JANUARY 2012
McKinsey Quarterly

MCKINSEY GLOBAL INSTITUTE
SUSTAINABILITY & RESOURCE PRODUCTIVITY PRACTICE

Mobilizing for a resource revolution

Richard Dobbs, Jeremy Oppenheim, and Fraser Thompson

Over the next quarter century, the rise of three billion more middle-class consumers will strain natural resources. The race is on to boost resource supplies, overhaul their management, and change the game with new technologies.

Progressively cheaper natural resources underpinned 20th-century global economic growth. But the 21st century could be different. Indeed, over the past ten years, rapid economic development in emerging markets has wiped out all of the previous century's declines in real commodity prices. And in the next two decades, up to three billion people (and their spending power) will be added to the global middle class. Is the world entering an era of sustained high resource prices, leading to increased economic, social, and geopolitical risk?

Similar questions have arisen in the past, but with hindsight the perceived risks proved unfounded. In 1798, land was at the center of such worries. In the famous *Essay on the principle of population*, Thomas Malthus fretted that rapid population growth would outstrip the world's supply of arable land, producing widespread poverty and famine.[1] But his dire vision never came to pass. Instead, the agro-industrial revolution swept across Britain and then the rest of Europe and North America, breaking the link between the availability of land and economic development.

Malthusian theories have enjoyed brief revivals, notably in the Club of Rome's report on the limits of growth, in the early 1970s. But a combination of technological progress, the discovery of (and expansion

[1] Thomas Malthus, *An essay on the principle of population* (New York: Penguin, 1970); the first of the six editions of the essay was published in 1798.

into) new low-cost sources of supply, and more productive ways of using it intervened. These developments pushed down—by almost half, in real terms—the price of an index of critical commodities (energy, food, steel, and water) during the 20th century. That reduction came despite demand for those resources growing as much as 20-fold during the period. (For more on 20th-century commodity trends, see "A new era for commodities," on mckinseyquarterly.com.)

Market forces, and the innovation they spark, could ride to the rescue in the 21st century too. However, the size of today's challenge should not be underestimated as we enter an era of unprecedented growth in emerging markets. Our recently completed research on the supply-and-demand outlook for energy, food, steel, and water suggests that without a step change in resource productivity and a technology-enhanced expansion of supply, the world could be entering an era of high and volatile resource prices.[2] Nothing less than a resource revolution is needed.

The evolving resource landscape

From 1980 to 2009, the global middle class [3] grew by around 700 million people, to 1.8 billion, from roughly 1.1 billion. Over the next 20 years, it is likely to grow by an additional 3 billion, to nearly 5 billion people. The world has never before witnessed income growth of this speed and magnitude: China and India are doubling their real per capita incomes at about ten times the pace England achieved during the Industrial Revolution and at around 200 times the scale. In all likelihood, the expansion of the global middle class will continue the acceleration in demand for resources—energy, food, materials, water—that has taken place since 2000.

Demand will soar at a time when finding new sources of supply and extracting it is seemingly becoming more and more challenging and expensive, despite technological improvements in the main resource sectors. Compounding the challenge are stronger links among resources, which increase the risk that shortages and price changes in one resource can rapidly spread to others. Our analysis shows,

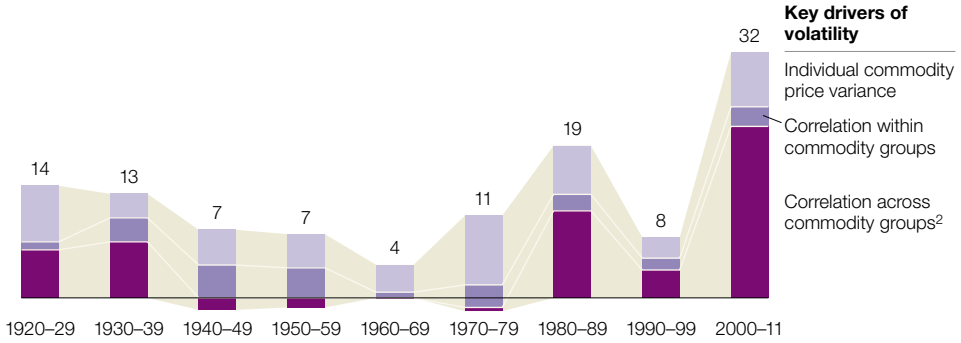
[2] Our report—*Resource Revolution: Meeting the world's energy, materials, food, and water needs*—resulted from a joint research effort between McKinsey's sustainability and resource productivity practice and the McKinsey Global Institute. Read the executive summary or download the full report at mckinsey.com/mgi.

[3] Defined as having daily per capita spending of $10 to $100 in purchasing-power-parity terms. See Homi Kharas, "The emerging middle class in developing countries," OECD Development Centre working paper, Number 285, January 2010.

Exhibit 1

Tighter correlations across commodity groups are a key factor driving volatility higher than it has been in the past century.

Annual standard deviation (relative to average) of McKinsey Global Institute's commodity price index and key drivers,[1] %



[1] Drivers of commodity index volatility determined by covariance analysis at commodity index and commodity subindex level, based on annual changes in prices. For further details, see the methodology appendix of *Resource Revolution: Meeting the world's energy, materials, food, and water needs*.
[2] Energy, metals, agricultural raw materials, and food.

Source: FAOSTAT; Grilli and Yang commodity price index, 1988; International Monetary Fund (IMF); OPEC; Stephan Pfaffenzeller et al., "A short note on updating the Grilli and Yang commodity price index," *World Bank Economic Review*, 2007, Volume 21, Number 1, pp. 151–63; World Bank commodity price data; UN Comtrade; UN Food and Agriculture Organization; McKinsey Global Institute analysis

for example, that the correlation between critical commodities is now higher than at any point over the past century (Exhibit 1). Potential environmental deterioration, itself driven by growing consumption of resources, could also constrain growth in the production of some resources. Food is the most obvious area of vulnerability, but there are others. Greater water use, for example, perhaps coupled with changes in rainfall patterns, could have a material impact on the percentage of electricity (now roughly 15 percent) supplied by hydropower.

But if the challenges are on a different scale from those of the past, so too is the potential technological know-how to address them. Techniques from the aircraft industry are transforming the performance of wind-turbine power generation. Advances in horizontal-drilling techniques, combined with hydraulic fracturing, have led to the rapid development of US shale gas, whose share of the overall US natural-gas supply climbed from roughly 2 percent in 2000 to upward of 20 percent today by some estimates. Developments in materials science and information technology hold the possibility of dramatically improving battery performance, thus changing the potential for storing electricity and, over time, diversifying energy sources for the transport sector. Organic chemistry and genetic engineering may help to foster the next green revolution, transforming agricultural productivity, the provision of bio-energy, and terrestrial

carbon sequestration. In sum, the world is not short of technological opportunities, and resource strains could accelerate the innovation race (for more on the potential for transformational change, see "Five technologies to watch," on page 56).

The case for a resource revolution

To shed light on the road ahead, we created some illustrative scenarios. One involves an expansion of supply: more of it becomes available and the productivity with which resources are used continues to increase at base-case rates consistent with current policy approaches. Another is a productivity response scenario, which adds a fuller range of productivity-enhancing opportunities to the base case and fills the remaining gap with growth in supply.

Our analysis suggests that it's possible to meet the resource challenge through an expansion in supply and base-case productivity-improvement rates. However, the pace of supply expansion would need to be significantly faster than historic rates. For land, the annual pace of supply additions over the next 20 years would have to be almost triple the rate at which it expanded over the past two decades. Water consumption by 2030 would be 30 percent higher than it is today. Up to 175 million hectares of additional deforestation would take place. Carbon dioxide emissions could reach 66 gigatons, a level that might, according to the estimates of many scientists, lead to a rise in global average temperatures of several degrees Celsius by the end of the century.[4]

The supply expansion case would require roughly $3 trillion in investment capital a year, about $1 trillion more than recent spending. Both the capital costs and carbon dioxide emissions in this picture (and in the other scenarios we created) could be improved through greater growth in shale gas. However, its promise is subject to concerns—which are not yet fully researched—about the potential impact on air, water, and land.

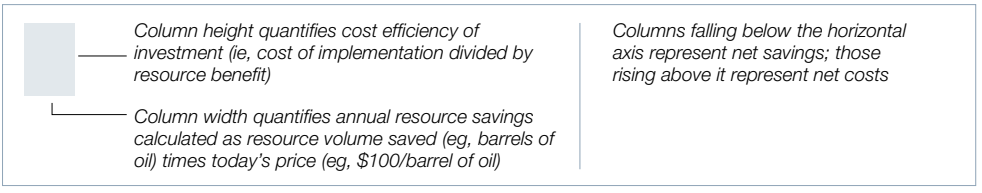
For a slightly higher price ($3.2 trillion per year), the world could pursue a fuller productivity response. Even in this scenario, much of the annual capital (about $2.3 trillion) would go to boost supply, but an additional $0.9 trillion would finance a wide range of opportunities

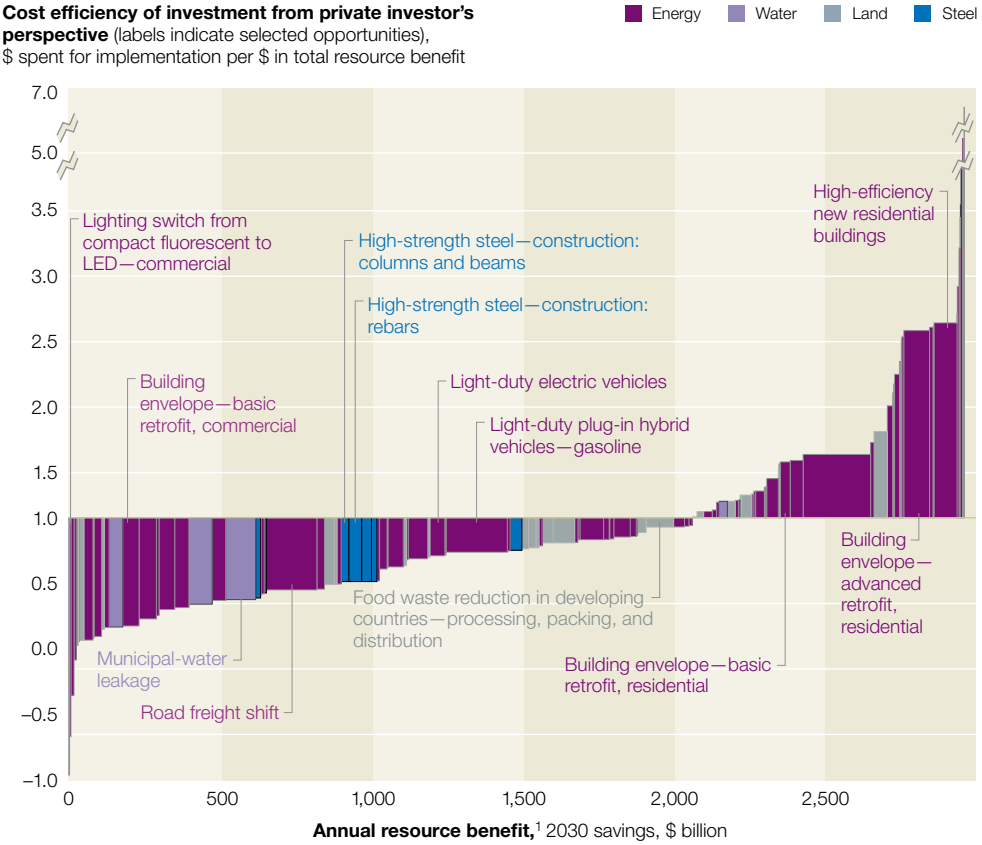
[4] *The Emissions Gap Report: Are the Copenhagen Accord pledges sufficient to limit global warming to 2° C or 1.5° C? A preliminary assessment*, UN Environment Program, November 2010.

to use resources more efficiently. At current market prices, 70 percent of these resource productivity opportunities would have an internal rate of return of more than 10 percent. By 2030, the annual market value (at today's prices) of the resources they save would be around $2.9 trillion.

Exhibit 2

Based on current resource prices, productivity opportunities could be worth $2.9 trillion in 2030.





[1] Based on current prices for energy, food, steel, and water at a discount rate of 10% a year. All values are expressed in 2010 prices.

For an interactive presentation of selected cost curve opportunities, visit mckinsey.com.

All told, the opportunities in our productivity response scenario could meet almost 30 percent of global demand for water, energy, land, and steel in 2030. They would also reduce global carbon emissions to 48 gigatons in 2030, about halfway to the target that the Intergovernmental Panel on Climate Change (IPCC) believes is consistent with limiting global warming to two degrees Celsius.[5] To help prioritize these opportunities, we developed a resource productivity cost curve (Exhibit 2), which groups more than 130 potential resource measures into areas of opportunity and arrays them according to their economic attractiveness; the top 15 could, collectively, deliver roughly 75 percent of the total resource productivity prize.

The top opportunities range from improving the energy efficiency of buildings to embracing more efficient irrigation systems. In combination, they suggest the potential for a resource productivity revolution comparable to the progress made in labor productivity during the 20th century. But capturing a significant proportion of this potential—up to 40 percent, by our estimates—will be difficult. After a century of cheap resources, few institutions, in either the private or the public sector, have made resource productivity a priority. In a global economy characterized by greater resource scarcity, companies, consumers, and countries that break with old patterns and take the lead on resource productivity should strengthen their competitive and economic position.

The resource agenda for business leaders

To thrive in an era of higher and more volatile resource prices, companies will need to pay greater attention to resource-related issues in their business strategies. The goal must be to improve a company's understanding of how resources will affect profits, produce new opportunities for growth and disruptive innovation, create new risks, generate competitive asymmetries, and change the regulatory context.

For resource-supplying industries, higher and more volatile prices could deliver significant windfall gains. But they also could generate input cost inflation, technological discontinuities, and a regulatory and societal backlash. For resource-consuming industries, higher and

[5] Our report also contains a third, "climate response" scenario, which describes what it would take to achieve a carbon pathway that the IPCC believes is consistent with limiting global warming to no more than two degrees Celsius. Crucial elements of this scenario include a greater shift to power delivered through renewables; the incremental production of biofuels for use in road transport; and further abatement of carbon emissions in land use through the reforestation of degraded land resources, the improved management of timberland, and measures to increase the productivity of pastureland.

more volatile input prices may be hard to pass through fully to consumers. In addition, such industries will probably face new challenges, especially in fast-growing emerging economies where resource scarcity, and therefore competition over access (for example, to water rights), will prove more acute.

A systematic approach

The strategic implications of resource-related trends will vary from company to company, of course. A starting point for many is simply to adopt a more systematic approach toward understanding how the changing resource landscape could produce new growth opportunities, create cost advantages versus less prepared competitors, and generate new stresses on the management of risk and regulation. Exhibit 3 provides a checklist for business leaders to address these critical priorities:

Pursue growth opportunities. Helping consumers and companies to use or access resources more efficiently should be very good business in the years ahead. For instance, the fastest-selling elevator line in Otis's 150-year history is the Gen2, which uses up to 75 percent

Between 20 and 30 percent of the world's food is wasted somewhere along the value chain.

Exhibit 3

A resource strategy checklist can stimulate valuable internal dialogue.

Growth	Composition of business portfolio	Guide investment and divestment decisions at portfolio level; decisions to be based on resource trends
	Innovation and new products	Develop resource productivity products and technologies to fill needs of customers and company (R&D function)
	New markets	Build a better understanding of resource-related opportunities in new market segments and geographies and develop strategies to capture them
Internal efficiency	Green sales and marketing	Improve revenue through increased share and/or price premiums by stressing resource efficiency in marketing efforts
	Sustainable value chains	Improve resource management and reduce environmental impact across value chain to reduce costs and improve products' value propositions
	Sustainable operations	Reduce operating costs through improved internal resource management (eg, carbon, energy, hazardous materials, waste, water)
Risk management	Operational-risk management	Manage risk of operational disruptions (from resource scarcity, climate change, or community risks)
	Reputation management	Reduce reputation risks and get credit for your actions (eg, through proper stakeholder management)
	Regulatory management	Mitigate risks and capture opportunities from regulation

less energy than conventional elevators. Major companies, such as General Electric and Siemens, are building resource productivity businesses by investing heavily in emerging clean-energy and clean-water opportunities ranging from wind turbines to industrial-energy efficiency. And in technology centers such as Silicon Valley, a broad range of clean-tech investors and entrepreneurs seek profits by revolutionizing resource productivity. In fact, venture capitalist Vinod Khosla predicted in a recent paper that positive "Black Swans" will "completely upend assumptions in oil, electricity, materials, storage, agriculture, and the like."[6]

Boost internal efficiency. Companies have large, profitable opportunities to improve the efficiency of their resource use across the value chain. Consumer-packaged-goods manufacturers have cut their energy costs by up to 50 percent by pulling productivity levers that pay back their costs in less than three years. Wal-Mart Stores has implemented a sourcing strategy that aims to reduce supplier packaging

[6] Vinod Khosla, *Black Swans thesis of energy transformation*, Khosla Ventures white paper, August 2011.

from 2008 levels by 5 percent no later than 2013, for estimated direct savings of $3.4 billion.[7] Capturing many of these supply chain opportunities will require much closer collaboration between upstream and downstream players.

Manage risk. As resource inputs to production processes become increasingly scarce, companies need to develop a more sophisticated understanding of their exposure to different natural resources, including supply chain dependencies and regulatory risks. Steel, for example, is becoming ever more critical in the oil-and-gas sector because of the shift to offshore deepwater drilling. Steel production depends crucially on the supply of iron ore, which in turn relies heavily on the water used to extract it. Almost 40 percent of iron ore mines are in areas with moderate to high water scarcity, and a lot of steel is produced in places where water is relatively scarce.

One major packaged-goods company recently discovered that even though natural resources account for just 35 percent of its current cost base, swings in their prices could easily account for more than 70 percent of likely changes in the company's overall cost structure during the years ahead. That company, like many in the packaged-goods and other industries, has long taken a fragmented approach to managing the supply of raw materials. A world with a greater correlation between resource prices will put a premium on a more integrated approach, including central coordination of raw-material strategy across business units and product designs that minimize raw-material risks. Input diversification strategies—such as augmenting petroleum-based plastics with bioplastics or recyclable aluminum in bottling—may rise in importance.

Four areas for action

To illustrate the business opportunity, we'll review 4 of the 15 resource productivity priorities that, collectively, represent 75 percent of the total productivity prize (Exhibit 4). These opportunities will give some companies a chance to build profitable businesses and help others to keep costs and risks in check.

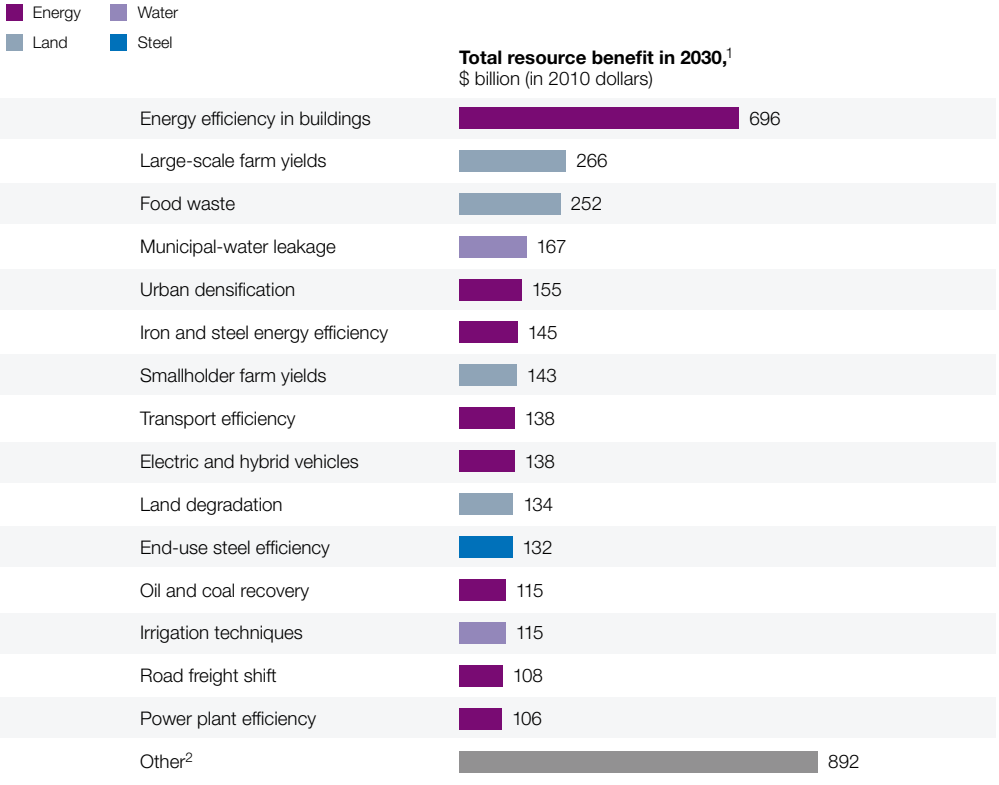
Energy efficiency for buildings. Improving the energy efficiency of residential and commercial buildings is the single largest opportunity identified in our research. Retrofitting them with improved envelopes—above all, insulation—as well as heating and cooling systems and

[7] *Roadmap to a Resource Efficient Europe*, European Commission, September 2011.

water heaters, is a large opportunity, particularly in developed countries (see "Competing for the home of the future," on page 59). Spotting it, emerging residential-scale energy-service companies are attempting to provide end-to-end turnkey efficiency services for home and small-business owners, attracting customers through guaranteed utility savings. Meanwhile, a broad range of companies can cut costs and boost returns on capital by making their buildings more energy efficient. "Simply cleaning the dust and dirt off the coils of a building's air-conditioning unit," says Walter Levy, CEO of the industrial-product manufacturer NCH, "allows the unit to operate more efficiently and thereby lowers its energy consumption up to 10 percent." Companies are likelier to pursue such opportunities when they "look at maintenance as a return on investment," says Levy.

Exhibit 4

Fifteen areas of opportunity represent 75 percent of the resource prize.



[1] Benefit calculations reflect current market prices for steel, food, water, and energy; adjusted to exclude energy taxes and subsidies on energy, water, and agriculture and to include carbon price of $30 per metric ton. These adjustments raise total benefits to $3.7 trillion, from the $2.9 trillion shown on the cost curve (Exhibit 2).
[2] For example, air transport, feed efficiency, industrial-water efficiency, municipal-water efficiency in areas other than leakage, steel recycling, and wastewater reuse.

Food waste. The world generates about ten million tons of food waste every day—20 to 30 percent of all food along the value chain. In developed countries, the vast majority of waste occurs during processing, packaging, and distribution. Developing countries waste a significant share of their food after harvest because of poor storage facilities and an insufficient distribution infrastructure. More than 60 percent of the food opportunity lies in reducing perishable waste—which requires modern cold-storage systems and better transport approaches. Both represent significant business opportunities, particularly in developing countries. So do business model innovations that address behavioral challenges. In Africa, for example, many farmers have resisted using metal silos, preferring to reduce the risk of theft by keeping grain stored in the safety of their own homes. Any savings from reducing food waste spill over to savings from the water and energy used in agriculture.

Next-generation vehicles. The future cost competitiveness of electric and plug-in hybrid vehicles will depend on technological-learning rates in producing batteries and electrified engines versus internal-combustion engines, which are themselves not standing still. One company looking for opportunities in the evolution of vehicles is truck maker Navistar, which in 2011 announced a development agreement with EcoMotors to support that company's opposed-piston, opposed-cylinder (OPOC) engine architecture. Opportunities also should abound for companies able to deliver breakthroughs in batteries. Our analysis suggests that if their costs fell to $100 per kilowatt hour by 2030 (from approximately $500 today and $250 in our 2030 base case), sales of electric vehicles could account for 30 percent or more of new-car sales.

High-strength steel. ArcelorMittal, the world's largest steel company, estimates that high-strength steel would reduce the weight of steel columns and steel beams by about 32 and 19 percent, respectively. Qube Design Associates has developed advanced reinforcing bars that weigh 30 percent less than conventional ones. High-strength steel represents a sales growth opportunity for companies such as these and major potential savings for any consumer of constructional steel: overall, we estimate, a modest increase in the penetration of high-strength steel could save 105 million tons of steel in 2030, a reduction of 9 percent. One major barrier to adoption is a lack of awareness among the many buyers of construction steel in emerging markets. But that may be changing: buildings such as the Shanghai World Financial Centre and Dubai's Emirates Towers already incorporate high-strength steel.

Priorities for government leaders

The speed and scale with which business leaders increase the supply of resources and pursue the four productivity opportunities described above (or the 11 other high-priority ones highlighted by our research) will depend on the rules of the game established by governments.

One critical challenge is the fact that officials at the ministries most relevant to the resource system—energy, water, and agriculture—are unlikely ever to have dealt with a global-resource market as complex as the one we have today. To respond to it, they will need new skills. Furthermore, many governments find it hard to coordinate strategic-planning activities across ministries. Water-related issues, for example, often fall between the responsibilities of the ministries for water, agriculture, urban development, energy, and the environment; land-use issues between those of the agriculture, forestry, energy, and environment ministries at the national level, with multiple other stakeholders at the provincial and district levels. The international system for development assistance exacerbates matters, since it has its own parallel set of international agencies, each with a vested interest in its own part of the agenda. This fragmented institutional approach means that governments may not sufficiently emphasize

Improving the energy efficiency of buildings is the world's largest resource productivity opportunity. Here, workers in Beijing add insulation to the exterior of an apartment building.

The pace of electric-vehicle penetration will depend on developments in battery technology and government policy.

the highest-priority resource opportunities, such as the 15 our research highlights.

Beyond this transformation of institutional mind-sets and mechanisms, policy makers can act on three fronts to ease the path to a resource revolution.

Strengthen price signals

Uncertainty about the future path of resource prices at a time when they are particularly volatile means that it is difficult for investors to judge what returns they might make on their investment. Furthermore, fiscal regimes in many countries provide a disincentive to the productive use of energy, land, and water resources by subsidiz-

ing them to the tune of more than $1 trillion per year. Replacing these subsidies with market-based prices would improve the attractiveness of resource productivity opportunities to private-sector investors. So would putting a price on externalities, potentially including carbon emissions.

Measures such as these are difficult to get right, though. Unwinding energy subsidies, for example, would require other means of protecting the poorer populations that the subsidies are often designed to support. Unwinding water subsidies may be even harder, given the impact on local agriculture and urban populations. And any new price signals must minimize the risk of competitive asymmetries while encouraging companies to continue providing the resource supplies that the world will need.

Address nonprice market failures

Under any combination of supply and productivity moves, meeting the global economy's growing resource demands over the next 20 years will require investment to increase by 50 to 75 percent, to at least $3 trillion per year. Achieving this ramp-up in investment will require measures to overcome start-up challenges and reduce associated investment risks, especially in resource systems with long-lived assets and hence significant stranded-asset risk. Strengthening private-sector lending (especially to capital-constrained households, small businesses, and project developers) will be crucial too. The same goes for clarifying property rights, particularly in the agriculture and fishery sectors, and for addressing principal–agent issues, such as those between building landlords who bear the cost of investments in efficiency and tenants who receive the benefits.

Build long-term resilience

In the face of these challenges, society's long-term resilience needs bolstering. Policy makers can help by raising awareness of resource-related risks and opportunities, creating appropriate safety nets to mitigate the impact of these risks on the very poor, and educating consumers and businesses to adapt their behavior to the realities of today's resource-constrained world. Action that strengthens the productivity of smallholdings would simultaneously expand the supply of resources and improve distributional outcomes. Providing universal access to modern energy services could cost less than $50 billion a year and transform the livelihoods of 1.4 billion people still suffering from basic energy poverty. Implemented the right way, such moves could also strengthen the resilience of ecosystems by encouraging better management of water and soil fertility, limit-

ing fuelwood-related deforestation, and enabling rural communities to adapt to the evolving, but uncertain, impact of climate change.

Supply and productivity opportunities can address the growing demand for resources and the environmental challenges associated with the rise of three billion new middle-class consumers. But these opportunities raise fresh questions: can business and government leaders, not to mention consumers, move with the speed and scale needed to avoid a period of dramatically higher resource prices, along with their destabilizing impact on economic growth, welfare, and political stability? Or do we need a crisis, with its associated problems, to accelerate technological innovation and investment? The questions are big, and the stakes are high.

The authors would like to acknowledge Daniel Clifton, Nicholas Flanders, Kay Kim, Pranav Kumar, Scott Nyquist, Matt Rogers, Sven Smit, and Marc Zornes for their contributions to this article.

Richard Dobbs is a director of the McKinsey Global Institute (MGI) and a director in McKinsey's Seoul office; **Jeremy Oppenheim** is a director in the London office, where **Fraser Thompson,** a senior fellow of MGI, is based.