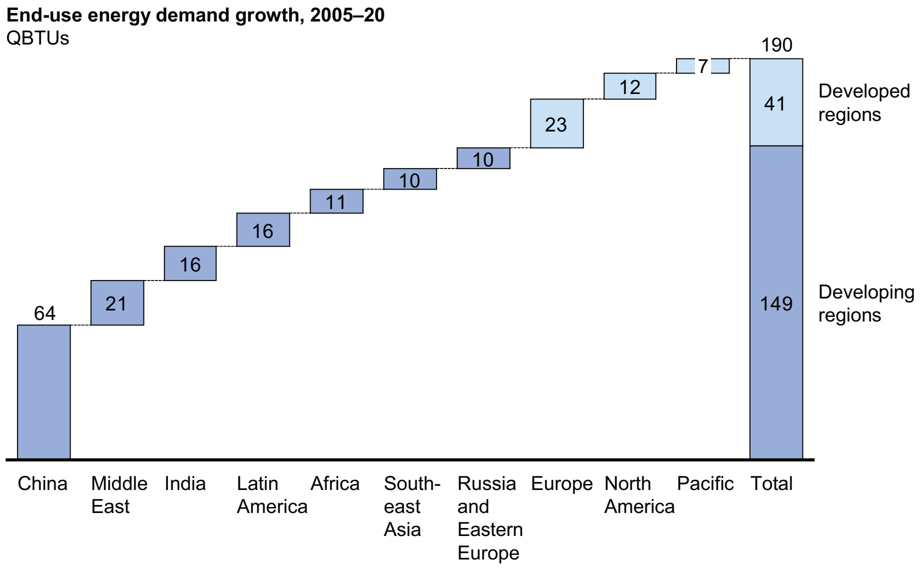
Source: IEA; Global Insight; national sources; McKinsey Global Institute analysis suggests that most countries have room to improve their energy productivity by adopting best practices developed elsewhere.

BY 2020, ENERGY DEMAND FROM DEVELOPING ECONOMIES WILL HAVE GROWN BY 65 PERCENT

Energy demand in developing countries will continue to increase at a rapid rate in line with fast GDP growth. Under the current policy environment, developing regions will generate 80 percent of global energy demand growth to 2020, raising their energy demand by 65 percent (Exhibit 8). By 2020, these countries will together represent 60 percent of total global energy consumption.[7] However, measured on a per capita basis, these countries' energy consumption will still be less than 40 percent of that of developed regions by 2020.

Exhibit 8

Developing regions will contribute 80 percent of global energy demand growth to 2020



Source: McKinsey Global Institute analysis

China alone represents 34 percent of the global energy demand growth that MGI projects to 2020. Even with the significant energy efficiency improvements expected under current policies in China, continuing industrialization and quickly

7 MGI's base case assumes global GDP growth of 3.2 percent annually to 2020 and an oil price of $50 a barrel.

expanding demand from the country's growing ranks of middle-class consumers will fuel rapid energy demand growth (see "China's energy demand is set to double by 2020").

China's energy demand is set to double by 2020

With current policies, China's energy demand will grow at 4.2 percent annually to 2020, almost doubling from 74 QBTUs in 2005 to 138 QBTUs in 2020. China's industrial energy demand will grow at 3.5 percent per year to 2020, faster than worldwide growth of 2.2 percent.[8] As a result, China's energy demand will account for 26 percent of global industrial energy demand in the next 12 years. With strong GDP growth, demand for basic materials is expected to soar. For instance, China's steel demand will grow by 4.4 percent annually by 2020, with the country consuming 48 percent of global steel. As a result, energy demand from the steel industry will grow even faster at 5.1 percent annually. Despite continuing improvements in energy efficiency, the average energy intensity of steel production will increase as scarcity of scrap steel will lead to more energy-intensive integrated steelmaking.

But it is not just China's rapid industrialization that will boost energy consumption. China's residential energy demand will grow at 4.4 percent per year over the next 12 years. China's growing and increasingly prosperous middle class already aspires to own more spacious houses and new, larger appliances, and higher incomes will reinforce this trend. China's floor space per capita today is 25 square meters, at the low end of the global spectrum. However, when housing privatization began to gather pace after 1995, per capita floor space started to rise and is expected to hit 38 square meters in 2020.

The penetration of energy-consuming appliances will be an important contributor to residential energy demand growth. As private-car ownership soars, road transportation energy demand will grow by 6.4 percent per year in MGI's base case—triple the pace of the global figure of 2.1 percent. China's vehicle sales posted a compound annual growth rate (CAGR) of 8 percent between 1995 and 2000, only to explode to 23 percent between 2000 and 2005. This strong growth is likely to continue. MGI's base case is that China's

8 *Leapfrogging to higher energy productivity in China,* McKinsey Global Institute, July 2007 (www.mckinsey.com/mgi).

vehicle stock will grow by close to 10 percent per year to 2020, expanding from 25 million vehicles in 2003 to 120 million in 2020—an increase of 350 percent.

China's commercial-sector energy demand is poised to grow by 6.3 percent per year to nearly triple by 2020—accounting for 40 percent of global commercial-sector energy demand growth during this period. This robust expansion in demand from this source reflects the increasing share of services in China's economy as incomes rise. We expect commercial floor space to expand by 4.8 percent per year by 2020 and, as a result, the penetration of energy-consuming appliances will increase too. Commercial buildings typically install basic heating and air conditioning when they are first constructed, and we expect space-heating penetration to increase from 35 percent in 2000 to 55 percent in 2020. Other power-intensive appliances and equipment—such as computers in office buildings and advanced medical equipment in hospitals—will then follow.

Interestingly, India represents a much smaller share of energy demand growth (8 percent of the global total) than China. There are three reasons for this. First, India has a lower income level than China and thus a lower penetration of energy-consuming appliances. Second, India is at an earlier stage in its industrialization and has a lower share of heavy manufacturing, and its industry therefore consumes less energy than industry in China. And third, a shift in India's fuel mix from biomass to more efficient electricity will act to mitigate energy demand growth.

On the other hand, the Middle East will account for 11 percent of energy demand by 2020, making it the second-largest contributor to the overall growth in energy demand of developing countries. The $50 a barrel oil price assumed in MGI's base case will boost the region's GDP growth—at even higher oil prices, the push to GDP growth will be even stronger. These countries' energy-heavy development strategies along with large energy subsidies to consumers will continue to make growth highly energy intensive.

Latin America and Asia (not including China and India) will represent 8 percent and 5 percent respectively of overall growth in energy demand, with both industrial and consumer end-use sectors driving expansion. Russia and Eastern Europe is an exception among developing countries in that this region will witness slower energy demand growth of 1.4 percent per year. This is due to the fact that these economies are shifting away from the extremely energy-intensive and inefficient production of the Soviet era.

We do not expect the fuel mix in developing countries to change much, the residential sector being an exception to this trend as this sector's use of biomass declines as electricity starts to take over. In India, for example, while we expect overall energy demand growth of 3.6 percent annually, we project growth in electricity demand at 5.2 percent. In itself, fulfilling this demand for electricity will be a significant task as the trajectory of electricity demand implies a tripling of installed capacity from the current level of about 140 gigawatts. This translates into an annual addition of 20 to 40 gigawatts, a five- to tenfold increase on the 4 gigawatts per year of additional capacity put in place over the past decade.[9]

In MGI's base case, the rapid acceleration of economic growth in developing countries is one of the major causes for a speeding up of energy demand growth over the next 15 years. However, changes in the GDP growth rate would impact energy demand evolution—to a much greater degree than changes in oil prices. Our research shows a substantial swing in energy demand growth between our low- and high-growth scenarios (Exhibit 9).[10] This swing is the equivalent of an 86-QBTU variation around our base-case demand forecast of 380 QBTUs of energy demand in 2020. China and the Middle East together account for more than 50 percent of this swing between the low- and high-growth scenarios.

Now take the impact of oil prices on energy demand growth. Here, the swing between low- and high-price scenarios is only 8 QBTUs around our base-case oil-price scenario of $50 a barrel. Oil at $30 a barrel decreases energy demand growth by 7 QBTUs, while oil at $70 per barrel leaves global energy demand virtually unchanged.

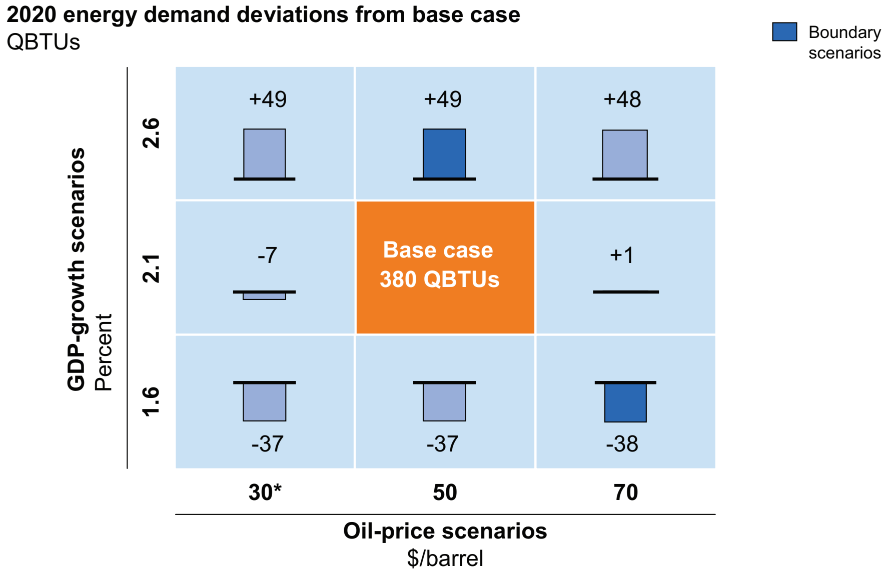
There are two reasons why the impact of oil prices on energy demand is so small. First, changes in the oil price have an impact on only a small proportion of the range of energy prices paid by end users. Coal prices don't necessarily correlate with those of oil. In residential and commercial sectors, electricity and gas prices are frequently subject to regulation, and, therefore, changes in the oil

9 *Powering India: The road to 2017,* McKinsey & Company, June 2008 (www.mckinsey.com/locations/india).

10 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.

Exhibit 9

GDP growth has a much stronger impact on energy demand than the oil price



* At $30 per barrel oil price, substitution of coal with natural gas for power generation; with higher efficiency of gas power plants, overall energy demand slightly decreasing over $50 per barrel scenario.

Source: McKinsey Global Institute analysis

price do not necessarily feed through to the prices charged to consumers and businesses. Even in transportation sectors, many consumers are partly insulated from movements in the crude price. One-third of global fuel consumption is either subsidized or heavily taxed (Exhibit 10).

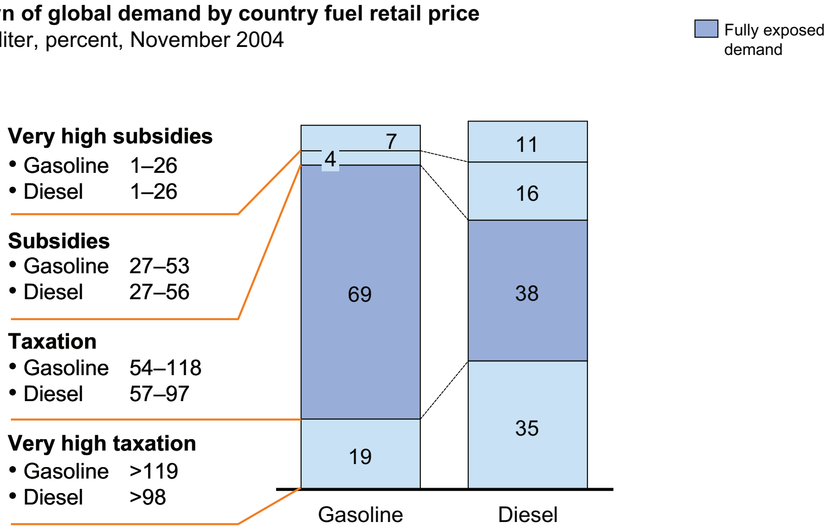
The other reason even high oil prices have such a limited effect on energy demand is that these prices have two main effects that go in opposite directions and therefore virtually cancel each other out. In road transportation sectors that are not subject to major subsidies or tax breaks, high oil prices directly lower energy demand. In the United States, for instance, MGI's projections show that oil prices of about $70 a barrel result in fuel demand being 15 percent lower than it is at $30 a barrel—the equivalent of 2.5 million fewer barrels a day. However, in oil-exporting countries in the Middle East, for example, high crude oil prices have the opposite result. High oil prices accelerate GDP growth and therefore energy demand. In addition, because energy prices are often subsidized and energy productivity is low, there is a very limited demand response even to very high oil prices, further reinforcing rapid energy demand growth.

High crude oil prices may not decrease or increase energy demand, but they do have a significant impact on the fuel mix. Because oil and natural gas prices

Exhibit 10

A large share of global fuel demand is insulated from the oil price by taxes or subsidies, especially demand for diesel

Breakdown of global demand by country fuel retail price
Cents per liter, percent, November 2004



Source: GTZ International Fuel prices 2005; McKinsey Global Institute analysis

paid by power companies tend to increase as oil prices rise, these energy consumers have a greater incentive to shift to coal. The problem is that this typically increases pollution and GHG emissions.

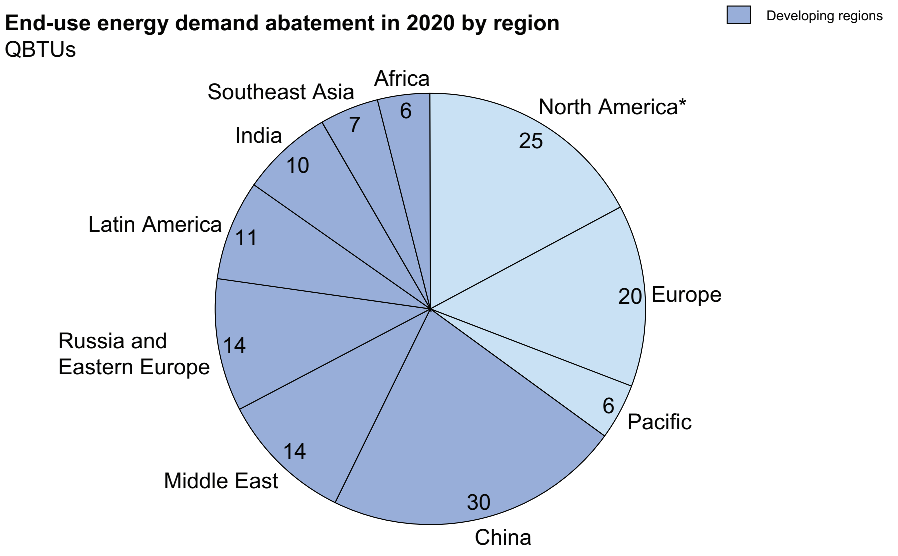
IMPROVING ENERGY PRODUCTIVITY COULD CUT ENERGY DEMAND GROWTH BY MORE THAN HALF

The good news is that there are large, economically attractive opportunities that can significantly reduce the rate of energy demand growth globally and in the developing world in particular. MGI projects that, across all developing regions, capturing the energy productivity potential would cut energy demand growth from 3.4 to 1.4 percent annually. We base this estimate on the adoption of existing energy-efficient technologies that pay for themselves in future energy savings, and on the removal of energy subsidies that discourage efficient energy use.

Our research finds that there are energy productivity opportunities across all the regions (Exhibit 11). Approximately 85 percent of the potential consists of energy demand reduction from adopting existing technologies that provide an

Exhibit 11

Developing regions represent 65 percent of the positive-return opportunities to reduce energy demand



* United States and Canada.
Source: McKinsey Global Institute analysis

IRR of 10 percent or more.[11] These opportunities are available in all the major energy end-use sectors.

- **Residential (22 percent of the opportunity).** Examples include very high-return opportunities in more efficient appliances and equipment as well as in compact fluorescent (CFL) and light-emitting diode (LED) lighting, and large, but more capital-intensive, opportunities with longer payback periods in high-efficiency building shells. To capture these opportunities, developing regions would need global incremental investment in the range of $21 billion annually to 2020—or a cumulative $13 billion per QBTU abated in 2020.

- **Commercial (9 percent).** There are significant opportunities in commercial buildings, largely in heating, cooling, and lighting. Yet because of the higher initial efficiency level in this sector, the average incremental capital requirement to abate 1 QBTU of commercial-sector energy in 2020 is a cumulative $16 billion in 2020.

- **Transport (5 percent).** While auto manufacturers are likely to adopt engine-

11 For a full analysis of the energy productivity investment opportunities, see *The case for investing in energy productivity,* McKinsey Global Institute, February 2008 (www.mckinsey.com/mgi).

related fuel-economy improvements when oil prices are $50 a barrel or above, some opportunities remain in reducing vehicle weight and size through material substitution and vehicle redesign. Given the high cost of lightweight materials such as aluminium or high-performance composites relative to iron and steel, the incremental capital requirements are larger than in the other sectors—cumulatively close to $18 billion per QBTU of energy abated in 2020.

- **Industrial (45 percent).** This is the largest area of potential with a broad array of fragmented opportunities in steel, chemicals, aluminium, food processing, textiles, electronics, and many other industries. Yet this aggregate figure consists of hundreds of smaller opportunities. These include large cross-sector prospects such as combined heat and power (CHP) generation and the optimization of motor-driven systems, as well as more sector-specific opportunities such as liquid-membrane separation in chemicals or thin slab casting in the steel industry. The global incremental investment required to capture this opportunity is $58 billion per annum—or a cumulative $19 billion per QBTU abated in 2020.

- **Power sector (20 percent).** Roughly two-thirds of the primary energy consumed in electricity generation is lost during the generation process itself and during transportation to end users. With conversion efficiencies ranging from less than 30 percent in older coal generators to 60 percent in advanced combined-cycle gas turbines (CCGT), there are large opportunities for reducing losses in both new and existing power generation plants.[12] It makes a big difference whether the rapidly expanding electric power capacity in many developing countries relies on high-efficiency technologies such as supercritical coal plants or advanced CCGTs. And in many regions, it makes economic sense to replace inefficient, old power capacity because future energy savings pay for the investment cost of new, more efficient equipment. In Russia today, almost 40 percent of existing power capacity is already at the end of its technical lifetime, so that replacing these plants with new-generation technologies makes economic sense. Lastly, large opportunities exist to increase the efficiency of the transmission system in order to reduce associated losses.

Reducing excessive energy consumption in subsidized environments today accounts for the remaining 15 percent of the total opportunity to boost energy

12 Conversion efficiency refers to the ratio of electric power output to the energy inputs required to generate it.

productivity (see “Estimating the energy wasted because of subsidies”).

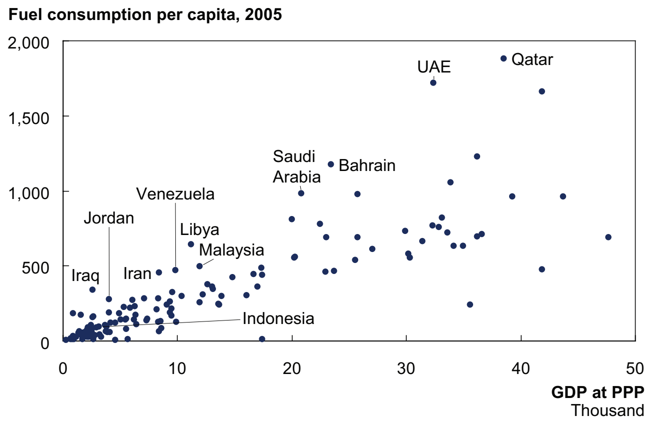
Estimating the energy wasted because of subsidies

The IEA estimates that energy subsidies in non-OECD countries totaled more than $250 billion annually in 2005—more than the annual investment required for electricity-supply infrastructure in these countries. This investment in supply is likely to be even higher in the current environment because of spiraling oil prices.[13]

Countries that subsidize transportation fuels encourage driving and have vehicle fleets with lower fuel economy. As a result, these countries consume up to twice the fuel per vehicle as other countries at similar income levels

Exhibit 12

Countries with fuel subsidies tend to have higher per capita fuel consumption



Source: IEA; Global Insight

(Exhibit 12). And because a subsidy covers each unit of energy wasted as well, the overall cost of such programs is substantial. For example, Iran spent 16 percent of its GDP in 2007 on energy subsidies. In Mexico, the estimated cost of such subsidies reached 2 percent of GDP in 2008. MGI estimates that reducing fuel subsidies by 80 percent globally (largely in the Middle East, Venezuela, and Mexico) would reduce global demand for road transportation fuel by 5 percent—the equivalent of shaving 2.5 million barrels per day off overall fuel demand.

13 *World Energy Outlook,* IEA, 2006.

In the Russian residential sector, nonmarginal pricing—or the zero marginal cost—of gas for heating removes incentives for insulation and has led to wasteful practices such as regulating room temperature by opening and closing windows during the winter. We estimate that removing the current subsidy on Russian gas alone would lead to 2 QBTUs in energy savings by 2020. Taking away kerosene subsidies in China and India and electricity subsidies in Russia and India would also help reduce consumption. In industrial segments, the major opportunities lie in removing energy subsidies and policies that give preferential treatment to particular industries (e.g., power subsidies for favored industrial operations in Russia), and introducing corporate-governance practices that create incentives to capture higher energy productivity opportunities with positive returns (e.g., improving refining conversion economics in Mexico). Together these represent an opportunity of about 5 QBTUs by 2020.

We believe our assessment to be a relatively conservative estimate of the overall potential available for developing countries. We have focused on currently available opportunities that do not account for technological innovations or additional scale benefits and learning that will accrue over time. Nor do we assess the potential available from comprehensive system redesigns—an area in which developing countries have a golden opportunity to implement more radical step-changes during today's era of rapid capital expansion. With the lower labor costs for, say, process design engineering and insulation installation, we believe that pioneering companies in developing regions have an opportunity to set standards far above what is commercially available today—and reap the economic benefits (see "Achieving more efficiency for less investment").

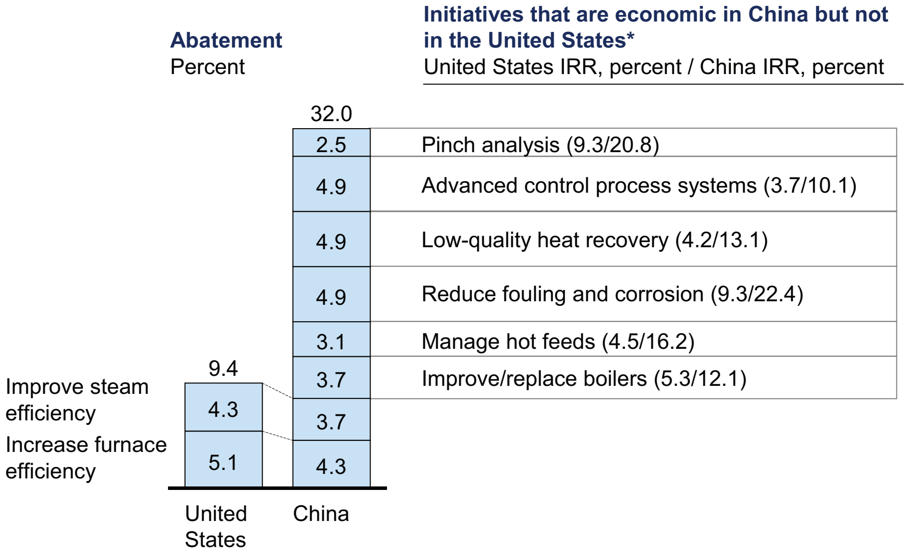
Achieving more efficiency for less investment

Average capital requirements for energy productivity investment across all end-use sectors are some 35 percent lower in developing countries than in developed regions. This largely reflects lower labor costs, which act to lower 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. In areas where these cost savings are particularly important, the gap can be much larger. For example, in China the capital required per QBTU of energy abated in steel and pulp and paper is more than 50 percent lower than in the United States.

The benefits of lower capital costs not only reduce investments needed to reach the same level of efficiency but also expand the range of efficiency solutions that meet the 10 percent hurdle rate. Take the industrial sector where developing regions represent 80 percent of the global total energy productivity opportunity. This large share reflects (1) the fact that, with expanding industrial capacity, developing countries can upgrade more economically to higher-efficiency technologies; (2) the remaining scope to increase energy productivity in low-efficiency legacy assets in a number of regions; and (3) 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 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, in effect tripling the pool of economically viable opportunities (Exhibit 13).

Exhibit 13

Lower capital costs in China push many refining initiatives over the 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

INVESTING IN ENERGY PRODUCTIVITY BRINGS LARGE ECONOMIC BENEFITS AND REDUCES EXPOSURE TO ENERGY-RELATED RISKS

MGI has identified opportunities that offer returns of at least 10 percent—and considerably more in many cases. The average IRR across all these solutions is 17 percent, with lighting and appliance opportunities providing returns in excess of 100 percent and paying back their initial investment in less than one year. As we have noted, to capture all the opportunities in all end uses, developing countries would need about $90 billion in incremental investment over the next 12 years. However, even by focusing solely on the highest-return opportunities, countries can achieve significant energy savings with a fraction of this overall investment.

Far from putting pressure on the economic development of these regions, investing in energy efficiency would generate large net economic benefits. We estimate that across all developing regions, the value of these savings would ramp up to $600 billion by 2020—or more if today's high energy prices prevail. This translates into lower energy costs for businesses, consumers, and the government and improves energy-related trade balances—either by reducing need for imports or by expanding export capacity. Higher energy productivity also helps reduce demand-driven energy price pressure and reduces the risks from international energy price and supply shocks in the future.

By lowering energy demand, higher energy productivity would also obviate the need to spend so heavily on expanding developing regions' energy supply capacity. To meet the demand growth projected in MGI's base-case scenario, energy supply will need to expand significantly in all regions at a cost of some $11 trillion.[14] If developing countries were to capture the full energy productivity prize and cut their energy consumption by more than 90 QBTUs by 2020, they would collectively save more than $2 trillion by avoiding investment in energy supply. This is roughly twice the cumulative investment required to boost energy productivity, representing a net decline in capital requirements of more than $1 trillion.

The resources that developing regions would save would then be available for investment or expenditure elsewhere—particularly valuable in those developing countries where access to capital is a constraint to growth today. For example, in India, we estimate that annual supply-side savings could be in excess of

14 *World Energy Outlook,* IEA, 2006.

$14 billion in 2020—greater than current government spending on health and education combined.[15]

So while there is a substantial opportunity to rein in growth in energy demand across the world by embracing energy productivity as a goal, the potential in developing countries is particularly attractive. These regions have a unique opportunity to leapfrog to more energy-efficient technologies and solutions—but they need to seize the potential urgently.

Rapid GDP growth in these countries means high investment rates on new buildings, machinery, and equipment. As a result, more than half of the capital stock in many developing countries in 2020 will be built in the next 12 years. The energy efficiency of the new capital stock will in turn determine future energy demand—and its environmental impact—for decades to come. It is much more economic to incorporate higher energy efficiency features when installing new capital than to retrofit at a later stage. This applies for all solutions, whether implementing double, versus single, windows or adopting new industrial-production technologies. For this reason, there are large benefits for developing countries to take action soon and install higher-efficiency capital during their rapid growth between now and 2020.

MANY BARRIERS TO ENERGY PRODUCTIVITY REMAIN

Despite the attractive economics of higher energy productivity, developing countries—and those in the developed world—have thus far left much of the potential on the table. The reason for this is that an array of policy distortions, market failures, and information barriers today stand in the way of consumers and businesses seizing an economically attractive course of action (Exhibit 14).

- **Energy subsidies.** Subsidies on energy in many developing regions directly discourage efficiency by shielding energy users from the true cost of the energy they consume. As we have discussed, low energy prices encourage waste among users—with large associated economic costs. Governments tend to offer energy subsidies for legitimate political reasons. For instance, the subsidized cost of cooking and heating fuels can stem from a desire to

15 “Large allocations for education and welfare,” Economic Times, March 2, 2008 (http://economictimes.indiatimes.com/Features/Financial_Times/Large_allocations_for_education_and_welfare/rssarticleshow/2829944.cms).

help the lowest-income segments of the population, while many oil-producing countries cap transportation fuel prices as a way to share the benefits accruing from national energy resources. Many governments consider access to electricity as a basic right and offer below-cost pricing to both consumers and industry. However, holding energy prices below a market level discourages the expansion of supply, and this can lead to shortages and rationing—and rationing tends to have the most direct negative impact on the poor.

Exhibit 14

Distorting policies and market imperfections reduce the capture of energy productivity opportunities

	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 making choices based on nonfinancial factors • Fragmented energy costs unnoticed by companies
Agency issues	• Appliance makers not adopting 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, Hospitals.
Source: McKinsey Global Institute analysis

- **Market failures and information barriers.** Even in markets where energy prices broadly reflect associated costs, a number of market failures and inefficiencies restrict the adoption of energy-efficient solutions.[16] In developing economies, capital constraints are an impediment to upgrading to more energy-efficient buildings, appliances, and equipment. Many low-income households face very high borrowing rates and simply cannot afford to invest in more efficient equipment, even with large potential savings in lower future energy costs. In many cases, an individual who will not benefit

16 For a synthesis of the research on the barriers to energy efficiency, see *The Experience of Energy Efficiency Policies and Programmes in IEA Countries: Learning from the Critics,* IEA, August 2005.

from the energy savings is the one making the investment decisions. For example, landlords are not inclined to make investments that benefit their tenants. Moreover, consumers are often unaware of ways to become more energy productive and tend to make choices based on nonfinancial factors such as convenience and comfort.

- Many companies in developing countries do not face financial or other incentives that would catalyze them into taking complete advantage of the opportunities to boost energy productivity. In some cases, government-owned businesses lack the managerial incentives to capture efficiency gains (e.g., Mexican refining sector); in others, companies enjoy high levels of other regulatory protection (e.g., until recently, the automotive industry in many regions). In the absence of the requisite market pressure, improving performance and being more energy efficient is hard work for managers, and companies simply forgo the opportunities. The small and fragmented nature of energy costs in most operations tends to deter businesses from capturing the full potential available. The absence of management incentives, capital allocation practices, and a lack of skills also explains why many industrial companies do not adopt economically viable energy-saving solutions.

Because changes in global oil prices do not typically translate into equally large swings in consumer prices, as we have discussed, escalating oil prices alone will not remove many of the barriers to higher energy productivity. In short, even with oil prices at $100 a barrel or more, consumers and businesses may well forgo the opportunity to boost energy productivity and reap its benefits.

GOVERNMENTS NEED TO CREATE THE RIGHT POLICY ENVIRONMENT FOR HIGHER ENERGY PRODUCTIVITY

There is much that governments can—and should—do to overcome today's barriers to higher energy productivity, creating an environment that rewards energy-efficient choices and encourages innovation by consumers and businesses. Governments need to shift the focus of energy policies toward pushing demand-side efficiency—a shift that we are beginning to see in many developing regions (see "Higher energy efficiency is becoming a policy priority").

Higher energy efficiency is becoming a policy priority

Governments in many developing countries have recently announced energy demand-side management policies. China has committed itself to a target of reducing energy intensity by 20 percent by 2010, while Vietnam has set a target of saving between 3 and 5 percent of the country's energy consumption in its five-year plan from 2007 to 2012.[17] In an effort to promote energy efficiency, the government of Ecuador has introduced a program in 50 public buildings.[18] In India, the Bureau of Energy Efficiency has joined forces with the International Finance Corporation and the Alliance to Save Energy in a large-scale effort to improve the energy efficiency of municipal buildings.[19] The Indian government introduced an Energy Conservation Code for commercial buildings in 2007 aimed at cutting their energy consumption by 25 to 40 percent.[20]

MGI highlights four areas that have the potential to support most effectively the energy efficiency agendas of developing world governments:

Reduce energy subsidies. Governments in developing countries need to reconsider the energy subsidies that today discourage the efficient use of energy and in some cases hinder a shift to more efficient fuels. Not only do these subsidies have significant economic implications, but also they are not necessarily the most effective policy tool to meeting the desired sociopolitical objectives.

We acknowledge that scaling back subsidies is fraught with difficulty. For one thing, consumers and businesses have already made choices that lock in high demand for subsidized fuels, and reducing subsidies could potentially escalate costs in the short term. Political resistance to losing energy subsidies can be robust, as we have seen in Malaysia, Indonesia, and South Korea.[21]

17 "Vietnam aims to save $8 billion by being more energy efficient," *Asia Pulse,* August 6, 2008.

18 "Ecuadorian government launches energy efficiency programme in public buildings," *Latin America News Digest,* March 26, 2008.

19 "IFC, Bureau of Energy Efficiency, and Alliance to Save Energy promote municipal energy efficiency projects in India," *States News Service,* March 10, 2008.

20 *Indian Business Insight, The Tribune,* May 28, 2007.

21 "Protests widen in Asia over fuel costs: Truckers block ports as governments are asked to help or quit," *International Herald Tribune,* June 14, 2008; "Indonesia raises its fuel prices," *The Wall Street Journal,* May 24, 2008.

Nevertheless, there is a strong economic case for seeking to decouple income subsidy programs from specific products or services. To ease a transition to more efficient energy use, governments should consider providing financing for upgrading to more efficient capital and equipment, and use some of the savings from high energy prices to target poor segments of the population. Other initiatives can achieve similar welfare goals—at a lower cost—as energy subsidies. For example, in Latin America and other countries, governments have used conditional cash-transfer programs to help reduce poverty, which can also help compensate low-income households for high energy costs. Direct cash payments that redistribute national oil revenues and boost household income and national welfare—as we are seeing in Alaska—are another option.[22] These programs have the additional benefit that, rather than solely financing inefficient energy consumption, they can generate broader multiplier effects in the economy as additional income is spent on other products and services.

Reform utility-company incentives. Utilities are typically rewarded for the volume of electricity delivered, which encourages growth in electricity consumption rather than energy efficiency. Instead, regulators can encourage utilities to promote energy efficiency and reduce energy consumption among their customers. In Thailand, the Electricity Generating Authority (EGAT) secured a mandate and dedicated financing in 1993 for a Demand Side Management (DSM) program focusing on labeling of and information programs about electrical appliances. By 2000, the program had already exceeded its electricity demand reduction targets and yet had spent less than half of the available funding.[23] Other policy options that governments can introduce include white-certificate programs that measure and reward progress toward achieving energy efficiency targets, as well as the adoption of technologies such as user-friendly smart metering to help better manage household energy use patterns, and smart grids to reduce transmission losses.

Improving transformation and distribution efficiency within the electricity sector itself can radically increase energy productivity. In India, 35 percent of all electricity is lost during transmission. Yet North Delhi Power Limited, a utility established in 2002 as a joint venture between the Delhi government and Tata

22 "Oil windfall leads to $3,269 payout for Alaskans," *Reuters News,* September 5, 2008.

23 *Thailand Promotion of Electrical Energy Efficiency Project,* World Bank GEF Post-Implementation Impact Assessment, 2006 (http://www.egat.co.th/en/images/stories/pdf/world_bank-post_evaluation_report.pdf).

Power, has reduced its transmission losses to 18 percent and is installing smart grid technologies aimed at enabling the company to further cut losses to less than 10 percent in three to seven years.

Set efficiency standards for selected appliances and equipment. Government efficiency standards are an effective, low-cost way to coordinate a transition to more efficient appliances, particularly white goods, consumer-electronics products, vehicles, and lighting products. With the implementation of such standards, economies of scale emerge and prices of energy-efficient products typically decline to the level of the old, less efficient products. Instead of regulating the use of specific technologies, standards are more effective if they set targets for overall efficiency, leaving the details of how to meet these targets to innovations at the company level. Several governments have introduced efficiency standards across industries and in specific sectors as a forcing mechanism toward higher energy efficiency. Indonesia, for instance, has recently adopted the United Nations' technical regulation on auto energy efficiency, and China has introduced a raft of standards across sectors in the past five years. In Africa, Ghana has been a pioneer in establishing standards for household appliances, and research shows that the country's energy efficiency standard on air conditioners, for instance, will save Ghanaian consumers an average of $64 million per year on their energy bills and reduce CO_2 emissions by some 2.8 million tonnes over 30 years.[24]

Encourage public-private partnerships in energy efficiency. These partnerships can help overcome barriers to energy efficiency investments by creating new ways of collaborating, financing, or sharing the benefits that accrue from such outlays. Innovation in this respect is likely to gather pace in future years, but thus far three areas have yielded significant results:

- **Information programs to increase awareness.** Many consumers don't realize the extent of the energy savings that they would achieve as a result of investing in higher energy efficiency. Information campaigns and the introduction of schemes on energy efficiency labeling can help to fill this knowledge gap. In China, for instance, Chongqing municipality has introduced an energy efficiency evaluation and labeling system for buildings.[25] India has also initiated energy

24 "AAGM: energy commission to enforce legislative instrument 1815," *Ghanaian Chronicle,* March 27, 2007.

25 "Chongqing initiates building energy efficiency labeling system," *China Industry Daily News,* February 15, 2008.

efficiency ratings of building projects.[26] South Africa mandates the labeling of appliances according to energy efficiency.[27] Singapore has made such labels mandatory on air conditioners and refrigerators.[28] Among the benefits of a well-established and clear labeling system is that it increases household awareness of the economic benefits of higher efficiency and encourages companies to offer more efficient products.

- **New ways of collaboration to improve building efficiency.** To overcome some of the information and agency barriers to higher energy productivity, some governments have encouraged collaborations between energy-service companies (ESCOs), mortgage companies, and utilities. These collaborations draw in technical expertise, long-term financing, and the capacity to tie housing energy efficiency to future energy-cost packages. For example, the Proesco program in Brazil helps finance energy efficiency projects undertaken by the country's ESCOs.[29]

- **Public financing of private energy efficiency investments.** Many households and businesses in developing regions face serious capital constraints, which public financing can help to overcome. In early 2008, China, which manufactures 70 percent of the world's light bulbs, announced very substantial subsidies for the promotion of energy-efficient bulbs.[30] Governments and utilities in sub-Saharan Africa including in Uganda, Namibia, and Ghana have been giving out free CFL bulbs to the public.[31] The Renewable Energy and Energy Efficiency Partnership (REEEP), a global public-private partnership, finances the West Africa Modern Energy Fund. Overall, 44 percent of the projects funded by the partnership promote energy efficiency.[32]

26 "India gets energy saving norms," *Indian Business Insight,* May 28, 2007.

27 "Energy-efficiency labelling will help consumers save electricity," *LiquidAfrica,* May 21, 2004.

28 "What is the energy labelling scheme?" *Straits Times,* March 14, 2008.

29 "Brazil BNDES, BB to finance projects under Proesco programme," *Latin America New Digest,* June 11, 2007.

30 "China: government subsidizes energy-efficient light bulbs," *Greenwire,* April 25, 2008.

31 "Region's governments look to save energy through distribution of free CFL bulbs," *Global Insight Daily Analysis,* November 5, 2007.

32 For details of the partnership's activities, visit www.reeep.org.

While national governments play a vital role in setting a regulatory and public-policy backdrop that encourages the pursuit of higher energy productivity, "smart growth policies" pursued by local governments on the ground can be highly effective. Urban planning can have a significant impact, and a number of major and fast-growing cities in developing countries are demonstrating innovations designed to abate energy consumption by increasing the efficiency of its use (see "Smart planning in China's cities could have a large impact on energy demand"). Mexico City, for instance, has already replaced 3,000 taxis with newer, more energy-efficient models and plans to have 10,000 taxis replaced at higher efficiency levels altogether, offering owners a subsidy of 20 percent of the purchase price and financing help for the rest.

Smart planning in China's cities could have a large impact on energy demand

China's cities have an opportunity to abate their energy demand in 2025 by at least 20 percent if they drive toward higher energy productivity and combine this effort with smart urban planning.[33] MGI research finds that the enforcement and wider deployment of building standards by China's cities could save 3 QBTUs of 2025 energy demand; accelerating the adoption of CFL or other energy-saving lighting devices could produce further savings of more than 3 QBTUs; and an even more aggressive build-out of efficient power capacity than current plans could save another 2 QBTUs.

Promoting urban density, in itself, is effective. By doing so, urban China could cut 4 QBTUs of energy demand in the transportation end-use sector. Multiple international studies have found that petrol use varies as a function of density and that driving declines by between 20 and 30 percent for every doubling of residential density. The key variables in these studies—residential density, nearby commercial areas, and good transit options, for instance—are typically highly interrelated, suggesting that density alone is not enough to deliver substantial savings but must be part of transit-oriented development. Higher density together with smart planning could reduce vehicle ownership in China by between 10 million and 30 million cars (although the number of cars in affected cities would still grow to around 90 million even in the most

33 *Preparing for China's urban billion,* McKinsey Global Institute, summary published March 2008 (www.mckinsey.com/mgi). The full report will be published early in 2009.

aggressive reduction case).

City governments have the opportunity to further abate energy demand and reap major environmental benefits through the use of alternative fuels in public fleets of buses, taxis, and official cars. An aggressive replacement program—taxis running half and half on compressed natural gas (CNG) and hybrid, official fleets being converted in full to hybrid, and buses running on a mixture of fuels—would reduce China's urban transportation energy demand by some 1.5 QBTUs by 2025. At the same time, this initiative could reduce PM_{10}, NO_x, and CO emissions by about 10 percent compared with levels today projected for 2025. Some Chinese cities are already leading the way—Chengdu, for instance, is aggressively converting its fleets to CNG. Action to increase the efficiency of public transport is timely and vital given building of mass-transit systems in China's cities on a huge scale. MGI research finds that investment in urban transport will increase by four to six times by 2025—including more than 2 million new buses.

HIGHER ENERGY PRODUCTIVITY IS A SUBSTANTIAL BUSINESS OPPORTUNITY FOR COMPANIES

Introducing public policies that incentivize and reward energy efficiency is a crucial first step. However, businesses operating in different sectors are the engine needed to exploit the full energy productivity potential—and to find ways to innovate and expand the opportunities beyond those on the scene today. Not only do companies have a substantial opportunity to secure energy savings in their own operations, but they can also seek partnerships with the public sector in their energy efficiency efforts, as well as position themselves for potentially lucrative new global markets in energy-efficient technologies and green solutions. Some companies from developing regions are already proving to be pioneers in this regard, but there is potential for more players to emerge as new champions.

Raise corporate standards for energy efficiency. In today's high energy-price environment, energy costs in themselves are proving to be a source of competitive disadvantage for some companies. Furthermore, the risk of GHG-related taxes being imposed on exports is higher for the least energy-efficient competitors. In many cases, this is sufficient motivation for senior management to focus on energy efficiency, thereby reducing their companies' energy consumption and costs (see “Examples of energy efficiency programs introduced in companies”). In the case of 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. As discussed earlier, because of the rapid expansion of industrial and electric power capacity in many regions, developing countries have a unique opportunity not only to adopt the latest available energy-efficient technologies but also to leapfrog beyond them to even higher levels of energy efficiency.

Examples of energy efficiency programs introduced in companies

Many companies in developing countries are embracing opportunities to save on their energy costs by boosting energy efficiency. In Thailand, for instance, the Central Food Retail Company, operator of Tops supermarkets, plans to modernize the energy efficiency of its outlets by 2009.[34] In Bahrain, Amwaj Gateway has formed a joint venture with Energy Management Services (EMS) to introduce green building solutions in its developments.[35] In Brazil, Ampla Energia is investing $6.7 million in energy efficiency projects in 2008.[36] In Russia, Lukoil is conducting energy audits of its subsidiaries.[37] Ericsson, the communications company, has recently received an award in China for its innovations in the area of energy efficiency. One such innovation is the Ericsson Tower Tube, a new way of designing radio base stations that cuts energy consumption by 40 percent and CO_2 emissions by 30 percent. In India, the Birla Cement Corporation has been one of a number of companies that have improved energy efficiency through the retrofitting of plants and improved operational control and optimization.[38]

Create and capitalize on new markets in energy efficiency. Beyond reducing energy costs, energy efficiency creates revenue-generating business opportunities. Companies can use energy efficiency to strengthen their position in their home

34 “Thailand: Central Food Retail Co. moves to increase energy efficiency at Tops supermarkets,” *Thai News Service,* March 13, 2008.

35 “Amwaj goes green,” *Mist News,* June 18, 2007.

36 “Brazil Ampla to invest $6.7 million in energy efficiency projects in 2008,” Latin *America News Digest,* February 21, 2008.

37 “LUKOIL implements energy savings program,” *RIA Oreanda News,* April 18, 2007.

38 “Cement co’s energy consumption seen falling,” *Business Line (The Hindu),* April 21, 2008.

market and also leverage their know-how in other regions of the world, depending on local market conditions and regulations. We have identified seven areas of commercial opportunity in energy efficiency that companies should examine: building-technology products, electrical devices and other household equipment, transportation fuel efficiency, transparency-creating products, customized solutions, energy services, and financing energy efficiency investment (see “Seven major energy efficiency business opportunities”).

Seven major energy efficiency business opportunities

Building-technology products. These include space-heating, ventilation, and air-conditioning equipment, windows, doors, elevators and escalators, and building insulation, as well as building and end-product components such as heat exchangers and solar-control glass. Improving the energy efficiency of building-technology products is becoming a key priority particularly when old equipment is due for replacement. In India, K. Raheja Corp., one of the largest developers in the real-estate and construction industries, has signed the first ever Project Development Agreement under the Clinton Climate Initiative’s Energy Efficiency Building Retrofit Program. Under this agreement, Johnson Controls will perform energy efficiency retrofits in the Inorbit Mall, the largest mall in Mumbai.[39]

Electrical devices and other household equipment. This opportunity spans a large variety of products including household appliances, white goods, light bulbs, PCs, printers, TVs, home-entertainment equipment, and office supplies. India’s Technology Informatics Design Endeavor has won a number of awards for its innovative energy-efficient wood-burning stove for use in small businesses.[40] China today produces 1.7 billion CFL bulbs a year, and numerous companies in China are already pioneering next-generation LED lighting and rechargeable polymer lithium-ion (PLI) battery cells for use not only in electric vehicles but also in a variety of consumer electronics.

Transportation fuel efficiency. Fuel efficiency is an increasingly important priority

39 “Largest mall in Mumbai, India, to benefit from energy efficiency building retrofit,” *Azobuild.com,* February 20, 2008 (http://www.azobuild.com/news.asp?newsID=5184).

40 “British Ashden Awards unveil global green energy prize winners,” *www.chinaview.com,* June 19, 2008 (http://news.xinhuanet.com/english/2008-06/20/content_8404214.htm).

for the buyers of cars, trucks, trains, or aircraft—and therefore for original equipment manufacturers. Companies innovating new, higher-efficiency technology in transportation have a major commercial opportunity. In China, for instance, the Beijing-based Chargeboard Electric Vehicle Company Ltd. was the first company to develop an energy-efficient braking retrofit for diesel buses that reduced fuel consumption by 30 percent. The company is now promoting the technology jointly with the Beijing Bus Company.[41]

Transparency-creating products. Such products help to educate energy users about the impact of their choices and behavior on their energy consumption and therefore encourage the more conscious use of energy. Advanced electricity metering and smart grids are the prime example today of transparency-creating products. In Russia, Kazakhstan, Ukraine, and Belarus, Incotex of Moscow is leveraging Texas Instruments technology in its electricity-metering systems and improving their energy efficiency by up to 30 percent.[42] In China, Guangzhou Keii Electro Optics Technology Co. Ltd. is a specialist manufacturer of infrared camera systems and their software programming, which can be used in energy surveys of buildings and in industry to detect heat loss and therefore promote more energy-efficient production.[43]

Customized solutions. These apply to complex systems integrating numerous products such as large heating, air-conditioning, lighting, refrigeration, and ventilation systems. We typically find large integrated systems installed in large premises, such as residential complexes, office and commercial buildings, industrial production facilities, or—especially for outdoor lighting—entire campuses or cities. Optimized overall system design together with smart management and control technology allows end users to run these systems with minimum energy consumption. In India, Wipro Technologies offers customers end-to-end services for data-center customers so they can use their capacity more efficiently and minimize their use of power, cooling, and housing equipment.[44]

41 "New buses could help Beijing cut fuel intake," *People's Daily Online,* January 3, 2006 (http://english.people.com.cn/200601/03/eng20060103_232502.html).

42 "Incotex automated meter management systems improve energy efficiency and accuracy using TI controller technology," Texas Instruments press release, January 29, 2008 (http://focus.ti.com/pr/docs/preldetail.tsp?sectionId=594&prelId=sc08001).

43 See www.keii.com.cn/application.htm for more detail.

44 "Wipro unit joins global energy efficiency consortium, ventures into renewable energy," *EnergyAsia,* June 23, 2008 (http://www.energyasia.com/content/view/15176/1/).

Energy services. ESCOs offer a wide range of activities to energy users, primarily in industrial and commercial sectors and to public institutions. The four major categories of services are (1) the operation and maintenance of installations such as cogeneration, district heating units, and small-scale residential boilers; (2) the supply of energy, often in the form of power and heat from cogeneration but also gas sourcing; (3) facility management in various areas ranging from technical management and cleaning to safety and security; and (4) energy management, including energy audits, consulting, and demand monitoring and management. ESCOs are increasingly common in developing countries. An ESCO in Latvia, for instance, is engaged in retrofitting street lighting to higher-efficiency technology.[45] However, many developing-world ESCOs need public partnerships to overcome initial financing difficulties.

Financing of investments in energy efficiency. This presents a business opportunity for banks and institutional investors. Financing may also be an option for utilities that often have low financing costs (or a significant amount of free cash) and long time horizons, particularly if utilities find themselves under pressure from regulators or the public to engage in energy savings and GHG abatement. In Pakistan, for instance, in partnership with the Building and Construction Improvement Programme of the Aga Khan Housing Board, First Micro Finance Bank is planning a credit scheme to enable households to purchase equipment to make their homes more energy efficient, paying back loans over time using savings in fuel costs.[46]

45 *Good Practice Case Study: First Lighting ESCO in Latvia: Effective Lighting in Cities—Tukums,* case study report presented at the European Conference on Local Energy Action: Optimising local action to drive sustainable energy and transport in the Europe of Twenty-Five, Brussels, October 20–21, 2004, Brussels (http://www.managenergy.net/products/R318.htm).

46 *Improving Energy Efficiency through Building Materials, Pakistan,* UNDP, 2003 (http://sgp.undp.org/download/SGP_Pakistan2.pdf).

INTERNATIONAL AND NONPROFIT ORGANIZATIONS CAN BRING EXPERTISE AND HELP OVERCOME CAPITAL CONSTRAINTS

The key challenges facing developing countries in their efforts to boost energy productivity are the lack of experience, expertise, and skills in energy-efficient policies and practices, as well as a lack of capital for investing in energy efficiency improvements. Both are areas where international organizations and nonprofit groups can assist, helping to find ways to ensure that the new buildings and equipment now being built in developing economies lock in lower energy consumption and emissions for future decades.

Provide technical and managerial expertise. Some international organizations and government entities are already helping countries to identify and explore energy productivity opportunities. For instance, the US Lawrence Berkeley National Laboratory (LBNL) has had a close relationship with China since the mid-1990s, using its experience elsewhere to advise China on designing energy efficiency standards on appliances and in buildings, creating labeling programs, and exploring options for energy efficiency policies in industry. Bodies such as the International Organization for Standardization (ISO) already have technical and/or certification relationships in developing regions.[47] The United Nations Division for Sustainable Development provides advisory services to governments and technical support to projects in the area of energy, including energy efficiency (see "Case study: China refrigerator project"). The United Nations is also involved in information sharing on this issue.

Ensure funding for energy efficiency investments. The international community can play a crucial role in this area. There are many examples of social-sector organizations providing concessionary financing for energy efficiency. The European Bank for Reconstruction and Development (EBRD) has disbursed €100 million in credits to Ukrainian banks to finance energy efficiency projects.[48] The EBRD also supports Severstal, Russia's second-largest steel company, in an effort to cut the energy consumption of the industry.[49] The World Bank, whose focus in the past has been on supply (whether through fossil fuels or alternative

47 *Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies, Executive Summary,* United Nations Industrial Development Organization, 2008 (http://industrial-energy.lbl.gov/files/industrial-energy/active/0/ind_energy_efficiencyEbookv2-1.pdf).

48 "Bank forum joins EBRD energy efficiency programme for Ukraine," *RIA Oreanda News,* January 30, 2008.

49 "EBRD increases Severstal energy efficiency loan to €600 million," *RIA Oreanda News,* April 9, 2008.

energy), is now increasing its work on energy efficiency. The Kyoto Protocol's Clean Development Mechanism (CDM) can also help developing countries. Russia, for instance, has implemented rules governing the use of carbon credits.[50] This in turn allows domestic companies to secure foreign investment for energy efficiency projects.

Reach out to rural residential segments. Foundations and other social-sector organizations can play a key role in reaching out to fragmented rural residential segments through their existing relationships, including microfinance operations. One of the biggest opportunities lies in facilitating the shift from inefficient and polluting biomass toward higher-efficiency fuels such as kerosene. These segments are also most vulnerable to changes in existing subsidy policies, and the social sector can play a vital role in finding ways to bridge the gap between the prices these communities pay and market prices.

Case study: China refrigerator project

China is the largest refrigerator market in the world, but the average efficiency of these appliances was comparatively low in the 1990s, consuming an average of 2.5k/kWh/year per liter volume compared with 1.5k/kWh/year in Europe. For this reason, the US Environmental Protection Agency and China's State Environmental Protection Administration (SEPA) set up the China Energy-Efficient Refrigerator Project in 1999, with financing assistance from the Global Environment Facility (GEF).[51]

To overcome a range of market barriers that were preventing a shift to higher-efficiency technology, the project undertook (1) a "technology push" to increase the supply of energy-efficient refrigerators through technical training and assistance, incentive programs for manufacturers, and the revision of China's original 1989 refrigerator energy efficiency standard in both 2000 and 2003; and (2) a "demand pull" to increase market demand for energy-efficient refrigerators by increasing retailer and consumer understanding of the benefits of energy efficiency.

50 "Russia, Ukraine next to trade Kyoto carbon credits," *Reuters News,* February 7, 2008.

51 For full details of the project, see *Case Studies of Market Transformation: Energy Efficiency and Renewable Energy,* Economic and Social Affairs Division, United Nations, 2007 (http://www.un.org/esa/sustdev/publications/energy_casestudies/full_rpt.pdf). SEPA has now been named the Ministry of Environmental Protection (MEP).

The project not only met all its targets but exceeded them by between two and three times. The United Nations reports that today there are 256 models of domestically manufactured energy-efficient refrigerators on the market that meet the energy efficiency requirement of grade 1 of the national standard for refrigerator energy consumption (superior to European grade A). Annual production of energy-efficient refrigerators has increased from some 1 million in 1999 to more than 14 million in the 12 months ending June 2005—and production of superefficient refrigerators (those at least 60 percent more efficient than the energy efficiency standard) increased from 400 units to 3.3 million during the same period.

The project leaders set a target of 40 percent lower energy use for approximately 20 percent of the projected refrigerator market (2 million refrigerators a year) over ten years—an average market-wide efficiency gain of 8 percent. However, the actual efficiency improvement achieved from 1999 to 2004 alone was more than three times that amount.

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The case for prioritizing higher energy productivity is stronger than ever, as high energy prices increase the value of energy savings generated. Time is of the essence for countries in the developing world—embracing higher energy productivity in a period of rapid capital-stock accumulation gives these economies a golden opportunity to lock in lower energy consumption and carbon emissions for decades to come. For businesses, energy productivity offers not just lower energy costs but also rich commercial opportunities. For policy makers in developing countries, making energy productivity a priority will help them to not only respond effectively to the challenges of climate change but also reap long-term economic benefits that will ensure their economies grow in a sustainable way.

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