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What countries can do about **cutting carbon emissions**

Greenhouse gas emissions can be cut significantly—and, surprisingly, without huge disruption.

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Reports published in 2007 by the Intergovernmental Panel on Climate Change (IPCC) reflect a broad scientific consensus about the link between global warming and greenhouse gas emissions resulting from human activity. The report, while acknowledging that there is still uncertainty in the scientific estimates, calls for a reduction in annual emissions from just under 50 billion tons of greenhouse gases today to 5 billion to 10 billion or less by 2050, so that the planet warms by no more than two degrees centigrade. This report and similar reports from the scientific community have spurred political leaders around the world to action. The European Union has set targets to reduce its greenhouse gas emissions by 20 to 30 percent of the 1990 level as of 2020. Political leaders elsewhere are discussing similar goals. Some countries even say that they wish to become carbon neutral by 2050.

What will a significant reduction in the level of greenhouse gases entail? Which approaches will be most effective? How much will it cost to achieve this goal, both in money and in lifestyle changes? Who will bear that cost?

These questions lie at the center of heated debate among policy makers and stakeholders in many nations. To get a better understanding of the ways to cut emissions, the cost of each, and the reductions they could achieve—in other words, to provide facts for the debate—McKinsey has undertaken

a multiyear research initiative to map the opportunities to reduce (or abate) greenhouse gas emissions. In 2007, we completed a broad-based global study. More recently, we have taken a focused look at what can be done in Australia, Germany, the United Kingdom, and the United States.[1] In each case, we collaborated with leading companies, academics, industry associations, and nongovernmental organizations (NGOs) to assemble the best available data on abatement measures.

Although we are studying other countries, some important observations can already be made: each of these four large economies can reduce its emissions by 25 percent below the levels they will reach in 2030 if nothing is done to abate emissions. In addition, such cuts can be achieved at relatively little or no cost and without significantly changing the lifestyles of these countries. In Australia, the potential is even bigger—a reduction of 70 percent at little or no cost.

What's more, many of these opportunities are profitable. Most involve improved energy efficiency—in other words, investments in better insulation for buildings, energy-efficient appliances and machinery, and more energy-efficient heating and air-conditioning systems, all of which will pay off through reduced energy bills (see sidebar, "How much capital is required for energy- and carbon-abatement investments?"). Although that is encouraging news, these measures won't suffice to reach the long-term emission cuts required to halt global warming. Additional efforts could include implementing more expensive technical measures, developing new technologies, maximizing the ability of forests to store carbon, and influencing the way consumers behave.

Lots of low-cost abatement options

Our research focused on opportunities that would not materially affect consumer lifestyles. We looked at the impact of more fuel-efficient vehicles of the same size and performance as the cars that consumers drive today, for example, but refrained from estimating whether and how consumers might instead opt for public transport or for small cars rather than sport-utility vehicles. Also, we quantified the cost and size of each opportunity.

What's interesting about our findings is the scope of the low-cost opportunities available to reduce emissions. If the United States makes no greater effort over the next 22 years than it does today, for instance, its emissions will increase from roughly 6 billion tons of greenhouse gases to almost 9 billion in 2030. This is the "business as usual" scenario.[2] But the United

[1] Readers can obtain copies of the full reports on the four countries on mckinsey.com.

[2] In other words, emissions will rise as an economy grows, so we measured the cuts against expected "business as usual" growth in emissions if countries go on doing what they do now.

States could instead eliminate 3.0 billion to 4.5 billion tons of its annual emissions by 2030 if it consistently and systematically adopted abatement options costing less than $50 a ton. These include raising the fuel efficiency of cars and light trucks, promoting second-generation biofuels, improving the management of methane gas emissions in coal mines, deploying cover crops on farmland in the winter more consistently, planting new forests, and building wind power systems in windy regions.

In the United Kingdom and Germany, total emissions and their growth in the business-as-usual scenario are much lower than in the United States. Although the opportunities to reduce UK and German emissions are on at least the same order of magnitude as the opportunities on the other side of the Atlantic (and in some cases even larger), the absolute reductions are smaller: about 230 million tons below €40 a ton of greenhouse gases in the United Kingdom and about 290 million tons in Germany. Australia stands out, with a possible 560 million tons of abatements—very substantial given the business-as-usual projections of less than 800 million tons of greenhouse gas emissions for 2030. In part, the opportunities to reduce emissions represent such a large share of their business-as-usual level because Australia could limit the large-scale land clearances now taking place in the country (clearances that continue in the business-as-usual projection) and could also shift the growth in its power sector from coal-fired plants to coal plants that capture and store carbon dioxide,[3] as well as other more carbon-efficient alternatives.[4]

In all four countries, many opportunities involve the adoption of low-carbon energy technologies. About 60 to 70 percent of the world's greenhouse gas emissions are energy related; the major sources are fossil fuels for transportation, heating (of buildings and water), and power generation. In transport, biofuels could replace 20 to 30 percent of current fuels by 2030 and push greenhouse gas emissions as much as 80 percent below the level they would reach with fossil fuels. (That level of reductions assumes the right combination of land use, feedstocks, and technology, as well as policies to limit potential indirect emissions resulting from land-use change.) In power generation, the use of low-carbon energy sources such as hydro, wind, solar, and nuclear could double by 2030 and account for more than half of total power production. Similarly, biomass, geothermal, district heating (using a network of pipes containing hot water to heat a neighborhood), and other low-carbon ways to heat buildings could reduce emissions significantly.

[3] Carbon capture and storage (CCS) is a technology to separate carbon dioxide from the combustion gases in power plants and other large emission sources and to store it underground instead of releasing it into the atmosphere.

[4] See Anja Hartmann, Jens Riese, and Thomas Vahlenkamp, "Cutting carbon, not economic growth: Germany's path," mckinseyquarterly.com, April 2008. This article is accompanied by an interactive set of exhibits.

Of course, the emission patterns of the four countries studied differ significantly. In the United States, cities spread out over larger areas than they do in Europe, increasing the need for transportation. The fuel efficiency of cars differs as well. We estimate that by 2030, the United Kingdom could cut auto emissions in half, from the current level of 0.17 kilograms of carbon dioxide per kilometer driven, by applying only measures costing less than €40 a ton. In the United States, cars now operate at a level of 0.24 kilograms. While this difference might suggest a higher potential for improvement, cars are, on average, bigger in the United States, so that even with improvements US cars will still consume twice as much fuel as UK ones by 2030.

Both Australia and the United States emit relatively high levels of carbon dioxide in power generation—above 0.6 kilograms of carbon dioxide per kilowatt hour. In a scenario addressing relatively low-cost measures, we estimate that carbon dioxide intensity in power generation will remain high

How much capital is required for energy- and carbon-abatement investments?

Even profitable steps to reduce carbon emissions often require an initial capital outlay. Consider, for example, efforts to boost energy productivity—the level of output achieved from the energy consumed. Approaches ranging from more efficient industrial processes to better insulation of residential buildings are among the most attractive carbon-abatement opportunities because they pay for themselves in saved future energy costs.

The McKinsey Global Institute (MGI) and McKinsey's global energy and materials practice estimate that $170 billion a year could be invested from now until 2020 in energy productivity opportunities that would yield an internal rate of return (IRR) of at least 10 percent.[1] These investments could cut the projected growth of energy demand by at least half—to less than 1 percent a year, from a projected 2.2 percent—and help save the equivalent of 64 million barrels of oil a day, almost 150 percent of today's entire annual US energy consumption.[2] Capturing these energy productivity opportunities could deliver up to half of the emission abatement required in 2020 to cap the long-term concentration of greenhouse gases in the atmosphere at 450 parts per million. This, experts suggest, is the level that will be needed to prevent the global mean temperature from increasing by more than two degrees centigrade.

Now, $170 billion equals some 1.6 percent of current global fixed-capital investment, or 0.4 percent of current global GDP. While this figure seems manageable, developing regions represent two-thirds of the incremental capital needed; China alone accounts for $28 billion annually. A broad effort by local companies and governments in emerging markets, multinational companies, international financial institutions, development agencies, and nongovernmental organizations will therefore be necessary.

The annual investment of $170 billion can also be analyzed by economic sector. Industrial sectors around the world need just under half of the total capital, residential sectors about one-quarter. The commercial and transportation sectors represent the remaining capital requirements, in roughly equal proportions. Sector-level opportunities and costs vary dramatically.

- The energy productivity opportunities for global industrial sectors are highly fragmented. A few opportunities (such as optimizing electric

in the United States but drop dramatically in Australia, as carbon-capture-and-storage (CCS) technology could be adopted at lower cost in its fast-growing coal-based power sector.

This finding underscores the impact that CCS could have if it becomes technologically and commercially proven, accepted by society, and embedded in the right legal framework. The technology addresses emissions from fossil fuels—and most researchers believe that coal and other hydrocarbons will remain an essential part of the global energy mix for the foreseeable future, even if countries do shift to low-carbon alternatives.

Profiting from emission reductions

A surprisingly high portion of the abatement options are profitable: they pay for themselves over their lifetime. The more consistent adoption of energy-efficient products and technologies—from energy-efficient bulbs, appliances, and machinery to better insulation in buildings—could reduce national

motors) are applicable in a great many industries, but dozens of others are smaller and quite sector and company specific. Many investments have an IRR of around 10 percent, so their economic attractiveness is very sensitive to the hurdle rates companies use to evaluate them.

- More efficient lighting (particularly compact fluorescent lightbulbs) and higher efficiency standards for appliances are the low-hanging fruit in the residential sector: they require little capital and pay back their costs quickly. In contrast, upgrading the efficiency of heating and cooling systems would deliver one-third of the energy savings available in the residential sector but consume three-quarters of the capital required to realize all of its opportunities.

- Lighting is already dramatically more efficient in the commercial sector, which has 60 percent of the energy productivity potential in developed regions. Further efficiency gains in this sector will require expensive steps, such as replacing halogen lamps with light-emitting diodes (LEDs), so the capital requirements per unit of energy saved will be nine times larger here than in the residential sector.

The economics of boosting energy productivity vary widely by sector and region, and capital constraints are a real barrier to adoption in many cases. Nonetheless, in today's energy environment, the economic case for investing in energy productivity is stronger than it has been for a generation. A growing number of players will find ways to tap into this opportunity.

Diana Farrell and Jaana Remes

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[1] This analysis assumes that oil will cost $50 a barrel. Higher prices would increase the number of energy productivity initiatives whose internal rate of return (IRR) exceeded 10 percent—thus possibly boosting the potential to cut demand for energy and increasing the capital required to finance additional projects. For more on the capital-requirements analysis, see "The case for investing in energy productivity," available free of charge on mckinsey.com/mgi.

[2] For more on McKinsey's energy productivity research, see Diana Farrell, Scott S. Nyquist, and Matthew C. Rogers, "Making the most of the world's energy resources," *The McKinsey Quarterly*, 2007 Number 1, pp. 20–33; and Diana Farrell, Scott S. Nyquist, and Matthew C. Rogers, "Curbing the growth of global energy demand," mckinseyquarterly.com, July 2007.

emissions by double-digit percentage points and save more money on energy than the additional cost of the bulbs and insulating materials. In Germany, industrial companies could eliminate more than 30 million tons a year of emissions by 2020 at a net gain (for instance, by increasing the adoption of energy-efficient motor systems with variable-speed drives). German industry could improve its energy efficiency by more than 1.5 percentage points a year and thereby compensate for the anticipated increase in production volumes.

If these opportunities are profitable, why haven't consumers and businesses already captured them? The answer is market imperfections—for example, a lack of awareness among consumers and decision makers in business. Studies show that large numbers of people aren't aware of many things they could do or technologies they could use to reduce their energy demand and energy bills.

Also, there aren't enough options yet to motivate a large number of consumers to make energy-efficient choices. More fuel-efficient cars are available in most developed markets, for instance, but perhaps not in the make or model consumers prefer. Financing the up-front investment can be a barrier too: retrofitting a home with high-performing insulation can cost tens of thousands of dollars, and many consumers can't or won't borrow or save to pay for it, even if the long-term payback is positive. Consumers balk at even smaller upfront costs—for more energy-efficient appliances, say—if the payback time exceeds two years.

Finally, agency problems bedevil some of the relevant markets. Building contractors, for instance, have no incentive to insulate homes beyond the level required by building codes, since home owners and renters resist paying more for higher-grade insulation, even if it would lower their electric bills. In Germany, regulations in many cases even prevent landlords from passing along to renters the cost of reinsulating buildings.

Making greater cuts

While the reductions we have discussed so far could be significant, they will not halt global warming. Given continued economic and population growth, cutting emissions by 25 to 30 percent below what they would otherwise be in 2030 will reduce the emissions of these four developed economies only in a marginal way compared with today's levels. Even if all other countries managed the same feat, it would still serve just to stabilize or marginally decrease global emissions. To limit global warming to two degrees centigrade, a growing consensus in the scientific community warns, the world must not only cut emissions by at least 50 percent of today's level as of 2030 but also cut them by 80 percent or more as of 2050,

even as the world's population and GDP rise. How and whether these goals can be reached isn't understood yet, though it is clear that if current climate science holds true, further cuts, beyond the technical measures discussed above, should be considered.

Countries will have to choose. First, some low-cost abatement measures could be expanded beyond their original remit, though they may start to lose their attractiveness in terms of cost. In Germany, for instance, we found that insulating buildings to a 7-liter standard, from a poor energy efficiency of 25 liters of oil equivalents per square meter, helps to lower energy consumption dramatically, with a positive payback on the investment. Moving beyond that, to a 2-liter standard, makes this a very expensive measure costing as much as €700 to €1,000 per ton of carbon dioxide reductions. Similarly, windmills can be installed not just in windy locations close to power grids but also in less windy or more remote locations. Likewise, solar-energy systems could also be deployed in less sunny regions. But if the conditions are suboptimal, the cost per ton of emissions reduced easily rises to more than €100 per ton of carbon dioxide. Then, too, though it would be possible to retrofit the technology for CCS in a large share of existing fossil fuel power plants, it would be expensive to do so. Countries might also choose to subsidize the adoption of hybrid cars, despite this technology's high costs.

Second, countries could focus on encouraging the development of next-generation low-carbon technologies, such as second-generation biofuels and solar photovoltaics, and on ensuring that they become cost-competitive. These will not help to reduce emissions in the short term, but they will create more options in the future.

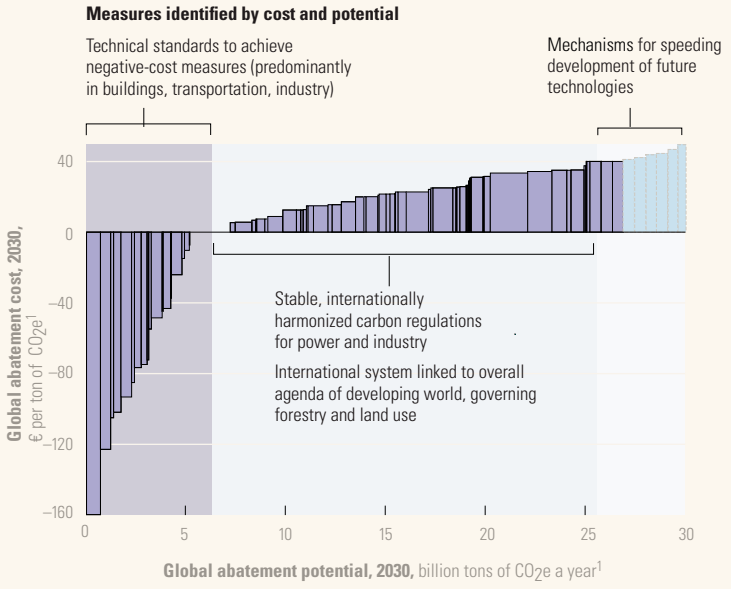
Third, forests around the world represent a considerable opportunity to reduce emissions. Currently, deforestation accounts for 10 to 30 percent of global emissions; the broad range of estimates indicates how little attention this field has received in the past. By avoiding deforestation or reforesting certain areas and by managing forests globally—for much of the potential lies in tropical countries—the world could reduce emissions of greenhouse gases by about seven billion tons annually. What's needed, though, are ways of motivating stakeholders to shift in this direction (providing alternative sources of income, for example) and mechanisms for managing forests more successfully. Cracking the code on designing regulations of this kind will be critical to reducing global emissions at low cost (exhibit).

Finally, countries could choose to influence the consumer's behavior through regulations, financial incentives, or both: citizens might be motivated to travel less, to use public transportation more, or to buy smaller cars.

EXHIBIT

Motivation through regulation

Key regulatory mechanisms identified in abatement study



[1] CO_2e = carbon dioxide and equivalent greenhouse gases.

Countries could also motivate their people to consume less water, use less floor space and fewer appliances, and unplug idle appliances. Regulation isn't the only way to change the consumer's behavior, though: businesses can foster change by promoting green products to the growing number of people who are receptive to them.

Implications

While our research provides facts for the debate, it does not offer prescriptions for what countries should do. Instead, public- and private-sector leaders must work together to agree on solutions and trade-offs. But from a purely economic point of view, our findings do suggest some issues that leaders might keep in mind.

First, timing is critical. The cost curves we have developed, showing the potential to reduce emissions significantly by 2030, assume that action to achieve these cuts will start now. If it starts in 2015, the cost curves will look less favorable.

Second, a financial incentive will be needed in the form of a carbon dioxide price signal that remains stable in the long term—perhaps a carbon tax

or certificates in a cap-and-trade system. International competition is intense in many industries, and a level playing field across countries is important. A price of €20 a ton for carbon dioxide could increase the cost of steel production in Europe by 15 percent or more if steelmakers had to buy emission rights, for example. This approach would make European steel uncompetitive in the absence of a global system or border tax adjustments.

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Third, establishing technical rules and standards, such as requiring high-performance insulation in newly constructed buildings, could correct the market imperfections that prevent people and businesses from realizing some profitable abatement opportunities.

Finally, by investing today in tomorrow's possibilities, the world could also generate options for future abatement mechanisms that might be ready by 2030 or 2050. Technologies now in the research-and-development stage, such as nuclear fusion and power generation from waves, hold great promise to reduce emissions if they become cost-competitive.

The good news is that much can be done to reduce emissions dramatically, and without great disruption. But the news will be good only if we start soon. Q

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