



India: Taking on the green-growth challenge

India has the potential to significantly increase its energy security to support continued rapid growth, while securing sustainability that exceeds current expectations.

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Over the next two decades, India is expected to grow at a rate of 7 to 8 percent. And during that same period, it will build approximately 80 percent of the physical assets—including infrastructure, commercial and residential real estate, vehicle stock, and industrial capacity—that will constitute the India of 2030.¹

Growth of this magnitude will bring tremendous benefits, but it also poses many challenges, particularly regarding sustainability. For example, demand for resources will increase dramatically, raising the country's dependence on imports for commodities such as crude oil and driving commodity prices higher in general. And

India will need to expand its capacity to generate electricity to meet increasing industrial and residential demand, which will impel a corresponding increase in greenhouse-gas (GHG) emissions.

India has already taken steps to curb expected increases in GHG emissions, including launching efforts to increase the efficiency with which it uses resources, reduce consumption, and accelerate the adoption of clean technologies. Yet even if most of its planned improvements are implemented, India's GHG emissions will still increase by a multiple of about 3.5 in 2030 compared



with 2005 levels, from 1.6 billion to 5.7 billion metric tons of carbon dioxide equivalent (CO₂e).²

Our research indicates that India can do much more to reduce energy consumption and GHG emissions without compromising its prospects for growth. Based on assessments of approximately 200 commercially viable opportunities, we believe the country has the technical potential³ to shrink its projected energy consumption by 22 percent and lower its consequent GHG emissions by an additional 30 to 50 percent. Specifically, its emission levels would only rise to between 2.8 billion and 3.6 billion metric tons of CO₂e in 2030⁴—more than 2 billion metric tons of CO₂e less than the level that might be achieved under current plans.

These are large figures, and we emphasize that they represent the potential rather than what might necessarily materialize, given the complicated forces at work in India and around the globe. Nevertheless, we believe that understanding what is theoretically possible encourages leaders to strive for—and achieve—more ambitious results than they would when concerned only with what they consider realistic.

What stands in the way of this potential? Briefly put, India will have to develop solutions to long-standing challenges in financing, regulation, skills, and technological and business-model uncertainty. It will also have to navigate the risk that some measures could increase the cost of doing business in some sectors, at least in the short term, which could threaten the country's global competitive positioning.

Despite the challenges, ignoring this potential is far riskier than pursuing it. India is unlikely to

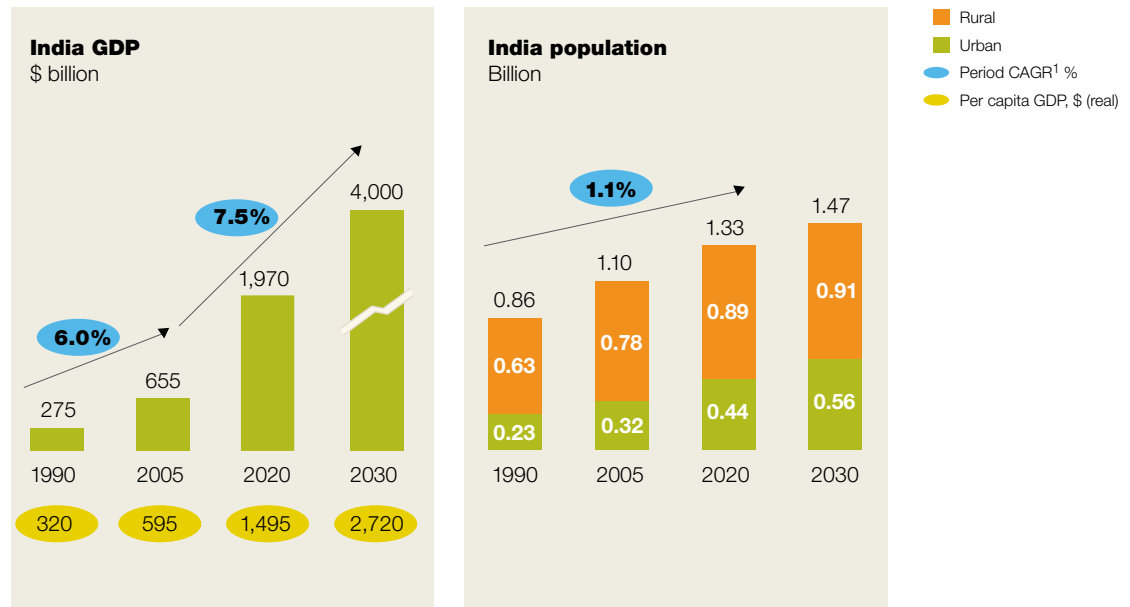
be able to maintain its expected rate of growth over the next 20 years unless it takes significant action to reduce its consumption of resources and energy, and capturing even a portion of the technical potential would make a tremendous difference in many areas. In addition to reducing its GHG emissions and increasing its energy security, India could decrease operating costs for many businesses by enabling sustainable process efficiencies and lowering demand for power and resources. Consumers would benefit in the form of lower prices, which would make products and services more widely available, potentially facilitating greater energy inclusion. And by accelerating large-scale adoption of new technologies, India could position itself to become a hub for a number of clean-tech industries.

To set a new standard for sustainability, India should focus on four areas that represent almost 75 percent of the technical potential for improvement in its GHG footprint: increasing energy efficiency in industry, vehicles, and appliances; accelerating the transformation of its power sector, promoting the adoption of clean technology; building green infrastructure for urban habitats and transportation; and establishing sustainable agriculture and forestry practices.

The current path

India already ranked as one of the 10 largest economies in the world in 2010, and it is expected to continue to grow rapidly over the next two decades. The country's GDP is projected to rise from \$595 billion in 2005 to \$2.72 trillion in 2030, and its population is expected to increase from 1.1 billion to 1.47 billion over the same period (Exhibit 1).

Exhibit 1

Economic and population growth continue.

¹Compound annual growth rate.

Source: McKinsey Global Institute–Oxford Economics model; National Commission on Population, Office of the Registrar General for Census of India; World Market Monitor Global Insight; McKinsey analysis

This is a cause for celebration, but celebration tempered by recognition of the challenges that accompany rapid growth. India will experience dramatic increases in demand for materials and energy, placing serious constraints on natural resources such as land, water, minerals, and fossil fuels, and driving up energy and commodity prices. All things being equal, increasing activity will lead to increasing generation of waste and pollution, particularly in the form of higher GHG emissions. Ultimately, these challenges could curb India's ability to grow, rendering its momentum unsustainable.

Recognizing the threat, India has already begun to take steps to increase its sustainability, including reducing energy demand and improving

energy efficiency. For example, it has launched efforts to upgrade its generation and transmission assets and optimize its power mix by increasing its use of nonfossil fuels. It has taken steps to reduce energy consumption by residential and industrial users, improve fuel efficiency in road transportation, and increase the percentage of forested land in the country, which will increase its CO₂ absorption capacity as well as prevent soil erosion. (See the sidebar, "Summary of key policy measures to reduce emissions," p. 68, for more details about efforts already under way in India.)

The technical potential

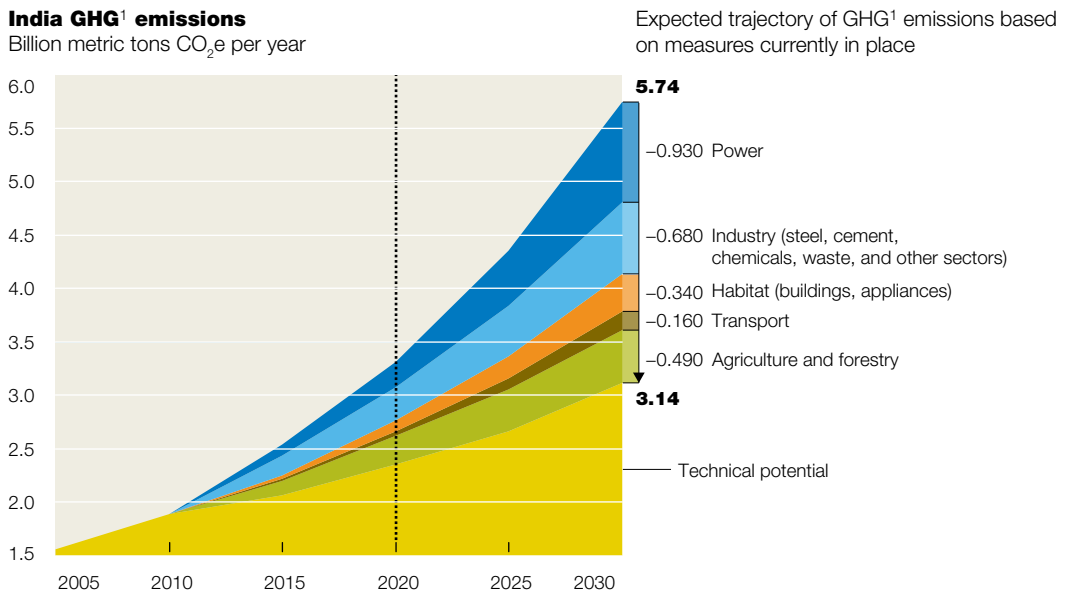
India's current efforts are impressive, but even if they were all implemented successfully, the

Exhibit 2

India has the potential to cut its expected 2030 greenhouse-gas emissions almost in half.

India GHG¹ emissions

Billion metric tons CO₂e per year



In 2020, energy efficiency and agriculture/forestry represent 60% of abatement potential.

Impact from nuclear and renewables starts by 2020 and triples by 2030 as more capacity is added.

¹Greenhouse gas.

Source: McKinsey India Cost Curve model; McKinsey analysis

country's total energy demand would be likely to increase to 1.8 billion metric tons of oil equivalent (btoe)⁵ by 2030, up from 0.5 btoe in 2005.

This would make India the third-largest energy consumer in the world, after the United States and China.

Our analysis reveals that India has the technical potential to achieve much greater environmental and energy sustainability than it is on track to accomplish. Expected energy consumption in 2030 could be lowered an additional 22 percent, from 1.8 btoe to 1.4 btoe.⁶ And expected GHG

emissions in 2030 could be cut almost in half, from 5.7 billion to 3.1 billion metric tons of CO₂e⁷ (Exhibit 2).

We estimated this potential by assessing more than 200 opportunities that reduce emissions and increase energy efficiency.⁸ We analyzed the emissions abatement potential and the cost of abatement for each measure. The results of this analysis are represented in our India abatement cost curve, which lists each measure in an order that reflects a combined understanding of its impact on emissions and cost through 2030

Summary of key policy measures to reduce emissions

In 2008, Prime Minister Manmohan Singh released India's first National Action Plan on Climate Change (NAPCC), which outlines existing and future policies and programs addressing climate mitigation and adaptation. Several other government and industry initiatives have also been established in India to reduce energy demand and optimize supply. The following summary highlights some of the most important efforts the country has launched to increase its sustainability:

Reduce transmission and distribution losses in the power sector. The Restructured Accelerated Power Development and Reforms Programme was launched in 2007 to reduce aggregate technical and commercial electricity losses from 30 to 15 percent by 2020. The effort is focused on strengthening the country's subtransmission and distribution network and expanding its adoption of state-of-the-art IT solutions.

Increase use of clean-coal technology. The NAPCC recommends that "supercritical boilers" be used in the immediate future for generating power using coal, and it recommends that "ultrasupercritical boilers" be used when we know the technology works commercially in India. The country is also considering adding a ninth mission to the NAPCC on clean coal or clean carbon.

Increase use of nonfossil fuel power. India's National Solar Mission aims to deploy 20 gigawatts of on-grid solar power and 2 gigawatts of off-grid solar power by 2022. At close to 15 gigawatts, wind power is now the largest renewable power source in India with significant untapped potential. India is also considering nuclear power as an alternative to coal-fired plants.

Lower electricity consumption in buildings and appliances. A variety of initiatives were launched by the Bureau of Energy Efficiency (BEE), including the Bachat Lamp Yojana program to promote compact fluorescent lighting, the Star Labeling program to encourage the use of high-efficiency appliances through energy-performance labeling, and the Energy Conservation Building Codes program to prescribe minimum efficiency standards for commercial buildings. Other measures include mandatory labeling of refrigerators, transformers, tube lights, and air conditioners.

Increase fuel efficiency in road transport. BEE has launched a program for labeling cars. Currently the labeling is voluntary, but it is expected to become mandatory in a few years. Additionally, norms are being finalized for fuel efficiency, which vehicle manufacturers will have to achieve by 2015 or 2016.

Improve energy efficiency in energy-intensive industries. BEE is establishing the Perform, Achieve, and Trade scheme, which will require companies in energy-intensive industries such as steel and cement to meet mandated reductions in their energy consumption. The reduction target will be based on companies' current level of energy efficiency.

Expand forest cover. The National Mission for a Green India has set a goal to afforest 6 million hectares of degraded lands and expand forests so they cover 23 to 33 percent of India's territory.



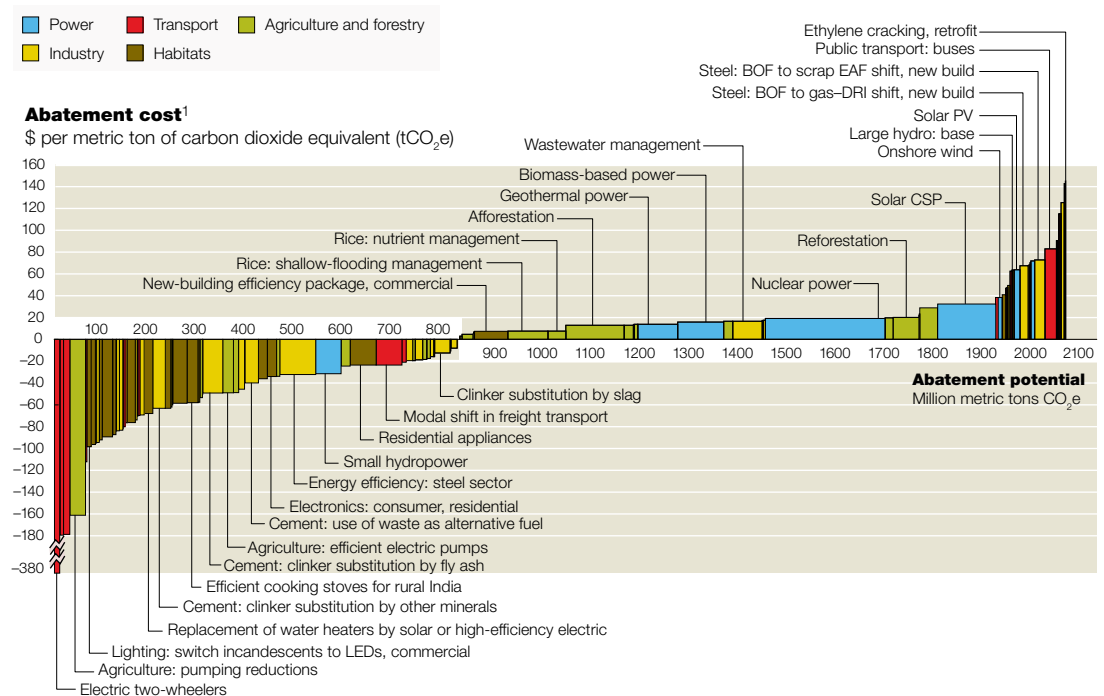
(Exhibit 3). Indeed, many of these opportunities would actually reduce costs from current levels. To ensure that our perspective was comprehensive, we also sought the views of more than 100 experts in government, business, academia, and society in India and around the world.

In addition to achieving GHG reductions, India stands to benefit in a variety of ways from seizing

the opportunities we considered. By capturing these energy-efficiency opportunities, India could avert the addition of about 120 gigawatts of power capacity. This represents \$100 billion in avoided capital expenditures. And reduced use of coal for power generation, steelmaking, and cement production could reduce coal demand by nearly half, thereby doubling the life of the country's coal reserves.

Exhibit 3

Our model shows India's abatement cost curve for 2030 (cost below \$145 per metric ton).



¹This curve estimates 2.1 billion metric tons of CO₂e potential. Additional potential below \$145 per metric ton includes reduction in technical-transmission and distribution losses (190 million metric tons (mt) CO₂e), auxiliary consumption (~50 mt), efficiency improvement in other sectors (~200 mt), improved urban planning (~30 mt), and distributed generation using combined heat and power (~15 mt). Levers costing more than \$145 per metric ton (not included in the cost curve) have a total abatement potential of 80 mt. Important levers are public-transport infrastructure in metropolitan regions (7 mt), electric vehicles, and full hybrids (6 mt). An 8% discount rate was assumed for the cost-curve analysis, based on benchmark yield for long-term Indian government bonds.

Source: McKinsey India Cost Curve model

Beyond pure economic benefits, these measures would also significantly increase energy inclusion and quality of life in India

Lessening the demand for energy and improving transportation would also increase India's energy security by easing its reliance on imports of coal and oil. The country has the potential to reduce the oil required for transportation by as much as 40 percent, thus reducing its annual import bill by about \$60 billion (at an assumed cost of \$100 a barrel) in 2030.

India could also take the lead in a few clean-technology industries by leveraging its engineering talent and low-cost manufacturing advantage. It could become a center of intellectual-property creation and a leader in the manufacture of clean-tech products. Areas of opportunity include clean-coal-based power plants, solar, efficient building technologies, smart grids, LED lighting, and electric two-wheelers. The global market potential in these areas is more than \$1.5 trillion over the period from 2010 to 2030 and offers a potential global revenue pool of \$70 billion to \$100 billion annually.

Beyond pure economic benefits, these measures would also significantly increase energy inclusion and quality of life in India, particularly for those

living in rural areas. For example, distributed power generation would increase access to electric power. Improved agricultural practices would reduce energy and water consumption as well as increase availability of food and water. Shifting freight transport to rail and coastal shipping would reduce road congestion, making driving safer. Urban citizens would enjoy improved public-transportation infrastructure, reduced road congestion, and lower vehicular pollution. Waste-to-energy technologies would help urban municipalities manage their waste-disposal obligations, and improved agricultural practices would better utilize the nation's supply of water. Moreover, many solutions would bring significant public-health benefits, particularly a reduced risk of respiratory diseases.

Practical constraints

While acknowledging the benefits, however, it would be naive not to identify the challenges that could inhibit India's ability to achieve this full potential.

Abatement opportunities vary widely in cost and ease of implementation (Exhibit 4). Our analysis suggests that only about 10 percent of the

abatement potential is readily achievable, mostly from opportunities involving improving energy efficiency in appliances, buildings, industry, and transport. The majority of the clean power, industrial technology, and green transportation opportunities are more difficult to implement.

India would have to incrementally invest from about \$850 billion to \$1 trillion between 2010 and 2030 to capture the full potential, even after accounting for likely reductions in the cost of emerging technologies. Policies would have to be altered in many areas, including those regulating electric power, buildings and construction,

Exhibit 4

Our model evaluates the feasibility of capturing abatement potential.

Abatement potential in million metric tons CO₂e, 2030

Cost/ metric ton	Ease of implementation ¹		
	Moderately challenging	Challenging	Very challenging
Negative <\$0	- Energy-efficient equipment and appliances (90) - Mileage standards (30) 120	- Energy efficiency in steel (90) - Lighting controls (20) - Clinker substitution by other mineral components such as low-grade limestone (25) 135	- Clinker substitution by fly ash in cement (40) - LED lighting (35) - Clinker substitution by slag in cement (30) - Efficient cook stoves (20) - Pumping reductions (30) 155
Modest \$0–\$30	- Small hydro (50) - Hydro run of river² (35) - Coal supercritical² (200) - Nuclear power: 30 gigawatts (GW)² (215) 50³	- Nuclear power (30–60 GW) (250) - Reduction in transmission and distribution/auxiliary losses (200) - Biomass power (95) - New-building efficiency (70) - Nutrient management for rice (40) 655	- Afforestation (120) - Efficiency from other sectors (190) - Geothermal power (80) - Wastewater management (60) - Degraded forest reforestation (50) - Organic soil restoration (20) - Rice: shallow flooding (80) 590
High >\$30	Bus-based public-transport systems (20) 20	- Shift to scrap-based electric-arc furnace in steel (20) - Shift to gas-based direct reduced iron (20) - Solar photovoltaic (PV) and concentrated solar power (CSP):² 30 GW (55) 40⁴	- Offshore wind energy (20) - Forest management (40) - Large hydro (15) - Solar PV (20) - Solar CSP (90) - Ultrasupercritical coal (15) - Modal shift in transport (40) 240

Readily achievable

Medium difficulty

Difficult

Sum of abatement potential

¹Ease of implementation based on financing issues, regulatory support, agency issues, entrenched behavior, supply constraints, and technological readiness; only key levers (covering about 80% of potential) are listed in the matrix.

²These levers are assumed to be implemented in the reference case.

³Without reference-case additions; 500 million metric tons after accounting for reference-case actions.

⁴Without reference-case additions; 95 million metric tons after accounting for reference-case actions.

appliances, agriculture, and water use. India would have to develop the capability to leverage new processes and technologies, including developing end-to-end supply chains to implement nuclear and solar-power solutions, and training engineers and designers to develop needed products and infrastructure.

A number of the opportunities we identified depend on technologies that are yet to be proved. In addition, new business models will have to be developed to address market imperfections, such as principal-agent failures that can arise if the interests of different stakeholders are not aligned.

Finally, India must take care to ensure that the steps it takes serve its national interest. It must manage the risk of taking unilateral action on climate policy, which could increase the relative cost of doing business within its borders. For example, requiring power generators to adopt more sustainable but more expensive technologies—renewable-energy technologies could increase costs for companies operating in global industries such as steel and automobiles, which could make Indian businesses less competitive.

Claiming the prize

The challenge is daunting, but as we have pointed out, India is already making significant progress. The government is driving advances through its National Action Plan on Climate Change, as well as through programs launched by entities such as the Bureau of Energy Efficiency (BEE). For example, it has made the solar sector more attractive for companies by making the bidding process for solar opportunities more transparent. India has also made it easier for

financial institutions to fund sustainability projects by helping banks manage the risk of default and by establishing mechanisms for fast-track lending.

We believe India has tremendous room for additional improvement. To claim as much of the opportunity as it can, India should prioritize efforts at the intersection of what is feasible and what will yield the greatest results. As noted, four broad areas represent approximately 75 percent of the technical potential available to reduce GHG emissions in India: energy efficiency in industry, vehicles, and appliances represents 40 percent; transforming the power sector, 15 percent; green urban and transport infrastructure, 10 percent; and agriculture and forestry, another 10 percent.

Energy efficiency in industry, vehicles, and appliances

In the steel industry, where India's demand is expected to grow about fourfold in the next 20 years, producers could adopt new technologies, such as top-pressure recovery turbines, and implement processes, such as pulverized coal injection and coke dry quenching, that will reduce the energy required per metric ton of steel. Newer steelmaking technologies such as direct smelt reduction could also decrease energy demand. Cement companies could lessen energy consumption by using higher amounts of fly ash from coal-based power plants in cement production and reduce their GHG emissions by transitioning to alternative fuels such as solid waste and biomass.

India's vehicle fleet is projected to increase sevenfold by 2030. The country could cut its oil consumption by 15 percent by lowering the



average weight of vehicles used for transportation. Using biofuels such as ethanol could reduce oil consumption in the sector by another 5 percent.

The BEE has already taken steps to promote the use of clean appliances, but market imperfections currently prevent full realization of the efficiency savings available.

The government could take further steps to introduce technical norms and standards for appliances and increase incentives to encourage use of the most efficient appliances available. It could also consider supporting research and development in high-efficiency appliances.

Transforming the power sector

About 30 percent of the power generated in India is lost due to technical and commercial issues in transmission and distribution. Technical losses account for 15 to 19 percent of total leakage, which is more than twice the average in developed countries. To reduce technical leakage, companies must improve transmission and distribution infrastructure—for example, by installing higher-quality transformers. To reduce commercial losses, which are mostly caused by theft, companies must ensure that all power use is metered.

To reduce reliance on more expensive peak-generation capacity, which typically generates more GHG emissions, utilities could implement demand-side management programs, such as time-of-day tariffs that shift power consumption from high- to low-demand periods. India could also shift generation capacity to cleaner technology

to reduce emissions and realize efficiency gains (which result from the fact that the technology is newer than that of the installed base). The country is currently trending downward toward generating 60 percent of its power from coal. It could further reduce coal demand by increasing its use of supercritical and ultra-supercritical technologies.

Other clean technologies could also be used to meet base- and peak-load demand. For example, completing all planned greenfield and brownfield nuclear expansion projects would increase base-load capacity by 60 gigawatts by 2030—although India must take care to incorporate lessons from events in Japan to manage nuclear risks.

India could meet a portion of its peak demand⁹ by increasing solar capacity as a replacement for oil and gas generation. Solar is already competitive with diesel-based power generation. If current cost trends continue, photovoltaic-based solar technology may become cheaper than power based on liquefied natural gas¹⁰ before the end of 2020. If solar capacity increases at the rate anticipated by the country's National Solar Mission, India could have more than 60 gigawatts of installed solar power capacity by 2030.¹¹ India could also increase its capacity in reservoir hydropower to serve peak demand with cleaner energy sources.

Green urban and transportation infrastructure

Sustainable building standards would reduce the demand for power by improving efficiency and reducing waste. The government could encourage, if not require, developers to adopt building codes¹² that prescribe sustainability measures such as using fly ash or slag-blended cement, high-efficiency insulation and windows, LED lighting, and energy-efficient air conditioners. Such measures can

reduce the energy consumption of a building by 30 to 40 percent.

More broadly, sustainability could be incorporated as a design parameter in urban planning. Planners could design townships to reduce the distances residents need to travel and thus the amount of energy they require for transportation. They could also develop integrated public-transportation plans that would establish metro railways for the country's nine largest cities and bus systems for the 250 largest cities. The plans could establish smart traffic-management systems, such as congestion-charging schemes, that encourage the use of public transportation and reduce congestion and road pollution.

Oil demand in freight transportation could be reduced by about 20 percent by shifting freight from road to rail and coastal shipping. To achieve this goal, India would need an integrated logistics policy that would direct investment to 7 long-distance rail and water corridors, 15 to 20 interchange points or logistic parks, and a large number of 100- to 300-kilometer expressways on road segments that are already in heavy use.¹³

Agriculture and forestry

Agriculture makes up about one-sixth of the Indian economy. The agriculture sector in India accounts for about 23 percent of the electricity and 15 percent of the diesel consumed in the country. Indeed, India has among the highest rates of diesel and electricity consumption per hectare of agricultural land in the world. Some of the agricultural practices used in India call for twice the amount of water that is required by state-of-the-art practices that generate the same yields. Wider use of efficient irrigation

techniques, such as drip and sprinkler irrigation, and efficient pump sets could reduce the sector's water needs by up to 25 percent and its electricity and diesel consumption by 15 to 20 percent.

Adoption of techniques to improve rice cultivation and reduce tillage could lower GHG emissions by 200 million metric tons of CO₂e. These techniques confer many important benefits in addition to emissions abatement, including improved crop yields and reduced water consumption, which would enable the country to increase its supply of food and water.

Flood irrigation, the most widespread method for growing rice in the country, causes anaerobic decomposition in fields and produces methane exhaust. In 2005, a fifth of India's emissions came from flood irrigation. India could reduce its emissions by 120 million to 150 million metric tons of CO₂e by using shallow flooding and nonnitrogen fertilizers to prevent anaerobic decomposition.

India could also make great strides in forestry. The National Mission for a Green India set a goal to cover a third of the country with forest. This would involve establishing 20 million hectares of additional forest-covered land. Doing so would reduce the country's emissions by about 150 million metric tons of CO₂e.

To increase its forest density, India could introduce fast-growing grass and tree species; apply fertilizers and organic amendments such as chicken manure, sawdust, compost, or leaves to hasten stock growth; and take steps to prevent forest fires. Enhanced forest management, along with reforestation of degraded forests, could increase carbon

sequestration—and hence abatement—by 53 million metric tons of CO₂e by 2030.



Our research indicates that India has a tremendous opportunity to increase its level of sustainability beyond what it expects to achieve through the ambitious programs already inaugurated. Achieving just a portion of this theoretical potential would yield immense economic and social benefits that would not only enable India to maintain its recent rapid rate of growth and increase its energy security but also to increase the quality of life of its citizens by expanding energy inclusion, increasing access to quality food and water, and improving air quality. And by acting quickly, India has the opportunity to establish itself as a hub for a range of clean-tech industries, thus laying the foundations for new avenues of growth. ○

¹ *Environmental and energy sustainability: An approach for India*, McKinsey & Company, 2009 (www.mckinsey.com).

² CO₂e stands for “carbon dioxide equivalent” and is a standardized measure of greenhouse gases. Emissions are measured in metric tons of CO₂e per year, that is, millions of metric tons (megatons) or billions of metric tons (gigatons). Greenhouse gases include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) emissions from human activity, in our estimate.

³ Our estimate reflects what could be achieved if India were to capture the full potential available from the 200 opportunities we analyzed, some of which may depend on technological innovations that are likely but are not yet proven to be commercially viable. We estimate feasibility of some of the most effective opportunities in Exhibit 3.

⁴ At an annual GDP growth rate of 7.5 percent; range is due to the uncertainty about measures implemented.

⁵ Reflecting greenhouse-gas emissions of approximately 5.7 billion metric tons of CO₂e in 2030.

⁶ Decreases in energy consumption in sectors discussed in this article. This does not include direct energy savings from opportunities in other industrial sectors (except steel, cement, chemicals, and refining).

⁷ Depending on the range of measures implemented, emission levels could be between 2.8 billion and 3.6 billion metric tons of CO₂e; for our analysis, assumed at 3.1 billion metric tons of CO₂e.

⁸ There are additional opportunities beyond those outlined that are difficult to quantify but could further reduce emissions. They include encouraging behavioral changes such as carpooling among consumers. These opportunities have not been included in our study.

⁹ Generally, only 60 percent of total capacity is required to meet base-load demand. The rest represents nonbase or peak demand and is usually required during particular times of the day such as evening, when lights and appliances are used simultaneously, or during particular seasons such as summer, when more power is needed for cooling. With the continued dominance of services in India's economy and the country's increasing urbanization and affluence, peak demand is likely to grow faster than base-load demand, as use of air conditioners and other appliances increases.

¹⁰ Calculated for closed-cycle gas turbines at landed Japanese Crude Cocktail—linked liquefied-natural-gas prices (\$16.5 per one million British thermal units) in India at \$100 per barrel of crude.

¹¹ The National Solar Mission aspires to have 20 gigawatts of grid connected and 2 gigawatts of off-grid solar power by 2022.

¹² The Energy Conservation Building Codes being developed by the government could reduce energy consumption in buildings by over 30 percent. Codes have already been developed in other countries, including the American Society of Heating, Refrigerating, and Air-Conditioning Engineers codes and the Leadership in Energy and Environmental Design codes that are gaining prominence in the United States.

¹³ *Building India: Transforming the nation's logistics infrastructure*, McKinsey & Company, July 2010 (www.mckinsey.com).