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McKinsey Infrastructure Practice




January 2013

Infrastructure productivity: How to save $1 trillion a year

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The McKinsey Infrastructure Practice

Infrastructure is a cornerstone of a stable and productive society. The right approach to delivering and maintaining transport, housing, energy, water, and communication infrastructure is essential to create a strong and competitive economy and provide social services. While infrastructure presents unique challenges, it also offers opportunities for both the public and private sectors.

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Nicklas Garemo
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Preface

Across the world, inadequate or poorly performing infrastructure presents major economic and social challenges that governments and businesses need to address. Without the necessary infrastructure—from transport systems to electricity grids and water pipelines—economies cannot meet their full growth potential and economic and human development suffers. Yet the imperative to invest more in infrastructure comes at a time when many governments are highly indebted and face competing calls on their scarce resources.

The size of the infrastructure gap and concerns about how to find the money to fill it are the linchpins of current debate on this issue. But this focus overshadows what we believe to be an equally compelling imperative—to improve the planning, delivery, and operation of infrastructure to get more, higher-quality capacity for less money, and to boost infrastructure productivity. *Infrastructure productivity: How to save $1 trillion a year*, a new report from the McKinsey Global Institute (MGI) and the McKinsey Infrastructure Practice, is the first in a series of planned reports on infrastructure. Our research raised several questions that we have not addressed in detail in this report and that we aim to address in future. These questions include the national balance sheet and financing of infrastructure, the challenges and opportunities faced by private-sector players, how to address the capability gap, the role of new technologies, and green infrastructure.

This report first addresses the question of the size of the infrastructure gap, focusing on transport (road, rail, ports, and airports), power, and water, as well as communications infrastructure. It then discusses in detail three main ways to achieve an improvement in infrastructure productivity delivering savings of 40 percent: selecting projects more carefully, delivering them more efficiently, and getting more out of existing assets as an alternative to building new ones. Many of our recommendations are equally pertinent for social infrastructure such as health care and education, as well as real estate. We believe that looking beyond what countries need to invest to rethinking *how* they invest can shift the debate on infrastructure policy from pessimism and paralysis to a renewed belief in the possible, and concrete action.

Richard Dobbs, a director of MGI and McKinsey & Company based in Seoul, and Herbert Pohl, a McKinsey & Company director based in Dubai, guided this work, supported by Nicklas Garemo, Jimmy Hexter, Stefan Matzinger, and Robert Palter, the leaders of the McKinsey Infrastructure Practice. Diaan-Yi Lin, a McKinsey & Company partner based in Singapore and Kuala Lumpur, and Jan Mischke, an MGI senior fellow based in Zurich, led the research. Rushad Nanavatty, a consultant based in Washington, DC, managed the project team, which comprised Marcus Agnew, Nicola Chiara, Stéphane Colas, Michael Guirguis, Kelli Hayes, Priyanka Kamra, Brandon Kearse, Alex Kim, Jinpyo Lee, Samuel Martins, Abdallah Salami, and Avkash Upendra.

We are grateful for the advice and input of many McKinsey & Company colleagues, including Byron Auguste, Giulio Boccaletti, Nadejda Bogdanova, Adrian Booth, Arief Budiman, Benjamin Cheatham, Kito de Boer, Tyler Duvall, Diana Farrell, David Fine, Aaron Flohrs, Moira Goulmy, Andrew Grant, Merle Grobbel, Anders Hallberg, Philipp Haugwitz, Staffan Hertzell, Martin Hjerpe, Csilla Ilkei, Luis Jimenez, Mike Kerlin, Ee Huei Koh, Acha Leke, Armin Lohr, Susan Lund, Samuel Magid, Laurie Mahon, Jiri Maly, Sebastian Maurus, David McHugh, John Means, Julian Mills, Carl-Stefan Neumann, Alexander Ng, Fabio Pedrazzi, Shannon Peloquin, Maria Joao Ribeirinho, Henry Ritchie, Abhishek Sahay, Thongchie Shang, Stuart Shilson, Giacomo Sonnino, Martin Stuchtey, Susan Sutherland, Amine Tazi-Riffi, Carrie Thompson, Fraser Thompson, Jonathan Woetzel, Alice Woodwark, Frank von Willert, Yu Yang, Stephen Young, and Haimeng Zhang. The team would like to thank Janet Bush, Geoff Lewis, and Lisa Renaud, MGI senior editors, for their editorial help; Julie Philpot, MGI's editorial production manager; Rebeca Robboy and John Cheetham, MGI external communications; Kay Scott, external communications manager in the McKinsey Infrastructure Practice; and Marisa Carder, graphics specialist.

Many experts in academia, government, and industry have offered invaluable guidance and suggestions. Our particular thanks go to: Richard N. Cooper, Maurits C. Boas Professor of International Economics at Harvard University; Rakesh Mohan, Professor in the Practice of International Economics of Finance, School of Management, and Senior Fellow, Jackson Institute of Global Affairs, Yale University; and Laura D. Tyson, S. K. and Angela Chan Chair in Global Management at the Haas School of Business, University of California, Berkeley.

This report contributes to MGI's mission to help global leaders understand the forces transforming the global economy, improve company performance, and work for better national and international policies.

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The infrastructure challenge

$57 trillion
global infrastructure investment needed in 2013–30

$101 billion
annual cost—in excess fuel costs and time—of road congestion in the United States

4 years average time to obtain complete permitting for a power infrastructure project in Europe

70% of water in Nigeria is "non-revenue" (unmetered or stolen)

$2.5 trillion
additional infrastructure financing by 2030 if institutional investors meet their target allocations

0 gain in construction sector labor productivity over the past 20 years in Japan, Germany, and the United States

...and opportunity

$1 trillion
annual savings from a viable 60 percent improvement in infrastructure productivity

35% proportion of infrastructure projects rejected upon scrutiny by Chile's National Public Investment System

15% potential savings from streamlining infrastructure delivery

20% reduction in Denmark's road maintenance costs through a total cost of ownership approach

30% potential boost in the capacity of many ports through more efficient terminal operations

$1.2 billion
overall net present value of Stockholm's congestion-charging scheme

Contents

Executive summary

The litany of infrastructure challenges confronting nations around the world is well known and much discussed. Advanced economies face the challenge of maintaining extensive transport, power, water, and telecommunications networks and upgrading and modernizing them as growth flags. In the developing world, countries dedicate a large proportion of their national income just to meet basic human development needs—access to water and sanitation, electricity, and all-weather roads, for instance—and still cannot cater to large swaths of their populations. The challenge in these countries is becoming even more daunting as rapid growth fuels demand for infrastructure to support economic and social development.

The McKinsey Global Institute (MGI) estimates $57 trillion in infrastructure investment will be required between now and 2030—simply to keep up with projected global GDP growth. This figure includes the infrastructure investment required for transport (road, rail, ports, and airports), power, water, and telecommunications. It is, admittedly, a rough estimate, but its scale is significant—nearly 60 percent more than the $36 trillion spent globally on infrastructure over the past 18 years. The $57 trillion required investment is more than the estimated value of today's worldwide infrastructure.[1] Even then, this amount would not be sufficient to address major backlogs and deficiencies in infrastructure maintenance and renewal or meet the broader development goals of emerging economies. Moreover, the task of funding the world's infrastructure needs is more difficult because of constraints on public-sector budgets and commercial debt in the wake of the financial crisis, higher and more volatile resource costs, and the additional costs of making infrastructure resilient to climate change and less harmful to the environment.

The size of the infrastructure "gap" and the undoubted challenges there are in finding the financing necessary to close it dominate political and public discussion on this topic. Yet this focus diverts attention from what we believe is just as compelling and urgent an issue—how the world can get more, better-quality infrastructure for less. This report focuses on rethinking how governments, together with the private sector, select, design, deliver, and manage infrastructure projects, and make more out of the infrastructure already in place. We argue that there is an emerging opportunity to raise the productivity of infrastructure investment by a substantial margin.

Based on McKinsey & Company's work with governments and private-sector infrastructure players around the world, an extensive literature review, and drawing on insights from more than 400 case examples, we project that if infrastructure owners around the world were to adopt proven best practice, they

1 We have arrived at an estimated value of today's infrastructure first by estimating the value of the capital stock for 13 countries using the methodology described in the technical appendix. This value is after depreciation but also includes capitalized maintenance. We then extrapolated from these 13 countries to the global level.

could increase the productivity of infrastructure investment to achieve savings of 40 percent. Put another way, scaling up best practice could save an average of $1 trillion a year in infrastructure costs over the next 18 years. While a 40 percent saving is an extrapolation that uses several simplifying assumptions, we believe a productivity boost of this magnitude is achievable in many countries if they are willing to invest in a systematic approach to infrastructure that drives improvement across agencies and private-sector owners and contractors. The measures that we discuss are not about inventing a completely new approach to infrastructure—what we propose is simply rolling out proven best practice on a global scale.

In this report, we begin by sizing the global infrastructure investment challenge. We then present a road map for improving infrastructure productivity, which we define broadly to include making better choices about which projects to execute, streamlining the delivery of projects, and making the most of existing infrastructure. These three main levers can result in annual savings of $1 trillion. In the final chapter, we discuss critically important improvements to infrastructure governance systems that can enable the capture of the potential to improve productivity. By implementing the reforms and best practice that we discuss, the world's governments can reduce the anticipated infrastructure challenge to a more manageable size, avoid paralysis, and build the foundation for continued economic growth and development.

The world needs to increase its investment in infrastructure by nearly 60 percent over the next 18 years

Simply to support projected economic growth between now and 2030, we estimate that global infrastructure investment would need to increase by nearly 60 percent from the $36 trillion spent on infrastructure over the past 18 years to $57 trillion over the next 18 years (see Box 1, "Estimating global infrastructure investment needs"). This baseline estimated investment requirement, which is equivalent to 3.5 percent of anticipated global GDP, would be sufficient to support anticipated growth, maintaining current levels of infrastructure capacity and service relative to GDP. It does not account for the cost of addressing the large maintenance and renewal backlogs and infrastructure deficiencies in many economies. Nor would it raise the standard of infrastructure in emerging economies beyond what we would expect as part of a normal development trajectory. In short, while access to basic human services such as water, sanitation, electricity, and all-weather roads would continue to expand, this would happen at current, often inadequate, rates. The World Bank estimates that on current trends, universal access to sanitation and improved water is more than 50 years away in most African countries.[2] Our projection also does not take into account the costs of making infrastructure more resilient to the effects of climate change or the higher cost of building infrastructure in ways that have less impact on the climate and the environment.

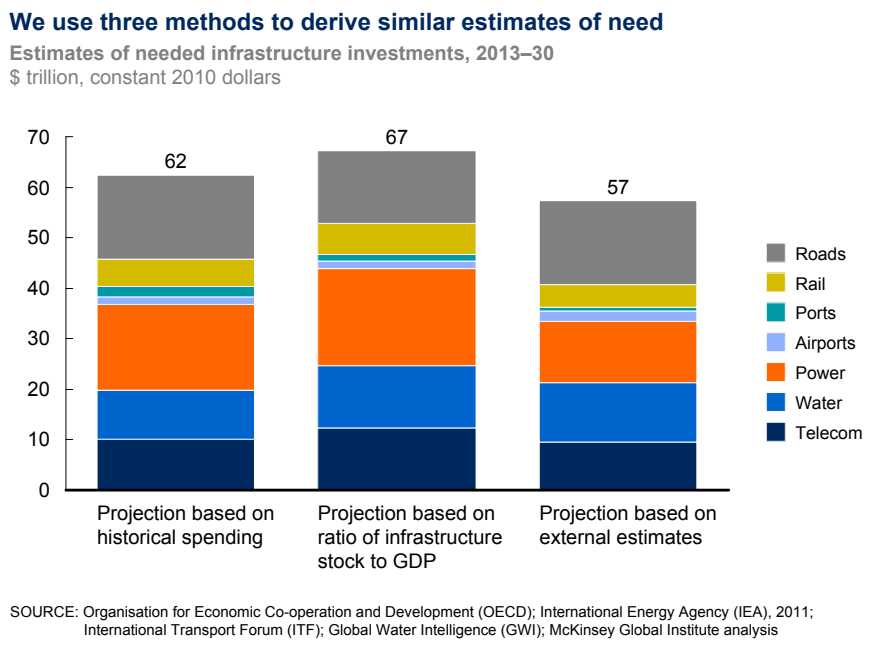
2 Vivien Foster and Cecilia Briceño-Garmendia, eds., *Africa's infrastructure: A time for transformation*, International Bank for Reconstruction and Development and World Bank, 2010.

Box 1. Estimating global infrastructure investment needs

We have used three approaches to calculate our baseline infrastructure need that together produce a range of $57 trillion to $67 trillion from 2013 through 2030 in 2010 prices, covering road, rail, ports, airports, water, and telecoms, but excluding social infrastructure such as schools or hospitals (Exhibit E1).

Historical spending on infrastructure. First, we looked at historical infrastructure spending for 84 countries that account for more than 90 percent of global GDP, using data from the International Transport Forum (ITF), IHS Global Insight, and (GWI).[1] This historical spending pattern indicates that global investment on roads, rail, ports, airports, power, water, and telecommunications infrastructure has averaged about 3.8 percent of global GDP—equivalent to $2.6 trillion in 2013. Applying that 3.8 percent ratio to IHS Global Insight's GDP projections (which estimate growth of about 3.3 percent a year) suggests a total investment need of $62 trillion from 2013 through 2030, or an average annual investment of $3.4 trillion.

Exhibit E1



SOURCE: Organisation for Economic Co-operation and Development (OECD); International Energy Agency (IEA), 2011; International Transport Forum (ITF); Global Water Intelligence (GWI); McKinsey Global Institute analysis

Stock of infrastructure. Second, we examined the value of infrastructure stock using a perpetual inventory model for 12 countries for which comprehensive historical spending data are available across asset classes.[2] This analysis shows that, with a few exceptions such as Japan (arguably an "over-investor" in infrastructure), the value of infrastructure stock in most economies averages around 70 percent of GDP. This 70 percent "rule of thumb" approach has limitations but provides one workable basis for estimating the infrastructure needed to support growth.[3] For infrastructure to remain at an asset-to-GDP ratio of 70 percent, $67 trillion of investment would be required from 2013 through 2030.

Projections of future need. Finally, we looked at independent estimates of future need by infrastructure asset class, including those of the Organisation for Economic Co-operation and Development (OECD), the International Energy Agency (IEA), and Global Water Intelligence (GWI). In combination, these estimates suggest a requirement of $57 trillion of infrastructure investment, or $3.2 trillion a year between 2013 and 2030, with roads and power accounting for almost half of this need.

1 Although we have tried to use the same databases for consistency, we used national account data for transport asset classes for Brazil, Nigeria, and South Africa since these data were not available from ITF. We also used data from the African Development Bank for African countries for 2005 (the only year available) if such data were not available from another source.

2 Gerhard Meinen, Piet Verbiest, and Peter-Paul de Wolf, *Perpetual inventory method: Service lives, discard patterns, and depreciation methods*, Department of National Accounts, Statistics Netherlands, 1998.

3 The 70 percent rule of thumb is in line with other estimates such as those derived from capital stock data in US national accounts (capital stock data in the US national accounts helps us estimate US infrastructure stock at around 61 percent of GDP, while our perpetual inventory model calculates it at 64 percent of GDP). However, we acknowledge that this benchmark has limitations. Beyond the fact that infrastructure spending data are often inconsistent or unreliable, there is not sufficient historical data to apply perpetual inventory methods for as long-lived an asset class as infrastructure.

Infrastructure investment faces a number of challenges including constrained public budgets, shortages in lending capacity, and more stringent regulation in the banking system. But failure to meet infrastructure needs will stifle growth in GDP and employment around the world and compromise a range of human development efforts in less-developed nations. Our analysis also suggests that an increase in infrastructure investment equivalent to 1 percent of GDP would translate into an additional 3.4 million direct and indirect jobs in India, 1.5 million in the United States, 1.3 million in Brazil, and 700,000 in Indonesia. While private finance can help, it is no panacea. Public private partnerships (PPPs) account for only a small share of total infrastructure investment—zero to 12 percent in the European Union (EU) in 2006 to 2009, or up to 22 percent in the United Kingdom if the country were to achieve its very ambitious goals between 2011 and 2015. If institutional investors were to increase their allocations for infrastructure financing to their target levels, this would result in an additional $2.5 trillion in infrastructure investment capital through 2030. This is a sizeable amount, but still only a fraction of global infrastructure investment needs. We therefore need to look elsewhere for a complete solution—increasing the productivity of global infrastructure investment.

Boosting infrastructure productivity could save $1 trillion a year

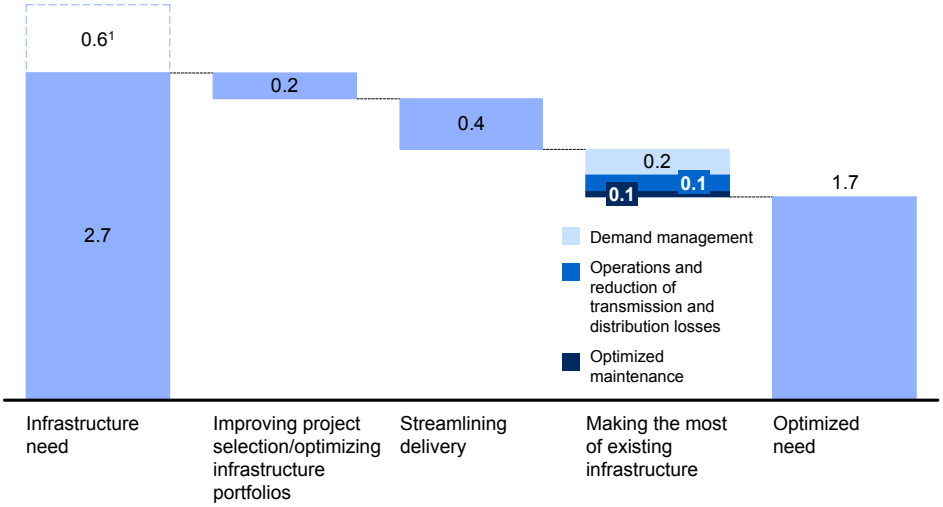
By scaling up best practice in selecting and delivering new infrastructure projects, and getting more use out of existing infrastructure, nations could obtain the same amount of infrastructure for 40 percent less—or, put another way, deliver a 60 percent improvement in infrastructure productivity. Over 18 years, this would be the equivalent of providing $48 trillion (excluding telecom, which we don't cover in our case studies of best practice) of infrastructure for $30 trillion—a saving of $1 trillion a year (Exhibit E2). We base this estimate on a review of more than 400 case studies of best practices—over 100 of which have quantified the savings they have achieved—and our subsequent global extrapolation of their impact (see the technical appendix for details). Achieving these productivity gains will not require groundbreaking innovation, but merely the application of established and proven practices from across the globe.

The potential to boost productivity is so large because of failings in addressing inefficiencies and stagnant productivity in a systematic way. On the whole, countries continue to invest in poorly conceived projects, take a long time to approve them, miss opportunities to innovate in how to deliver them, and then don't make the most of existing assets before opting to build expensive new capacity. In many countries, the process of selecting, building, and operating infrastructure—and the governance systems that could force improvements—has not changed for the better in decades. In the construction sector, for instance, labor productivity has barely moved for 20 years in many developed countries despite steady and significant gains in the productivity of other sectors.

Exhibit E2

The $1 trillion-a-year infrastructure productivity opportunity

Global infrastructure investment need and how it could be reduced
Yearly average, 2013–30
$ trillion, constant 2010 dollars



1 Telecom investment need beyond the scope of this paper.
SOURCE: McKinsey Global Institute analysis

All too often, a surprisingly stable status quo persists in which inaccurate planning and forecasting lead to poor project selection. A bias among public officials to build new capacity, rather than make the most of existing infrastructure, is common, leading to more expensive and less sustainable infrastructure solutions. A lack of incentives, accountability, and capabilities as well as risk aversion has prevented infrastructure owners from taking advantage of improvements in construction methods such as the use of design-to-cost and design-to-value principles, advanced construction techniques, and lean processes. Infrastructure authorities frequently lack the capabilities necessary to negotiate on equal terms with infrastructure contractors, rendering them unable to provide effective oversight and thereby drive performance.

Our analysis finds that pulling three main levers can deliver the potential savings.

IMPROVING PROJECT SELECTION AND OPTIMIZING INFRASTRUCTURE PORTFOLIOS

Our analysis of global best practice indicates that one of the most powerful ways to reduce the overall cost of infrastructure is to optimize infrastructure portfolios—that is, simply to select the right combination of projects. All too often, decision makers invest in projects that do not address clearly defined needs or cannot deliver hoped-for benefits. Equally often, they default to investments in additional physical capacity (for example, widening an arterial road into a city) without considering the alternatives of resolving bottlenecks and addressing demand through, for instance, better planning of land use, the enhancement of public transit, and managing demand. Improving project selection and optimizing infrastructure portfolios could save $200 billion a year globally. To achieve these savings, owners must use precise selection criteria that ensure proposed projects meet specific goals; develop sophisticated evaluation methods to determine costs and benefits; and prioritize projects at a system level, using transparent, fact-based decision making.

For example, to guide its selection of transit projects, the government of Singapore has a clear metric: to support its broad socioeconomic goal of building a densely populated urban state, any project must contribute to the specific objective of achieving 70 percent use of public transit. In Chile, the National Public Investment System evaluates all proposed projects using standard forms, procedures, and metrics, and rejects as many as 35 percent of all projects. The organization's cost-benefit analyses consider, for instance, non-financial costs such as the cost of travel time, and a social discount rate that represents the opportunity cost for the country when its resources finance any given infrastructure project. Final approval rests with Chile's finance ministry, which allocates funding based on a combination of these cost-benefit analyses and national goals.

STREAMLINING DELIVERY

Streamlining project delivery can save up to $400 billion annually while accelerating timelines materially. Speeding up approval and land acquisition processes is vital given that one of the chief drivers of time (and time over-runs) is the process of acquiring permits and land. In India, up to 90 percent of road projects experience delays of 15 to 20 percent of the planned project timeline because of difficulties in acquiring land. England and Wales in the United Kingdom have, for instance, implemented one-stop permitting processes. In Australia, the state of New South Wales cut approval times by 11 percent in just one year by clarifying decision rights, harmonizing processes across agencies, and measuring performance. Both the United Kingdom and Australia have implemented special courts to expedite disputes over land acquisition.

A key source of savings in project delivery is investing heavily in early-stage project planning and design. This can reduce costs significantly by preventing changes and delays later on in the process when they become ever more expensive. Bringing together cross-functional teams from the government and contractor sides early in the design process can avoid the alterations that lead to 60 percent of project delays.

Owners can structure contracts to encourage cost-saving approaches, including design-to-cost principles that ensure the development of "minimal technical solutions"—the lowest-cost means of achieving a prescribed performance specification, rather than mere risk avoidance. Contractors can also be encouraged to use advanced construction techniques including prefabrication and modularization—facilitated by having the appropriate standards and specifications—as well as lean manufacturing methods adapted for construction. Strengthening the management of contractors, a weakness of many authorities, can also head off delays and cost over-runs. Finally, nations should support efforts to upgrade their construction sectors, which often rely heavily on informal labor (a situation that often contributes to corruption), suffer from capability gaps and insufficient training as well as from ill-conceived regulations and standards, and under-invest in innovation. Enhancing construction industry practices is necessary to raise the productivity, quality, and timeliness of infrastructure projects.

MAKING THE MOST OF EXISTING INFRASTRUCTURE ASSETS

Rather than investing in costly new projects, governments can address some infrastructure needs by getting more out of existing capacity. We estimate that boosting asset utilization, optimizing maintenance planning, and expanding the use of demand-management measures can generate savings of up to $400 billion a year. For example, intelligent transportation systems for roads, rail, airports, and ports can double or triple the use of an asset—typically at a fraction of the cost of adding the equivalent in physical capacity. Reducing transmission and distribution losses in water and power (which can be more than 50 percent of supply in some developing countries) often costs less than 3 percent of adding the equivalent in new production capacity and can be accomplished significantly faster.

Maintenance planning can be optimized by using a total cost of ownership (TCO) approach that considers costs over the complete life of an asset and finds the optimal balance between long-term renewal and short-term maintenance. By one estimate, if African nations had spent $12 billion more on road repair in the 1990s, they could have saved $45 billion in subsequent reconstruction costs.[3] To optimize maintenance programs, nations should assess and catalog needs. London, for instance, has a 20-year model for pavement deterioration. Denmark has reduced the expense of maintaining its roads by 10 to 20 percent by adopting a total cost of ownership approach.

Finally, governments need to make more aggressive use of tools and charges that allow them to manage demand. Advances in technology are broadening the range and improving the effectiveness of such demand-management approaches. To fully capture the potential of demand management, governments need to take a comprehensive approach and use all available tools. The city of Seoul, for example, is dealing with congestion by combining improved bus operations, access restrictions, and electronic fare collection with an integrated traffic-management system. Congestion pricing, widely regarded as the most effective measure to reduce congestion and reduce the need for capacity additions, especially in advanced economies, can be paired with intelligent traffic solutions to achieve even greater benefits.

Infrastructure governance systems need to be upgraded in order to capture potential savings

To boost the productivity of infrastructure and secure the considerable savings that we have identified, the infrastructure governance and delivery system needs to be upgraded in four important practical ways. First, there needs to be close coordination between the infrastructure authorities responsible for the different types of infrastructure, guided by a common understanding of broad socioeconomic goals and the role of each asset class in achieving them.[4] Switzerland's Department of Environment, Transport, Energy, and Communications, for instance, develops a national infrastructure strategy by unifying approaches in the full range of relevant sectors including the country's policies on air travel policy and the information society, its spatial development report, its plan for the transport sector, and its energy strategy. Second, a

3 *World development report 1994: Infrastructure for development*, World Bank, June 1994.

4 We include roads, rail, airports, ports, water and sanitation, power, and telecoms as infrastructure asset classes.

clear separation of political and technical responsibilities for infrastructure is necessary; politicians and government leaders set policy goals but should let technical experts create the specific projects and plans to meet these goals. This separation can take different forms. Hong Kong's Mass Transit Railway Corporation and Infrastructure Ontario in Canada both have organizational autonomy, while Singapore's Land Transport Authority relies on a very clear delineation of roles.

Third, governments must spell out how they divide roles and responsibilities between the public and private sectors, establishing clarity on market structure, regulation, pricing and subsidies, ownership, and financing. Many countries are realizing value by expanding the participation of the private sector in infrastructure beyond financing and delivering it to include an active role for private players in identifying and scoping projects. Some have developed frameworks to encourage and manage unsolicited proposals. In short, government should look beyond project-specific PPPs toward much broader public-private cooperation. Fourth, there needs to be trust-based engagement of stakeholders throughout the process to avoid suboptimal solutions and unnecessary delays.

Finally, an effective infrastructure system needs two critical enablers—reliable data on which to base day-to-day oversight and long-term planning, and strong public-sector capabilities across the value chain of planning, delivery, and operations.

In the private sector, companies, too, have a role to play on three main fronts. They can drive productivity within their own operations, engage in a productive dialogue with public-sector stakeholders on constraints and improvement ideas, and develop business and contracting models to benefit from today's shortcomings.

□ □ □

Meeting the world's large and growing infrastructure challenges is vital for growth and development. How those challenges are met will have a huge impact on all of our daily lives. It will determine how many of the world's citizens will have access to water, who has a job, or how long people are stuck in the daily traffic jam. It is no exaggeration to say that there is a moral imperative to improve the way that infrastructure is planned, delivered, and operated.

Our analysis finds that a range of practical steps can boost the productivity of infrastructure by 60 percent—and save $1 trillion a year. In short, there may be more cause for optimism than this subject usually generates. At a time of fiscal constraint and rising demand, the world needs to focus not only on the magnitude of the infrastructure gap and the resources required to fill it, but also on the many ways that it can get more, higher-quality infrastructure for less.

1. Sizing the world's infrastructure investment challenge

There has been an immense amount of discussion and debate about the "infrastructure gap" but very little agreement about how to define and measure it. The basic concept of an infrastructure gap is simple—the gap is the difference between investment need and the resources available to address that need. But the definition of need is more complex not least because it depends on the aspirations of each country, and these may differ widely. One country may aim to ensure that its infrastructure simply meets basic human requirements such as those defined by the United Nations Millennium Development Goals. Another may want to achieve a complete modernization of its national transport network. For a third, the goal may be to lay the groundwork for future global competitiveness by, for instance, building a national broadband network.

Taking this full range of aspirations and distinct differences among countries into account, we estimate that, in aggregate, the world needs to boost its investment in infrastructure by nearly 60 percent from the $36 trillion spent on infrastructure over the past 18 years to $57 trillion over the next 18 years. The $57 trillion required investment is more than the estimated value of today's worldwide infrastructure.[5] This estimated need would be sufficient to support projected economic growth between now and 2030 and maintain typical current levels of infrastructure capacity and service relative to GDP. However, this amount would not be enough to address backlogs and deficiencies. Nor does it include the cost of infrastructure that would be necessary to meet developmental aspirations in developing countries such as providing universal access to roads, clean water, sanitation, and electricity. Finally, the $57 trillion estimate of need does not include the cost of present- and future-proofing infrastructure to cope with environmental stresses.

Funding such a level of investment will be difficult given an array of constraints including fiscal pressure on many governments, resource and capital constraints, and a shift in the weight of infrastructure investment to developing countries that investors perceive to be risky. While there is some potential to unlock further capital from both the private and public sectors, this will be a part of the solution at best. Even if the world's institutional investors were to hit their target allocations for infrastructure, their commitments would amount to only 4 percent of the $57 trillion "baseline" requirement that we have estimated.

5 We have arrived at an estimated value of today's infrastructure first by estimating the value of the capital stock for 13 countries using the methodology described in the technical appendix. This value is after depreciation but also includes capitalized maintenance. We then extrapolated from these 13 countries to the global level.

The world needs to invest $57 trillion in infrastructure through 2030 just to keep pace with anticipated growth

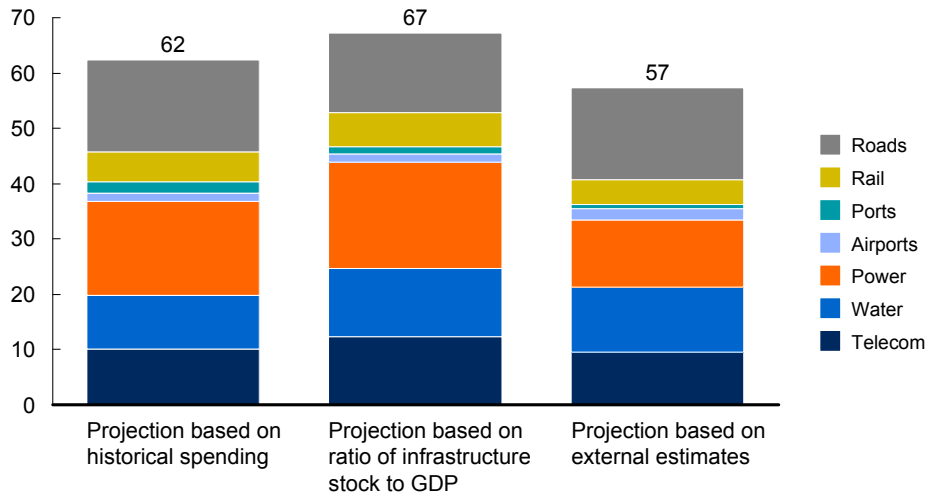
Given the complexity of estimating the global infrastructure investment need, we have chosen to estimate the baseline investment required solely to keep pace with anticipated growth and not to meet a range of broader aspirations. We have used three approaches to calculate our baseline, discussed in some detail below, that produce a range from $57 trillion to $67 trillion from 2013 through 2030 (Exhibit 1; see the technical appendix for more detail on our methodology).

For the purposes of our analysis, we have used an estimate of $57 trillion, arrived at by using a bottom-up analysis and drawing on the expertise of leading authorities, and validating it through two other methods of estimating infrastructure need. For the sake of consistency, we chose 2030 as our end date as this was the one that many other studies of this issue used.

Exhibit 1

We use three methods to derive similar estimates of need

Estimates of needed infrastructure investments, 2013–30
$ trillion, constant 2010 dollars



SOURCE: Organisation for Economic Co-operation and Development (OECD); International Energy Agency (IEA), 2011; International Transport Forum (ITF); Global Water Intelligence (GWI); McKinsey Global Institute analysis

We now briefly discuss the three approaches we took to estimating the global infrastructure need, starting with how much has been spent on infrastructure historically and is spent today, then examining the stock of infrastructure, and finally looking at how much infrastructure is likely to be needed in the period to 2030, using data on spending and stock as a guide.

HISTORICALLY, 3.8 PERCENT OF GLOBAL GDP HAS BEEN SPENT ON INFRASTRUCTURE, SUGGESTING INVESTMENT NEED OF $62 TRILLION THROUGH 2030

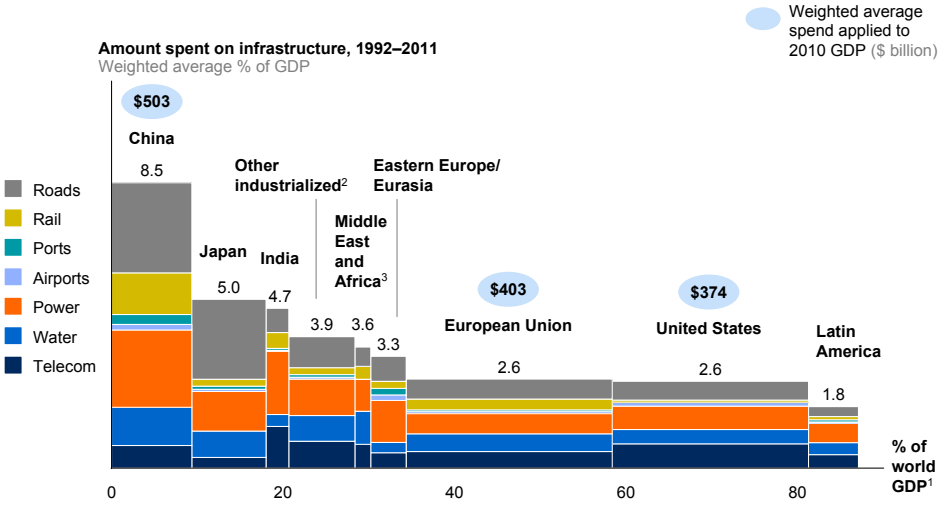
First, we looked at historical infrastructure spending for 84 countries that account for more than 90 percent of global GDP, using data from the ITF, IHS Global Insight, and GWI.[6] This historical spending pattern indicates that global investment on roads, rail, ports, airports, power, water, and telecommunications infrastructure has averaged about 3.8 percent of global GDP. Applying that 3.8 percent ratio to IHS Global Insight's GDP growth projections of about 3.3 percent a year suggests a total investment need of $62 trillion from 2013 through 2030, or an average annual investment of $3.4 trillion (although, as we have noted, this figure will ramp up over time). We used historical spending to validate external estimates, discussed below.

The "center of gravity" of this global infrastructure spending has already shifted to developing economies, following the path of economic growth. With its rapid economic expansion and urbanization, China has overtaken the United States and the EU to become the world's largest investor in infrastructure (Exhibit 2). We expect many large lower-income and middle-income countries to continue to raise infrastructure investment rapidly over the coming years to support their growth. In addition to China, four of the world's most populous countries—Brazil, India, Indonesia, and Russia—are all in need of infrastructure expansion to support their growing economies. In 2012, Brazil and India both announced plans to increase infrastructure investment in order to support economic growth. In India, the Prime Minister and urban development minister are urging $1 trillion in infrastructure investment over the next five years. At the same time, many of the world's least-developed countries are likely to increase infrastructure spending as they work toward meeting economic and human development goals. Advanced economies, many of which have concerns about slow GDP growth and high public deficits, are likely to be relatively constrained in their ability to increase infrastructure investment and, as a result, will need to take a more targeted approach.

6 Although we have tried to use the same databases for consistency, we used national account data for transport asset classes for Brazil, Nigeria, and South Africa since these data were not available from ITF. We also used data from the African Development Bank for African countries for 2005 (the only year available) if such data were not available from another source.

Exhibit 2

China has overtaken the United States and the European Union to become the world's largest investor in infrastructure



1 Percentage of 2010 world GDP generated by the 86 countries in our analysis.
2 Australia, Canada, Croatia, Iceland, Lichtenstein, New Zealand, Norway, Singapore, South Korea, Switzerland, Taiwan (Chinese Taipei), and the United Arab Emirates.
3 Excludes unusually high port and rail data for Nigeria; including these data brings the total weighted average to 5.7 percent.
SOURCE: IHS Global Insight; GWI; IEA; ITF; McKinsey Global Institute analysis

FOR INFRASTRUCTURE TO REMAIN AT AN ASSET-TO-GDP RATIO OF 70 PERCENT, $67 TRILLION A YEAR OF INVESTMENT WOULD BE REQUIRED FROM 2013 THROUGH 2030

While there are extensive data on physical stock (for example, kilometers of roads, number of airport runways, and port container berths), little information is available on the financial value of such assets. We calculate the value of infrastructure stock using a perpetual inventory model for 12 countries for which comprehensive historical spending data are available across asset classes.[7] This analysis shows that, with a few exceptions such as Japan (arguably an "over-investor" in infrastructure), the value of infrastructure stock in most economies averages around 70 percent of GDP (Exhibit 3). This 70 percent "rule of thumb" approach has limitations but provides one workable basis for estimating the value of infrastructure.[8]

Applying this 70 percent rule of thumb, we estimate that global infrastructure assets were worth around $50 trillion in 2012 (expressed in 2010 US dollars). We further calculate that maintaining this asset-to-GDP ratio would require raising infrastructure investment rates from 3.8 percent of global GDP on average over the past 18 years to 4.1 percent through 2030. This would accommodate slightly higher expected global GDP growth as developing economies gain weight in the

7 Gerhard Meinen, Piet Verbiest, and Peter-Paul de Wolf, *Perpetual inventory method: Service lives, discard patterns, and depreciation methods*, Department of National Accounts, Statistics Netherlands, 1998.

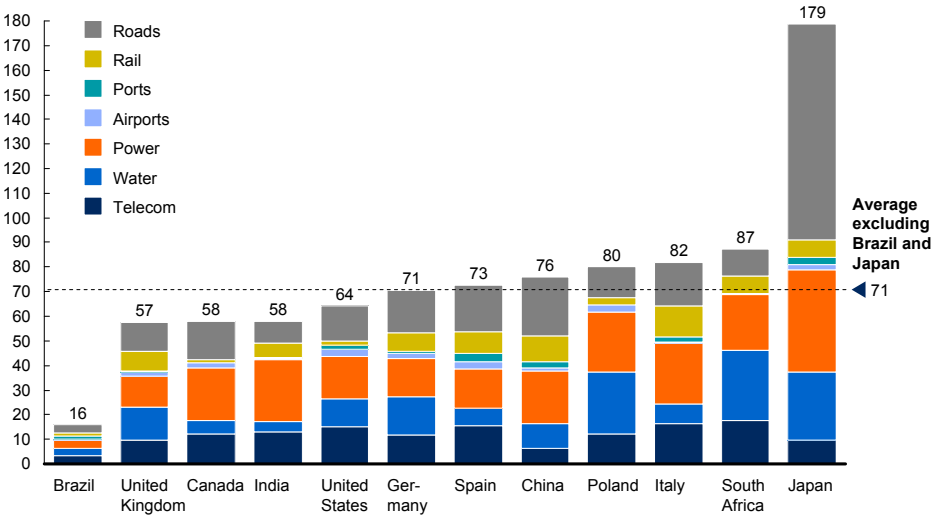
8 The 70 percent rule of thumb is in line with other estimates such as those derived from capital stock data in US national accounts. (Capital stock data in the US national accounts help us estimate US infrastructure stock at around 61 percent of GDP while our perpetual inventory model calculates it at 64 percent of GDP.) However, we acknowledge that this benchmark has limitations. Beyond the fact that infrastructure spending data are often inconsistent or unreliable, there are not sufficient historical data to apply perpetual inventory methods for as long-lived an asset class as infrastructure.

world economy, as well as resolving issues related to apparent under-investment in some countries. This equates to a total of $67 trillion, or $3.7 trillion annually (Exhibit 4). This rule of thumb also allows us to estimate explicitly the share of investment required to renew aging infrastructure and therefore compensate for asset depreciation. This amounts to 40 percent of total investment—with the remainder going toward the expansion and improvement of infrastructure in line with GDP growth (the cost of asset renewal is implicit in the other approaches that we have discussed).

Exhibit 3

The value of infrastructure stock averages 70 percent of GDP—with significant variation across countries

Total infrastructure stock
% of GDP

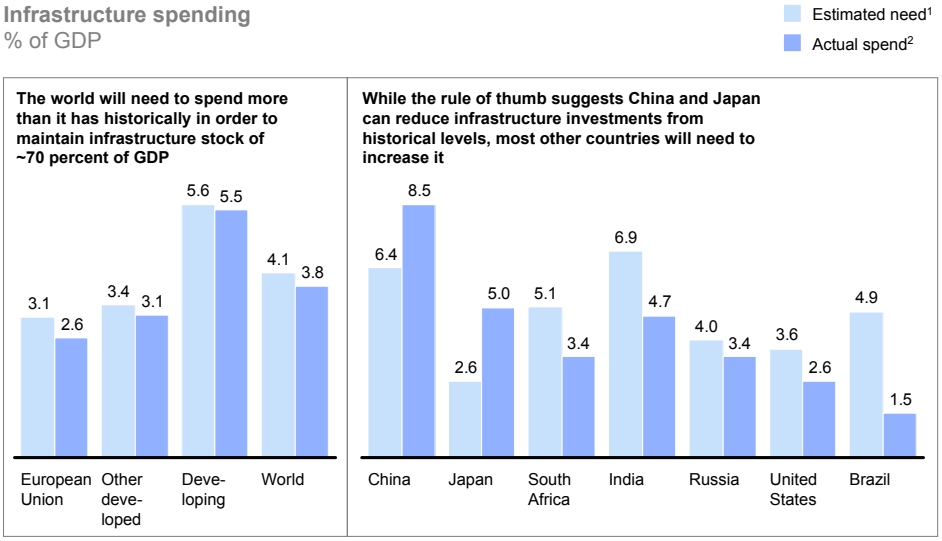


SOURCE: ITF; GWI; IHS Global Insight; *Perpetual inventory method*, OECD, 1998; McKinsey Global Institute analysis

Exhibit 4

Using the 70 percent rule of thumb, infrastructure investment would need to rise to 4.1 percent of GDP to keep pace with growth through 2030

Infrastructure spending
% of GDP



1 Estimated need based on projected growth, 2013–30.
2 Weighted average annual expenditure over years of available data, 1992–2011.

SOURCE: ITF; GWI; IHS Global Insight; *Perpetual inventory method*, OECD, 1998; McKinsey Global Institute analysis

INDEPENDENT ESTIMATES SUGGEST A NEED FOR $57 TRILLION OF INFRASTRUCTURE INVESTMENT, OR $3.2 TRILLION A YEAR, THROUGH 2030

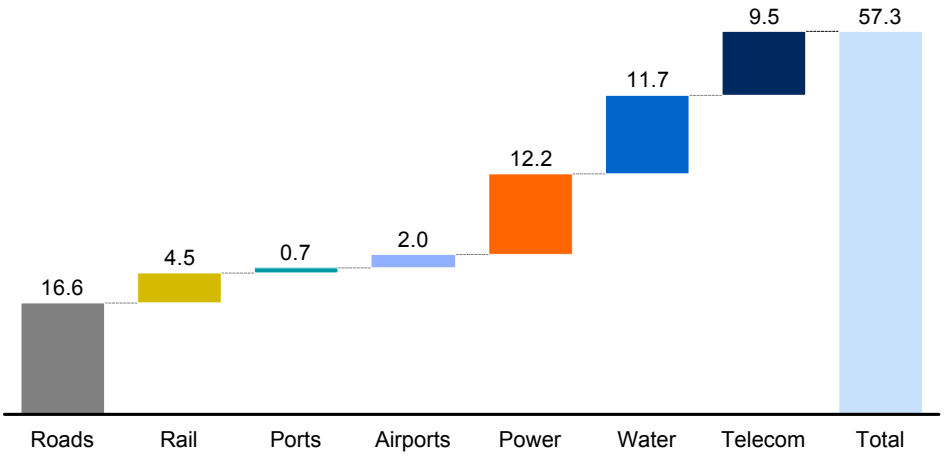
We also looked at projected regional and global need for roads, rail, ports, airports, power, telecommunications, and water projects to gauge future need for infrastructure investment. We draw on authoritative sources, including the OECD, World Bank, Asian Development Bank, African Development Bank, IEA, and GWI. The estimates are not aligned, and the OECD was the only institution that provided, in its 2006 and 2012 reports on infrastructure, global estimates for all the asset classes we examined. Other sources produced either global data for a single asset class (for example, power from the IEA), or data across asset classes for a single region (for example, African data from the African Development Bank). With that caveat, analyzing these sources we calculate the world's estimated need for infrastructure investment to be $57 trillion between 2013 and 2030 (see the technical appendix for more detail). Road and power account for about half of this need (Exhibit 5).

Exhibit 5

Based on projections of demand by infrastructure segment, about $57 trillion, or 3.5 percent of global GDP, is needed through 2030

Global investment, 2013–30

$ trillion, constant 2010 dollars



1 OECD telecom estimate covers only OECD members plus Brazil, China, and India.
NOTE: Figures may not sum due to rounding.
SOURCE: OECD; IHS Global Insight; GWI; IEA; McKinsey Global Institute analysis

Annual infrastructure investment needs will not remain constant from now through 2030 but rather will rise alongside growth in global GDP and population. Depending on the method we use for estimating need, we project that, to keep pace with GDP growth, annual global infrastructure investment will have to rise from around $2.6 trillion in 2013 to between $3.0 trillion and $3.5 trillion by 2020 and $4.1 trillion to $4.8 trillion by 2030 (Exhibit 6).[9] To put these numbers in perspective, global military spending in 2011 was $1.7 trillion.[10] The GDP of

9 All amounts are expressed in constant 2010 US dollars.

10 Stockholm International Peace Research Institute, *Background paper on SIPRI military expenditure data, 2011*, April 17, 2012.

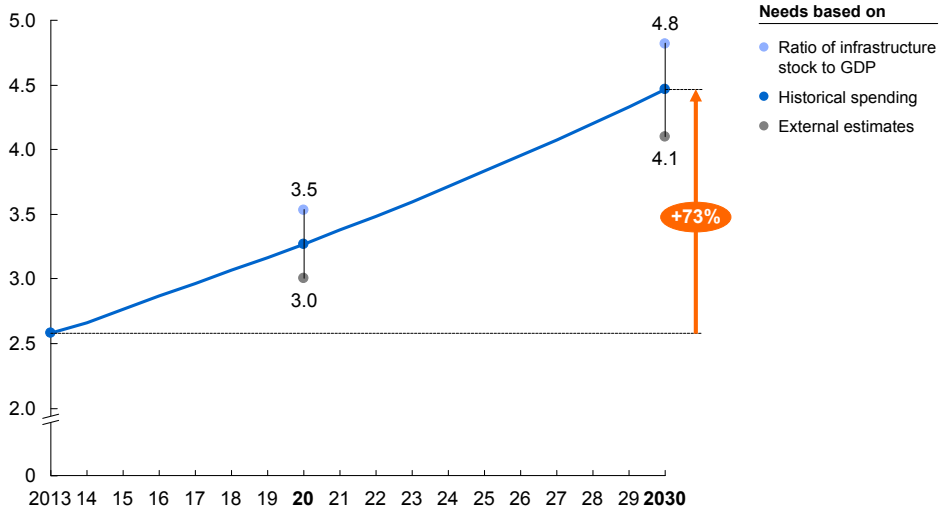
Japan, the world's third-largest economy, was about $5.9 trillion in GDP in 2011. The GDP of the whole of Africa is expected to be $2.6 trillion in 2020.[11]

Exhibit 6

Annual baseline infrastructure investment needs are expected to rise by ~70 percent from ~$2.6 trillion in 2013 to ~$4.5 trillion in 2030

Global "baseline" infrastructure investment needs, 2013–30

$ trillion, constant 2010 dollars



SOURCE: OECD; IHS Global Insight; GWI; IEA; ITF; McKinsey Global Institute analysis

EVEN $57 TRILLION IS UNLIKELY TO BE SUFFICIENT TO ADDRESS SOME MAJOR INFRASTRUCTURE DEFICIENCIES

The $57 trillion of investment that we estimate is necessary is equivalent to 3.5 percent of projected cumulative GDP, which is broadly in line with the 3.8 percent that the world has spent historically. In absolute terms, the $57 trillion figure that needs to be spent over the next 18 years is nearly 60 percent higher than the $36 trillion invested over the past 18 years. The true scale of the infrastructure investment challenge could be considerably higher than this as the $57 trillion we estimate is a minimum or baseline amount that would not be sufficient to tackle a number of major infrastructural shortcomings and deficiencies and broader aspirations for the role that infrastructure needs to play in many (particularly developing) countries.

11 McKinsey Global Institute, *Lions on the move: The progress and potential of African economies*, June 2010.

First, global estimates for the infrastructure investment required (including our own) do not account fully for maintenance and renewal backlogs left by years of deferred maintenance and postponed replacement or upgrade programs that must eventually be addressed. South Africa's power distribution network, for example, has an estimated maintenance backlog of $4 billion—equivalent to half of the country's total investment in electric power generation and distribution in 2011.[12] In 2010, the US Department of Transportation estimated that the United States would need to increase spending on public transit systems by 40 percent to $18 billion a year to bring them to a state of "good repair" by 2028. Even this would not be sufficient to accommodate growth or improve service.[13]

Another shortcoming of global spending and requirement estimates is that they mask geographic imbalances. While some countries arguably overspend, others consistently fail to make the infrastructure investment that is "appropriate" to their economic growth trajectories. Applying our rule of thumb for the ratio of infrastructure assets to economic output, Japan's growth over the past 18 years would have "justified" infrastructure investment of around 3 percent of GDP, but the country actually spent 5 percent. Brazil's growth, substantially above the global average, indicates a need for annual infrastructure investment of around 4.7 percent of GDP but its actual investment has averaged just 1.5 percent over the past 18 years. The consequences are plain to see: Brazil ranks 76th out of 185 countries in terms of per capita GDP, and 84th out of 187 on the Human Development Index—but the quality of Brazil's airports ranks 122nd out of 142 countries.[14]

If less-developed economies are to meet their human development needs such as making safe drinking water, basic sanitation, and power widely accessible, they will need to invest substantially more than a baseline 3.5 to 4.1 percent of GDP (Exhibit 7). Today, only 34 percent of rural Africans live within two kilometers of an all-weather road, only 25 percent have electricity, and only 61 percent have access to "improved" water sources (that is, water sources that are protected from external contamination). The World Bank estimates that on current trends, universal access to sanitation and improved water is more than 50 years away in most African countries.[15] The UN Economic Commission for Latin America and the Caribbean estimates that investment equivalent to 7.9 percent of GDP is necessary to raise infrastructure in the region to the standard of developed East Asian countries.[16]

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12 Siseko Njobeni, "Ageing power network needs upgrades," *Business Day Live*, October 5, 2012.

13 US Department of Transportation, *2010 status of the nation's highways, bridges, and transit: Conditions and performance*, 2010.

14 *World Economic Outlook database, 2011*, International Monetary Fund, 2011; *Human development report 2011*, United Nations Development Programme, November 2011; *Global competitiveness report 2011–2012*, World Economic Forum, September 2011.

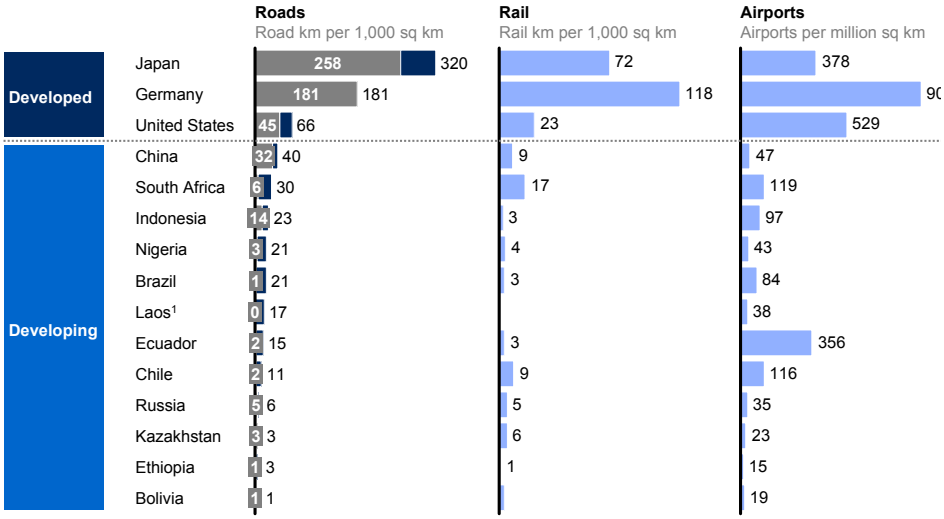
15 Vivien Foster and Cecilia Briceño-Garmendia, eds., *Africa's infrastructure: A time for transformation*, International Bank for Reconstruction and Development and World Bank, 2010.

16 United Nations Economic Commission for Latin America and the Caribbean, "The economic infrastructure gap in Latin America and the Caribbean," *FAL Bulletin*, issue 293, number 1, 2011.

Exhibit 7

Infrastructure capacity in developing economies lags significantly behind that of developed economies

Network density, 2012



1 Rail data not available.

SOURCE: CIA World Factbook 2012; Infrastructure Africa; Economic Research Institute for ASEAN and East Asia; World Economic Forum, *Global Competitiveness Report 2011–2012*; McKinsey Global Institute analysis

ESTIMATES OF INFRASTRUCTURE NEED OFTEN FAIL TO CONSIDER THE ADDITIONAL COST OF CLIMATE CHANGE ADAPTATION AND MITIGATION

Most estimates of global infrastructure do not account for either the additional cost of making infrastructure more resilient to the effects of climate change or of lessening the impact of infrastructure on the environment.[17] Large sections of infrastructure around the globe have not been hardened against rising sea levels and more frequent extreme weather events. In the wake of Hurricane Sandy in autumn 2012, for instance, New York City is planning to alter its building codes to mitigate the damage from future storm surges. Mayor Michael Bloomberg has called for the identification of new protections that might include dunes, jetties, levees, and berms along coastal areas.[18] The city authorities have not offered any specifics on what these measures might cost (although we do know that, in the wake of Hurricane Sandy, the city's subway system alone needs an estimated $4.8 billion to recover). Failure to invest in these measures would result in massive repair and renewal costs in similar circumstances in the future.

Many water and power systems have not been designed with sufficient reserve capacity to continue functioning adequately during extreme weather events such as severe storms and droughts that will become more frequent as a result of climate change. In addition, expanding infrastructure to accommodate growing demand can often threaten fragile ecosystems and therefore pose new design and engineering challenges that need to be met to mitigate risks and cope with

17 Tom Wilbanks et al., "Industry, settlement and society," in *Climate change 2007: Impacts, adaptation and vulnerability*, M. L. Parry et al., eds., Cambridge University Press, 2007. Also see Robert Watson, Marufu Zinyowera, and Richard Moss, eds., *The regional impacts of climate change: An assessment of vulnerability*, Cambridge University Press, 1998.

18 David W. Chen and Michael M. Grynbaum, "Mayor pledges to rebuild and fortify coast," *New York Times*, December 6, 2012.

greater legal and regulatory scrutiny of environmental impact. The environmental costs of infrastructure development in some developing countries have already reached an estimated 4 to 8 percent of their GDP, with the effects falling disproportionately on the poor.[19]

FAILURE TO MEET THE INFRASTRUCTURE INVESTMENT NEED COULD JEOPARDIZE A RANGE OF IMPORTANT SOCIOECONOMIC OUTCOMES

Failure to meet these infrastructure needs could stifle growth in GDP and employment around the world and compromise a range of human development efforts in less-developed nations. Low-income countries in central Africa could add as much as 2.2 percentage points to their annual growth if they had the same level of infrastructure as India or Pakistan, according to some estimates.[20] Middle-income nations in Latin America could add two percentage points to annual growth rates if their infrastructure were comparable with that of middle-income nations such as Turkey or Bulgaria.

Infrastructure investment is a rare "win-win" that generally boosts overall economic productivity in the long run and creates jobs in the short term, the latter being of significant importance given the current employment challenges and excess construction capacity in many countries. Our analysis suggests that an increase in infrastructure investment equivalent to 1 percent of GDP could translate into an additional 3.4 million direct and indirect jobs in India, 1.5 million in the United States, 1.3 million in Brazil, and 700,000 in Indonesia.[21]

In addition to supporting growth and job creation, infrastructure investment can lead to improved health, education, and social outcomes, a number of studies have found. Upgrading water and sanitation systems in a slum in Ahmedabad, India, reduced health insurance claims by more than 50 percent.[22] Female employment rates increased by 9 percent after rural households in one area of South Africa gained access to electricity that enabled women to spend less time on housework and more time building micro-enterprises.[23] In the Indian state of Assam, a 1 percentage point increase in the electrification rate resulted in a 0.17 percentage point improvement in the literacy rate, suggesting that complete rural electrification of the region could raise the literacy rate to 74 percent from 63 percent.[24] The presence of infrastructure can also reduce income inequality—

19 *The nexus between infrastructure and environment*, Independent Evaluation Group evaluation brief 5, World Bank, June 2007.

20 Justin Yifu Lin, "Bridges to somewhere," *Foreign Policy*, September 1, 2011, based on César Calderón, Enrique Moral-Benito, and Luis Servén, *Is infrastructure capital productive? A dynamic heterogeneous approach*, World Bank, June 2011.

21 We calculate and apply domestic employment multipliers for the construction sector as an approximation to derive an estimate of the number of jobs related to infrastructure demand.

22 Neel M. Butala, Michael J. VanRooyen, and Ronak Bhailal Patel, "Improved health outcomes in urban slums through infrastructure upgrading," *Social Science & Medicine*, volume 71, issue 5, September 2010.

23 *World development report 2012: Gender equality and development*, World Bank, September 2011.

24 Makoto Kanagawa and Toshihiko Nakata, "Assessment of access to electricity and the socioeconomic impacts in rural areas of developing countries," *Energy Policy*, volume 36, issue 6, June 2008.

a one standard deviation increase in the quality and quantity of infrastructure can reduce a country's Gini coefficient by 0.06.[25]

Simply sustaining current levels of investment will be a challenge

Sustaining infrastructure investment even at current levels relative to GDP will be challenging thanks to four significant barriers: fiscal pressure that limits direct public investment; the cost and availability of financing; a higher proportion of higher-risk projects (i.e., greenfield projects in developing countries) that are in the investment pipeline, discouraging equity-type investment opportunities; and growing resource-related costs as demand for construction-related commodities rises faster than their supply. We now discuss each of these in turn.

CHALLENGE 1: FISCAL PRESSURE

Many governments face years of fiscal consolidation and "deleveraging" to bring public debt down to more manageable levels—60 percent of GDP or less, according to a standard prescribed by the International Monetary Fund (Exhibit 8). This creates difficult choices between infrastructure investment and other pressing priorities including education, health care, and the costs of pensions, social services, and other benefits, which are a particular concern in economies with aging populations. We have already seen a link between rising deficits and falling infrastructure spending (Exhibit 9). Between 1980 and 2003, annual investment in infrastructure fell by 0.2 percent of GDP across EU nations. In Latin America, the reduction was 0.8 percent of GDP.[26]

Part of the challenge is that most governments apply cash-accounting standards that do not sufficiently differentiate between long-term investment that adds to a country's balance sheet or generates savings over the long term, and near-term consumption. This cash-flow-oriented accounting overlooks the value of public assets, future income, and the inter-temporal dimension of solvency. It often forces countries to finance the build up of infrastructure through tax increases and leads to under-investment in times of fiscal constraints. Very few governments subscribe to the notion of a national balance sheet.

25 A Gini coefficient is a basic measure of inequality, where 0 represents perfect equality and 1 represents perfect inequality (i.e., where one person has all the income). See César Calderón and Luis Servén, *The effects of infrastructure development on growth and income distribution*, Central Bank of Chile working paper number 270, September 2004.

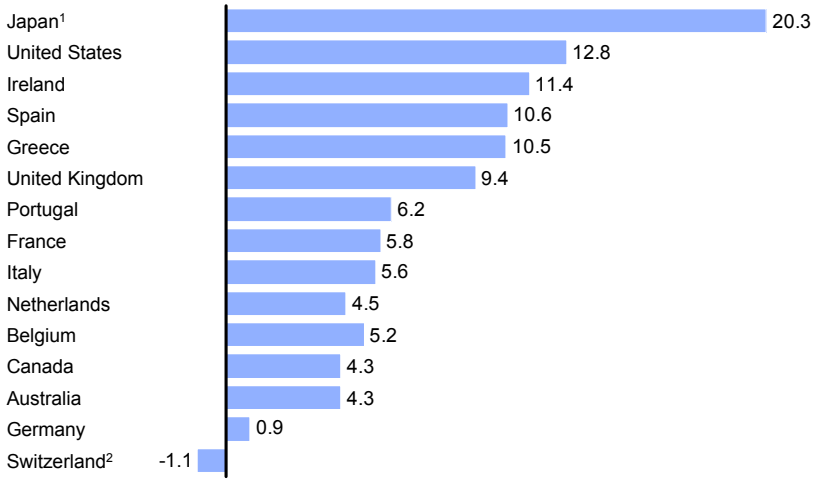
26 César Calderón and Luis Servén, *The effects of infrastructure development on growth and income distribution*, Central Bank of Chile working paper number 270, September 2004.

Exhibit 8

Restoring government debt to 60 percent of GDP by 2030 will require significant fiscal adjustments in many countries

Government debt reduction needed (2011–20) to reach 60 percent of GDP by 2030

% of GDP



1 Japan's target for fiscal adjustment is set at 80 percent of GDP.
2 Switzerland's target is to stabilize debt at the end-2011 level by 2030.

SOURCE: *Fiscal Monitor*, International Monetary Fund, October 2012; McKinsey Global Institute analysis

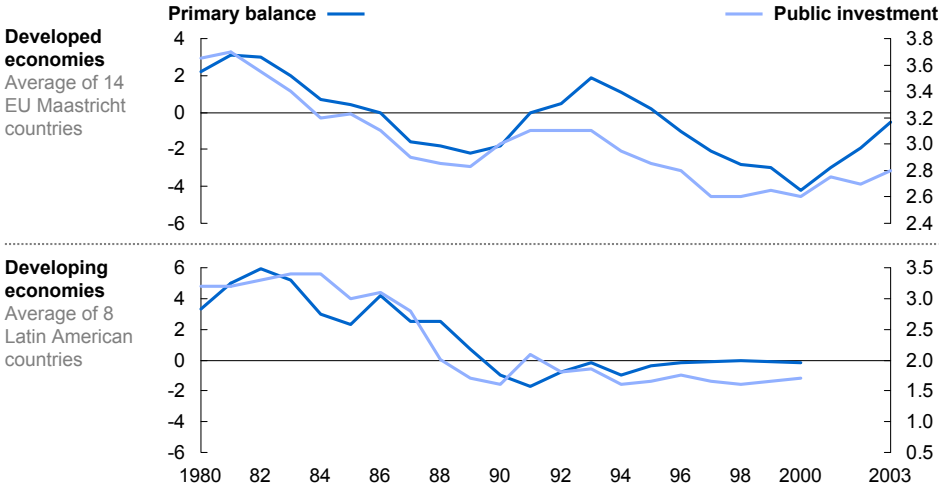
Exhibit 9

Infrastructure investment has historically suffered when deficits are rising

Primary balance and public investment trend

Observed period, 1980–2003

% of GDP



NOTE: Not to scale.

SOURCE: Calderón and Servén (2004); Fitch database; World Development Indicators; McKinsey Global Institute analysis

CHALLENGE 2: THE COST AND AVAILABILITY OF FINANCING

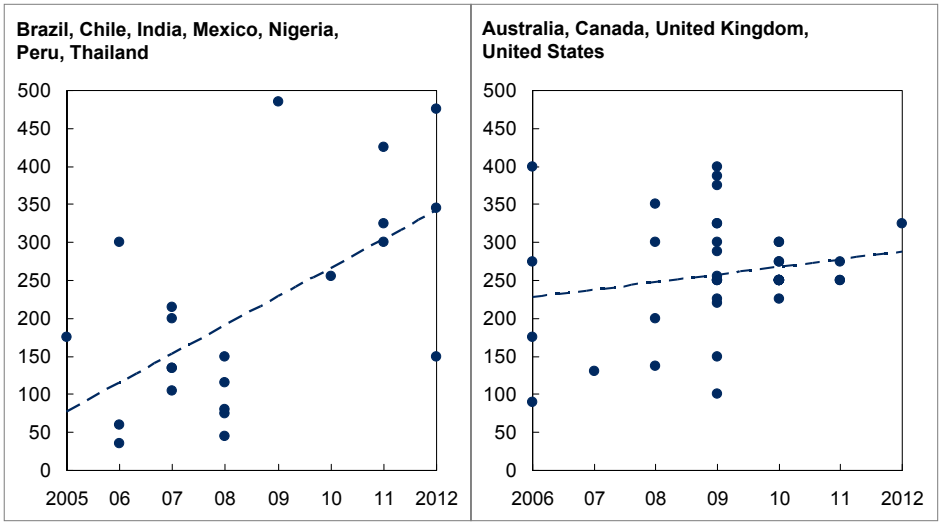
The financial crisis has hit the lending capacity of the banking sector heavily both in terms of volume and price. Interest-rate spreads on loans have widened, particularly in developing economies (Exhibit 10). Constrained lending capacity has had a negative impact on infrastructure financing across the board, while wider interest-rate spreads have an adverse effect on the ability to finance greenfield projects, which make up most of the pipeline in developing countries. These lending restrictions are likely to be aggravated with the advent of more stringent banking regulation such as Basel III. Compliance with Basel III requirements on specialized lending—which includes project-finance lending—will increase the loan interest-rate spread and will discourage long-term lending by financial institutions that have prevailing short-term liabilities.[27] Under normal conditions, banks limit loan tenors to five to eight years, while project-finance borrowers need to amortize the debt over 15 to 20 years. This means that refinancing is required after the initial loan period, involving additional refinancing risk for borrowers. Some of the gap in debt capacity might be filled by new players (insurers, for instance, that are subject to Solvency II regulation, which tends to favor debt investment over equity investment), or public-sector-led efforts such as Europe's Project Bond Initiative (see Box 2, "Europe's Project Bond Initiative can help attract additional capital"). However, the overall scale of their offerings will be far lower than the financial institution lending that has been lost.

Exhibit 10

Interest rate spreads have widened in developing countries, making it even harder to finance their greenfield projects

Loan interest rate spreads for more than 50 projects
Basis points

● Loan spread over Libor for one specific public-private partnership project



SOURCE: Public Works Financing database; McKinsey Global Institute analysis

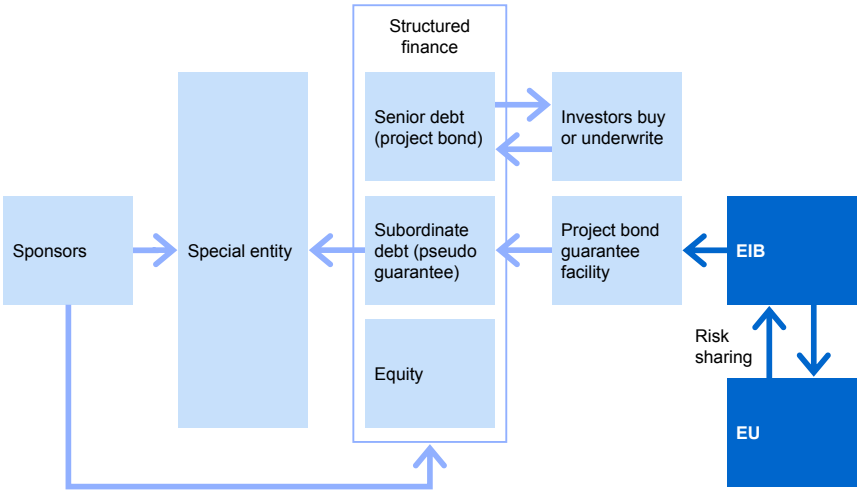
27 *Farewell to cheap capital? The implications in long-term shifts in global investment and saving*, McKinsey Global Institute, December 2010.

Box 2. Europe's Project Bond Initiative can help attract additional capital

The European Commission and the European Investment Bank (EIB) have initiated an effort to fill the gap in the supply of debt called the Europe 2020 Project Bond Initiative. The program has been established to take advantage of the appetite of capital markets for long-term debt instruments with an A-minus credit rating or higher. The EIB scheme works by splitting the debt in two tranches; "senior debt" with an A credit rating, and "subordinate debt" with a BBB credit rating. The senior debt can be sold on the capital market as a project bond (because it fulfills the rating requirements of institutional bond buyers) while the subordinate debt is financed by the EIB. In essence, the program will take on the role traditionally played by monolines—credit enhancement companies that were swept out of the market in the aftermath of the financial crisis (Exhibit 11).

Exhibit 11

The EU-European Investment Bank guarantee takes on subordinate debt in order to enhance the credit rating of the project bond



SOURCE: European Commission; McKinsey Global Institute analysis

The debt crunch has also had a collateral effect. The leverage ratio of megaprojects (i.e., projects larger than $1 billion) has moved from a typical 90:10 ratio to 70:30 or less. In 2006, for instance, the leverage ratio of the Indiana Toll Road was 85:15, which was close to typical for the time. Only two years later, the ratio for a similar project—the Pennsylvania Turnpike—was 59:41.[28] The combined effects of a higher leverage ratio and the higher cost of debt are expected to increase the cost of capital for infrastructure in the years ahead (Exhibit 12). Additionally, over the longer term, today's historically low interest rates may prove unsustainable. If real interest rates in the United States returned to their 40-year average, they would rise by 150 basis points.[29]

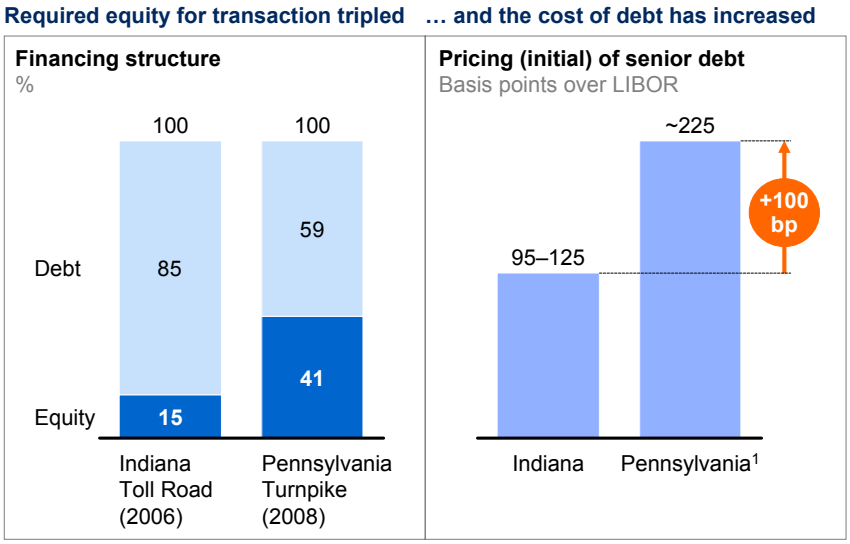
28 Bloomberg Data (loan subsection) and *Infrastructure Journal* online subscription service databases.

29 *Farewell to cheap capital? The implications in long-term shifts in global investment and saving*, McKinsey Global Institute, December 2010.

Exhibit 12

Equity requirements and the cost of capital have increased for many infrastructure investments

US ROADS EXAMPLE



1 Offer rescinded at end of September 2008.
SOURCE: *Infrastructure Journal*; Bloomberg Data; McKinsey Global Institute analysis

CHALLENGE 3: THE SHIFT TO GREENFIELD AND DEVELOPING WORLD INVESTMENT

Over the past 18 years, advanced economies have been responsible for more than 70 percent of global infrastructure investment. Over the next 18 years, emerging economies are likely to account for 40 to 50 percent of all infrastructure spending. Around 70 percent of the current pipeline available to equity investors consists of greenfield projects, which they view as much riskier than brownfield projects that have demonstrated returns.[30] An increasing number of financiers are rethinking their strategy and starting to develop financing offerings also for greenfield projects in emerging markets. However, because they perceive such projects to be riskier, they will seek higher returns and be more selective. As we have noted, the spreads on debt for emerging-market infrastructure investment have widened in the recent past, further eroding investor interest.

CHALLENGE 4: RESOURCE CONSTRAINTS

The expansion of large developing economies such as India and China has already led to sharp increases in demand for steel and other raw materials that are used in infrastructure development. Over the past decade, price increases linked to this strong demand have wiped out a century's worth of real price declines in commodities, according to previous MGI analysis. By 2030, MGI estimates that the demand for commodities is likely to rise by between 30 and 80 percent depending on the commodity.[31]

30 Computed from a range of sources including *Infrastructure Journal*, the *Public Works Financing* newsletter, and *Infrastructure Investor* magazine. Together these publications show 126 greenfield and 49 brownfield projects.

31 These estimates are based on an index of four commodities: food, non-food agricultural items, metals, and energy. See *Resource revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and McKinsey Sustainability & Resource Productivity Practice, November 2011.

Increased private financing can help, but it's no panacea

Some policy makers, commentators, and infrastructure experts have held out the hope that increased private financing, particularly from institutional investors such as pension funds, insurance companies, and sovereign wealth funds, will help address the growing need. Indeed, these funds are attracted by the fact that life cycles of infrastructure assets often match the long-term nature of their liabilities. We project that funds under management by institutional investors will grow significantly, and infrastructure projects have the opportunity to capture more of their capital. Institutional investors have expressed frustration about not being able to find enough suitable vehicles to reach their target allocations for infrastructure. If these institutional investors reached their current target allocations of around 6 percent—on average, based on data from Preqin—from 3 percent today, it would result in an additional $2.5 trillion in infrastructure investment capital through 2030. While substantial, this would still be only a fraction of the $57 trillion (or more) that the world needs over this period.

Public-private partnerships are also often viewed as a possible solution to infrastructure funding shortfalls. However, while PPPs play an important role in developing large infrastructure projects and serve as direct investment vehicles for institutional investors, they account for only a small share of total infrastructure investment—zero to 12 percent in the EU in 2006 to 2009—with the remaining share split in widely varying degrees between pure public and pure private financing, depending on the country. For example, 76 percent of total infrastructure investment in Poland is public compared with 84 percent of it being private in Austria.[32] Even if the United Kingdom's plan for expanding PPP use from 2011 to 2015 were to meet its goal, the share of infrastructure funded by PPPs would not exceed 22 percent of the total.[33] There are many barriers to PPP financing, including asset-management regulations, limited capability to successfully structure and manage PPPs, the economic characteristics of the asset, and high transaction costs. Even now in mature markets, the share of PPPs actually executed is low. For instance, only 40 percent of transport PPPs planned in the United States since 1985 had been funded by the end of 2010.[34]

There are other obstacles to increasing private infrastructure financing. Privatization, also suggested by some experts as a promising means of attracting more capital to infrastructure, often faces opposition from politicians and citizens wary of handing over public assets to private ownership. Many of these concerns stem from the potential for conflicts and corruption. According to one analysis, concern over enriching vested interests has been one of the top five constraints to privatization in sub-Saharan Africa.[35]

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32 Rien Wagenvoort, Carlo de Nicola, and Andreas Kappeler, *Infrastructure finance in Europe: Composition, evolution and crisis impact*, European Investment Bank, EIB Papers, volume 15, number 1, 2010. These estimates include educational infrastructure, transport, storage, communications, energy, water supply, and sewage and waste management.

33 *National infrastructure plan 2011*, HM Treasury and Infrastructure, United Kingdom, November 2011.

34 PW Finance, October 2011.

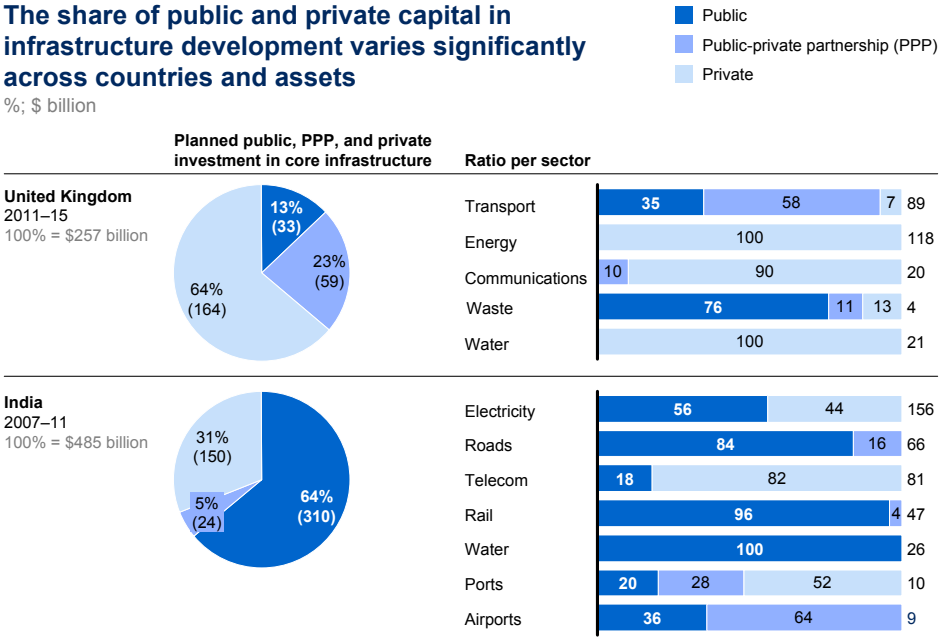
35 Daniele Calabrese, *Strategic communication for privatization, public-private partnerships, and private participation in infrastructure projects*, World Bank working paper number 139, 2008.

The deployment of public versus private capital for infrastructure varies across countries and assets. As a rough rule, developed economies have a higher share of private financing, but variation across assets is significant even across countries with similar development profiles, driven primarily by country-specific policies and conventions (Exhibit 13).

Exhibit 13

The share of public and private capital in infrastructure development varies significantly across countries and assets

%; $ billion



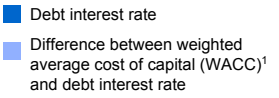
SOURCE: HM Treasury, United Kingdom; Planning Commission, India; McKinsey Global Institute analysis

It is often assumed that public capital is cheaper than private capital, but in practice the two are difficult to compare. In order to attempt the comparison, it is important to distinguish between the cost of debt and the true cost of capital. The true cost of public capital is higher than the cost of debt because of a hidden risk premium in the form of implicit government guarantees ultimately borne by taxpayers (for example, revenue guarantees, or the implicit assurance that a government will continue to provide an essential service, regardless of the financial implications). The private-sector cost of capital is the weighted average cost of capital including the cost of equity and debt, which includes the higher private-sector risk premium. The difficulty in comparing the public and private cost of capital is exacerbated by the fact that the public risk premium differs from that of the private sector; governments have more control of regulatory risks and less control of construction and operational risks.

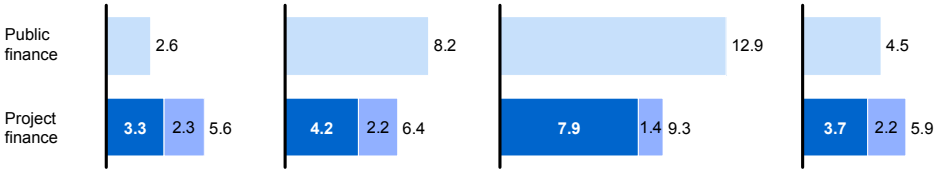
Furthermore, comparisons between private and public financing costs are not the same around the world. While the cost of public debt is lower than the private cost of debt in many advanced economies, this may not always be the case in developing ones and in countries that are experiencing severe economic downturns (Exhibit 14).

Exhibit 14

Public debt is generally cheaper in mature economies, but this is not always the case in developing ones



	United Kingdom	India	Portugal	Brazil
Example	Transportation	Energy	Energy	Transportation
Financial close	December 2011	July 2012	June 2011	November 2011
PF loan tenure	18 years	8 years	5 years	12 years
Treasury bond	15 years	10 years	5 years	15 years



1 WACC assuming leverage ratio of 80 percent and cost of equity of 15 percent.
SOURCE: McKinsey Global Institute analysis

GOVERNMENTS CAN PARTIALLY ALLAY THE FINANCING CHALLENGE BY EXPLORING ALTERNATIVE SOURCES OF FUNDING

A broad range of funding tools is available to governments, including various forms of taxes, user fees, and divestitures. Here we focus on those that have traditionally been under-exploited—road pricing, property value capture, and capital recycling.

Roads are arguably the greatest untapped source of user fees. William Spencer Vickrey, a Nobel laureate in economics, made a powerful case for higher road pricing in the mid-1950s, asserting that that roads and other services should be priced so that users bear the cost of the negative externality (i.e., congestion) that arises when traffic volumes exceed the free-flow capacity of a road (see Box 3, "The economic case for road pricing"). His arguments are only now starting to be more widely embraced, driven in part by advances in technology that have broadened the possibilities for road pricing—for instance, in the form of cordon tolls, which impose fees on motorists entering a certain part of the city at particular times of the day, or variable tolls, whose charges are adjusted based on traffic conditions.[36]

36 Richard Arnott et al., eds., *Public economics: Selected papers by William Vickrey,* Cambridge University Press, 1994.

Box 3. The economic case for road pricing

Road pricing is not just about raising revenue; it is a strategy to reduce congestion by affecting both the supply and demand of road space. When the capacity of an infrastructure asset is constrained, the introduction of pricing helps to determine where, when, and how to add capacity, and to monetize the benefits of that new capacity. The more widely this pricing is implemented across facilities, the lower these prices can be.

All too often, the default option is simply to expand an infrastructure asset as it reaches capacity constraints. But this approach entails losing an increasing portion of the benefits every year as additional demand is induced and capacity fills up. This erosion in benefits does not occur (at least to the same extent) when the road is priced. Therefore, over a reasonable period, pricing will always be a more effective strategy from a cost-benefit perspective (helped further by the fact that it is so much cheaper than expanding a road).

Initially a net negative for drivers (for whom the previous lack of pricing was effectively a subsidy), road pricing has very large net benefits to society in the form not only of revenue and lower environmental costs, but also in terms of journey times for individual drivers and freight carriers. Over time, drivers adjust to road pricing to reduce their costs, including driving at off-peak times (which is cheaper where variable tolling systems are employed), chaining trips (that is, combining multiple tasks on a single trip), shifting onto public transport, telecommuting, or carpooling. As drivers increasingly adopt such strategies, the overall net benefits from road pricing grow, assuming the effective use of revenue.

While economists agree on the broad merits of road pricing, there is no consensus on the best way to set prices, how to address equity concerns, or how spend the revenue raised. Nor is there consensus on the case for road privatization.[1]

We discuss some practical lessons on the implementation of road pricing—in the form of congestion charges—later in this paper.

1 Robin Lindsey, "Do economists reach a conclusion on road pricing? The intellectual history of an idea," *Econ Journal Watch*, volume 3, number 2, May 2006.

Another relatively under-exploited funding stream is property value capture. The most prominent form of this is the acquisition and, later, sale or lease of excess land. Governments that acquire (or already own) land around an infrastructure project can either lease or sell it at a profit once the project is completed, using the funds raised for new infrastructure investment. For the construction of the outer-ring circumferential highway in Changsha, capital of Hunan Province in central China, the Ring Road Investment Corporation (RRIC) acquired strips of land 200 meters wide on both sides of the highway. The RRIC was able to borrow against the anticipated future value of the improved land from the China Development Bank and commercial banks, pledging to sell land parcels to service the debt after the highway was completed. In India, Mumbai's Metropolitan Region Development Authority took the same approach with the sale of land in

the Bandra-Kurla, a 553-acre commercial center developed from marshland in the early 1990s, raising more than $500 million in revenue to fund public works in the city. A variation of this was employed in the Madinaty real estate development in New Cairo, Egypt, where developers built the required infrastructure in exchange for government land. Hong Kong's Mass Transit Railway (MTR) has become one of the region's major property developers, using profits from new housing, commercial, and retail schemes to pay for part of the construction cost of new subway lines, and allowing them to operate without any subsidy support from the local government. MTR has, for instance, developed dozens of new housing projects ranging in size from 300 to 7,000 apartments along its urban rail lines.

Tax increment financing (TIF) is an increasingly popular way to fund improvements. TIF arrangements enable governments to capture anticipated increases in property or other tax revenue that result from infrastructure development and use them to finance that infrastructure. The tax increment or "betterment levy" is the increase in tax that accrues from an increase in a site's value and is used to service the debt that is issued to pay for the project. TIF is commonly employed to redevelop blighted areas where private investment is often hard to attract. The city of Bogotá, for instance, is financing more than $1 billion of infrastructure using betterment levies, much of it in areas that have struggled to attract private investment. While there are valid concerns about abuse of TIF—governments can take on too much risk, for instance, or employ it in areas where development would have happened anyway—there is no question that it is a valid and valuable tool. Recognizing its promise at a time when federal funding is threatened and responsibility for delivering infrastructure is falling increasingly to state and local governments, 48 of the 50 US states have passed legislation to enable TIF.

Capital recycling refers to the divestiture of infrastructure assets and the earmarking of all or part of the proceeds for new infrastructure developments. Given the understandable sensitivity that often surrounds the sale of public infrastructure, governments will need to employ this measure in one of two situations: as part of a comprehensive package of infrastructure reforms that includes a strategic decision to transfer ownership of a particular asset class to the private sector, or as an emergency measure, or option of last resort, when faced with an acute need. In Australia, for instance, the state of Queensland conducted a series of infrastructure divestitures between 2006 and 2009, ranging from power generation and gas distribution to airports and motorways, which resulted in revenue of $17 billion. A portion of these proceeds was used to redevelop infrastructure that had been damaged over the course of an extraordinary period of natural disasters.

□ □ □

Infrastructure funding and finance is likely to become even more challenging in the decades ahead. Tapping new revenue streams and innovating with sources and structures for finance is important. However, to bridge the infrastructure gap, governments and the private sector must look beyond what they need to invest and rethink *how* they invest. That effort should include new ways of scoping and selecting infrastructure projects, delivering those projects more efficiently, and getting more out of existing infrastructure through improved operations, maintenance, and demand management. In the next chapter, we discuss such solutions and the savings that their widespread adoption could achieve.

2. How to boost infrastructure productivity by 60 percent

Given the scale of the need for infrastructure and the severity of the funding constraints, the world has to find ways to boost productivity of infrastructure—getting greater value from each dollar of investment. We have examined more than 400 case studies across the spectrum of the planning, delivery, operation, and financing of infrastructure. We estimate that scaling up some of the best practices from these examples globally could lead to a 60 percent productivity improvement, or savings of 40 percent; countries could deliver $48 trillion of infrastructure for only $30 trillion in investment and reinvest the savings.[37]

There are many reasons that productivity gains in infrastructure have been so limited

The productivity of infrastructure projects has been low, slow-growing, and even stagnant for many reasons. A major factor in many countries is the weakness of the infrastructure planning, delivery, and management system. Governments too often treat infrastructure on a project-by-project basis and pay insufficient attention to overall portfolios or to overarching governance, processes, and capabilities. In Chapter 3 we discuss ways in which governments can strengthen their overall infrastructure systems. In this chapter, we examine the common issues that arise under weak or non-existent infrastructure systems and how these issues constrain infrastructure productivity.

- **Persistent biases in planning and forecasting, leading to poor project selection.** Many poorly conceived projects have been approved "because benefit-cost ratios presented to investors and legislators were hugely inflated, deliberately or not," according to Bent Flyvbjerg, professor and chair of major programme management at Oxford University. The accuracy of such analysis has not improved despite advances in technology and data, suggesting that the main reason for failure is not technical but politico-economic. "Competition between projects and authorities creates … an incentive structure that makes it rational for project promoters to emphasize benefits and de-emphasize costs and risks," Flyvbjerg notes.[38] McKinsey's experience in helping governments rationalize infrastructure project portfolios confirms the need for projects to be more clearly linked to national priorities and more accurately evaluated in terms of their system-wide costs and benefits. Otherwise, we will continue to see the type of waste that has been exemplified by the redundant bridges to Shikoku, Japan, and excess power generation capacity across Spain.

37 The $57 trillion total infrastructure need less the need for investment in telecommunication, which we did not include in this study, study, results in a $48 trillion investment need.

38 Bent Flyvbjerg, "Survival of the unfittest: Why the worst infrastructure gets built—and what we can do about it," *Oxford Review of Economic Policy*, volume 25, number 3, 2009.

- **Persistent biases toward building new capacity rather than getting the most out of existing assets.** Governments tend to favor building new assets or major expansions over operational improvements or demand-management measures that would achieve the same results with existing facilities.[39] Governments tend to favor building new assets or major expansions over operational improvements or demand-management measures that would achieve the same results with existing facilities. According to Stephen Ezell of the Information Technology and Innovation Foundation, a non-profit, non-partisan think tank, one source of such bias is a narrow view of mission. "Transport agencies were created to build and maintain infrastructure, not manage transport networks, and therefore place more emphasis on building new roads than ensuring the system functions optimally," he says.[40] Typically, new roads provide only temporary relief of congestion because expansions induce additional demand, eventually leaving assets as congested as before, and are more expensive and carry greater environmental risks than demand-management alternatives. One meta-analysis of academic studies on induced demand found that between 50 percent and 100 percent of new road capacity is typically used up within five years.[41]

- **Lack of performance pressure, weak regulation, and informality in infrastructure construction.** Labor productivity in the construction sector has been flat or has even been falling in many advanced economies over the past 20 years and has trailed productivity in the rest of these economies (Exhibit 15). Some of this under-performance relates to more stringent quality standards. In addition, some upstream productivity gains by suppliers of raw material and prefabricated components are not reflected in construction productivity data. Even adjusting for these factors, our analysis shows that construction sector productivity growth has lagged behind that of other sectors.

  Construction productivity is hampered by many factors. The industry is highly fragmented and, in many places, operates as part of the informal economy; construction has a higher proportion of undocumented workers than other sectors—2.5 times as high as the economy-wide average in Brazil, for instance, and as high as 15 to 20 percent even in the United States (Exhibit 16). These conditions make it hard for the industry to realize economies of scale or to reap the advantages of adopting best practices, leading to under-investment in R&D and slow growth in capital per worker in all but the most advanced companies. They also raise a host of concerns about worker protections, further underscoring the importance of industry-wide efforts to address the issue.[42] Other reasons for low productivity in construction include insufficient education and training, regulatory bottlenecks

39 See also Matthew E. Kahn and David M. Levinson, *Fix it first, expand it second, reward it third: A new strategy for America's highways*, The Hamilton Project Discussion paper 2011-03, February 2011. The authors find that 37 percent of the National Highway System (NHS) is in fair, poor, or very poor condition and yet that new capacity attracts a higher share of federal spend on the NHS than maintenance. Also see Michael A. Pagano, *Funding and investing in infrastructure*, Urban Institute, December 2011.

40 Stephen Ezell, *Explaining international IT application leadership: Intelligent transportation systems*, Information Technology and Innovation Foundation, 2010.

41 Todd Litman, "Generated traffic: Implications for transport planning," *ITE Journal*, volume 71, number 4, Institute of Transportation Engineers, April 2001.

42 Jeffrey S. Passel and D'Vera Cohn, *A portrait of unauthorized immigrants in the United States*, Pew Hispanic Center, April 2009.

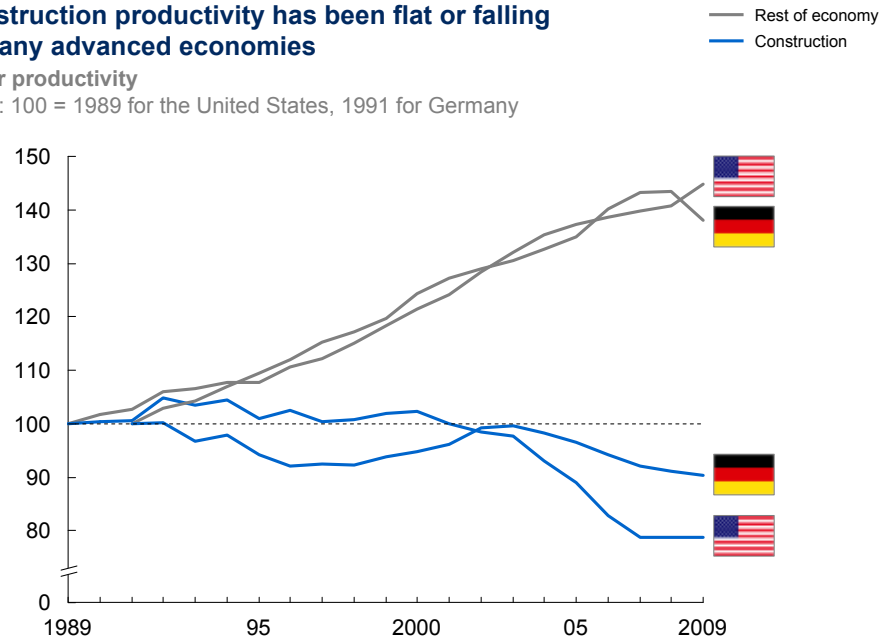
(overly restrictive materials standards or zoning regulations, for instance), a fragmented value chain with limited incentives at each stage to optimize cost, and over-specification on public projects, which can stifle innovation in design and materials.[43]

Exhibit 15

Construction productivity has been flat or falling in many advanced economies

Labor productivity

Index: 100 = 1989 for the United States, 1991 for Germany



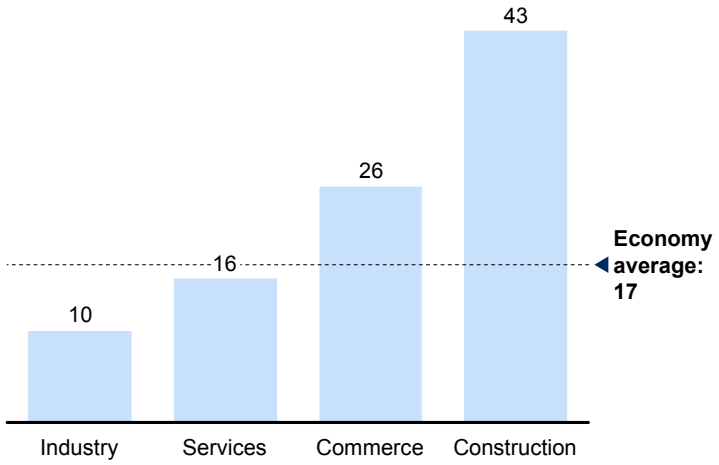
SOURCE: OECD Labour Productivity by Industry (ISIC Rev. 3); McKinsey Global Institute analysis

Exhibit 16

Brazil's construction sector has a significantly higher proportion of informality than the rest of its economy

Informality in different sectors of the Brazilian economy

%



SOURCE: Departamento Intersindical de Estatística e Estudos Socioeconômicos (Dieese), 2011; McKinsey Global Institute analysis

43 See, for example, *Beyond austerity: A path to economic growth and renewal in Europe*, McKinsey Global Institute, 2010; and *How Brazil can grow*, McKinsey Global Institute, December 2006.

- **Capability constraints.** Insufficient skills in infrastructure administration have an impact on performance across the value chain, from initial project analysis and planning through delivery and operation. Because of capability constraints, governments often fail to get the infrastructure that they are paying for when they engage sophisticated private-sector contractors. The attempts of African governments to use fixed-fee contracts and concessions, for example, have come up against the considerable legal and contract-management resources of large multinational firms. Richer countries can also struggle to develop home-grown talent in critical areas such as project management. In Saudi Arabia, some observers have noted that the biggest cause of delay in infrastructure projects is a lack of qualified and experienced personnel.[44]

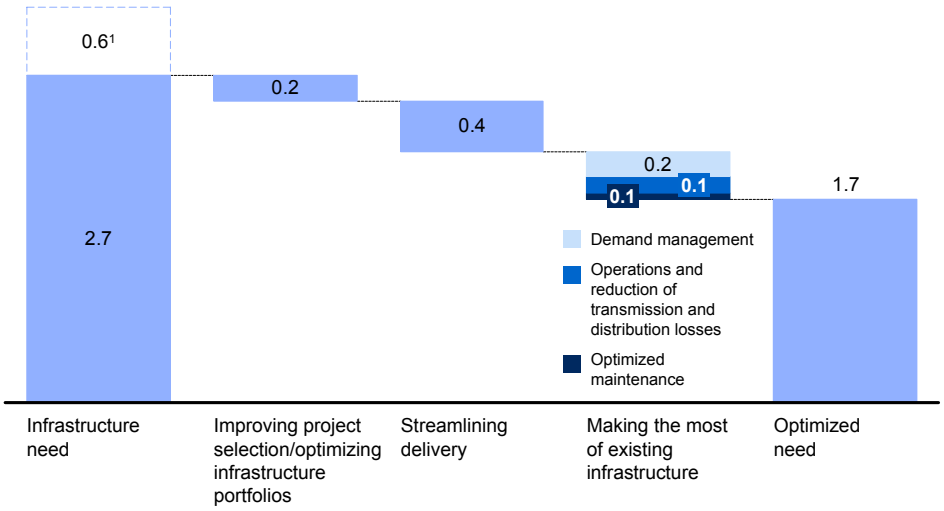
A 60 percent increase in infrastructure productivity is possible—and worth $1 trillion a year through 2030

Extrapolating the impact of the examples of effective infrastructure planning, delivery, and operations that we have collected suggests potential to reduce infrastructure investment needs by 40 percent—or by an average of $1 trillion a year based on average global investment needs of $2.7 trillion a year from 2013 through 2030 (Exhibit 17). Put another way, there is potential to get 60 percent more infrastructure from the same spending.[45]

Exhibit 17

The $1 trillion-a-year infrastructure productivity opportunity

Global infrastructure investment need and how it could be reduced
Yearly average, 2013–30
$ trillion, constant 2010 dollars



1 Telecom investment need beyond the scope of this paper.
SOURCE: McKinsey Global Institute analysis

44 Adel Al-Kharashi and Martin Skitmore, "Causes of delays in Saudi Arabian public sector construction projects," *Construction Management and Economics*, volume 27, number 1, 2009.

45 The total global need is an estimated $3.3 trillion a year, but we exclude the telecommunications sector in our analysis. All yearly figures should be interpreted as averages over the time interval 2013 to 2030, the horizon taken for our analysis.

We base this extrapolation on more than 100 case studies (of the 400 that we carried out overall) that quantify the impact of a range of improvement levers from across three broad categories of opportunity: improving project selection and optimizing infrastructure portfolios; streamlining delivery; and making the most of existing infrastructure assets. The case studies come from a range of countries covering different geographies and development profiles. Some of these cases were drawn from McKinsey's work, and some from external literature and interviews. They mostly come from the past five years, with a few going back as long as ten years. The following sections, as well as the technical appendix, provide more detail on how we quantify the savings potential.[46]

While the 60 percent productivity gain is an extrapolation that uses several simplifying assumptions, we believe that it is achievable if nations are willing to invest in a systematic approach to infrastructure that drives improvement across agencies and private-sector owners and contractors. Capturing this opportunity is not rocket science or a bet on unproven technologies or ideas—our research reveals well-established practices and processes observed from around the world.

In addition to reducing the amount of capital investment the world requires, many of the productivity levers we discuss in this chapter can increase the contribution that infrastructure makes to GDP growth by producing savings that can be reinvested in additional infrastructure or other public spending that brings similar benefits, accelerating the delivery of projects with attendant advantages, and reducing environmental and social externalities by making the most of existing assets rather than building new ones. Increased productivity would also produce improved returns and lower volatility on infrastructure investment, drawing in additional private financing. This could increase the global share of planned PPP projects that receive funding, which currently stands at only 54 percent.

We now discuss each of the three major types of lever in turn.

46 For any lever, in order to extrapolate impact from the case studies to a global savings figure, we adjust estimates for their applicability to different countries and regions. We apply each lever only to those asset classes where this lever is relevant, and only to the relevant portion of capital spend for that asset class—that is, we differentiate between spending on new construction to either build new assets or to physically expand existing ones (and further between generation, transmission and distribution in energy and water), and spending on capitalized asset renewal. For each lever and asset combination, we make the analysis as specific as possible. To calculate the potential global impact, we make a number of simplifying assumptions. First, we assume that the case examples, and corresponding assessments of savings potential, are still applicable to the average case encountered today. Second, we assume that the savings are achieved immediately, ignoring the fact that any real implementation would involve a ramp-up period before the full potential is realized. Third, we ignore the fact that contractors and operators would capture some of this prize in the form of additional profit, and assume that the right contract terms would help ensure that much of the benefit accrues to society more broadly. It is also important—though perhaps obvious—to note that these global estimates provide little insight on the potential for individual countries for which more detailed, country-specific analysis would be required.

OPPORTUNITY 1: MAKING BETTER DECISIONS ABOUT PROJECT SELECTION

Despite the increasing constraints on their resources, many governments continue to misallocate them in the case of infrastructure spending. But a number of government initiatives in countries as diverse as Chile, South Korea, and the United Kingdom have shown potential savings of 15 to 20 percent of capital expenditure by reprioritizing projects and picking more cost-effective alternatives. This savings figure applies only to capital spending on anticipated new projects and translates into savings of 7 percent on total anticipated infrastructure spending. The relative size of these savings is similar to those that the private sector achieves in capital portfolio optimization in heavy industries.

Some of the root causes of poor planning and decision making include the failure to link infrastructure planning to broader social and economic goals, routine under-estimation of costs and over-statement of benefits, the pressure to allocate resources to cater to narrow political interests, and, in the most extreme cases, the damaging impact of corruption on the selection of projects.

The evaluation of projects also tends to be carried out in isolation rather than as part of an overall system that considers broader socioeconomic development objectives, resulting in incomplete and inefficient solutions that often address local symptoms and conditions rather than network-wide problems. This is particularly obvious in cases where highway expansion happens without coordination with local rail systems, or where ports and airports are expanded without solving bottlenecks on connecting roads and rail. In South Africa, the Richards Bay Coal Terminal cannot operate at its full potential without an expansion of rail connections to the terminal.

Exacerbating all of these challenges is a longstanding tendency for countries to attempt to build their way out of problems by constructing large new projects rather than making the most of existing assets through demand-management measures and improved asset utilization, which typically costs far less. We discuss demand management later in this chapter.

The optimization of infrastructure portfolios, through the elimination of poorly conceived projects and selection of better alternatives, would free up an estimated 15 to 35 percent of new capital spending. This range of estimates is borne out by the experience of several countries. South Korea's Public and Private Infrastructure Investment Management Center (PIMAC), established to eliminate the routine cost under-estimation, benefit over-estimation, and fraud that had plagued the country's infrastructure planning, has saved 35 percent of spending, rejecting 46 percent of projects that it reviews compared with the 3 percent that were rejected before its establishment. Chile's National Public Investment System (SNI) process rejects 25 to 35 percent of projects. South Africa optimized its infrastructure portfolio by auditing it and stripping out poorly conceived, low-value projects; it achieved 33 percent savings. The United Kingdom's cost review has saved 10 to 15 percent on the 40 major projects that it has reviewed. These figures are similar to the savings that McKinsey typically sees in its private-sector portfolio optimization work in analogous capital-intensive industries, including utilities, energy companies, steel, and heavy manufacturing.

Achieving these outcomes requires a goal-driven, analytical, and transparent strategy and planning process with three key components: identify projects with a clear purpose; evaluate projects using improved cost-benefit analyses and reference-class forecasting; and prioritize projects at the portfolio level. We now discuss each in turn.

Identify projects with a clear purpose, based on socioeconomic priorities

Infrastructure planning should be rooted in broader socioeconomic objectives set through a political process, and selected projects should address those objectives directly. Some countries are closer to achieving this ideal than others. Singapore, for instance, has a national goal for dense urban living that has led to the specific aspiration of achieving a 70 percent usage rate for public transit. This aspiration has, in turn, guided the selection of transport projects by the country's Land Transport Authority. Similarly, Australia set an objective of delivering high-speed Internet connectivity to 93 percent of its population and identified the establishment of a national broadband network as the best way to achieve that goal. Malaysia has a national goal to achieve "developed nation status," which informs a national physical plan that cascades into sector-specific plans, such as the highway development plan. In Switzerland, the Federal Council has established overarching objectives around economic, ecological, and social sustainability. Switzerland's Department of the Environment, Transport, Energy and Communications publishes an infrastructure strategy for the Federal Council based on these objectives and individual infrastructure authorities develop specific strategies that focus on the most important objectives established by the department and the Federal Council.

When governments and other players think about infrastructure, they should not focus entirely on major new construction of infrastructure. Instead, they need to focus on the underlying need and find the most efficient solutions to address that need. Sweden has institutionalized this way of thinking with a four-step principle for transport investment. The first of these steps is considering measures that may affect the need for travel and choice of mode. The second is implementing measures that result in more efficient use of existing infrastructure. The third step, if necessary, is investing in small-scale redevelopment. The fourth, which comes into play only if the first three do not address the infrastructure need, is consideration of new investment or large-scale redevelopment. Australia's power demand-management regulatory and policy framework follows a similar logic, developing what it refers to as a "neutral" regulatory framework that allows demand-management options to compete with other, more traditional and capital-intensive solutions. These options include, for example, incentive schemes that enable the capture of savings that result from the deferral in investment in new assets.

Evaluate projects using improved cost-benefit analyses and reference-class forecasting

Infrastructure assets vary widely in terms of the types of benefits and costs that they deliver and impose, and therefore they need to be evaluated differently (Exhibit 18). Where there is a competitive market, a particular class of infrastructure and assets can be privatized, and planning and project evaluation can take the form of normal business plans. These activities can be left to market forces as long as regulation allows for rational, cost-covering price signals. (It

is, however, important to note that, even when infrastructure can be privatized or evaluated in purely financial terms, governments often either set regulation or invest to address other policy goals such as stimulating jobs, providing access to rural telecommunications access, or increased mobility.)

Exhibit 18

Infrastructure projects can vary widely in terms of how their costs and benefits are expressed, and therefore need to be evaluated differently

	Financial returns	Economic returns/ cost-benefit analysis	Social cost-benefit analysis
	Projects with discrete revenue streams and clear costs can be evaluated in purely financial terms	Projects where both financial returns and economic spill-over effects need to be quantified	Projects where benefits are largely social (equity, health, environment) and difficult to quantify in economic terms
Example	**Wireless telecom** ▪ Typically private competition, and user fees cover costs ▪ Investment decisions on a purely financial basis (net present value, return on investment)	**Toll highways, roads** ▪ Toll revenue assessable in terms of return on investment (ROI) ▪ Non-financial economic costs and benefits (e.g., mobility and higher economic activity) justify additional charges or subsidies and require evaluation in economic terms	**Parks** ▪ Typically publicly funded with no user fees ▪ Most benefits intangible, such as improved health, better air quality, or increased sense of community, and require societal agreement on their value

SOURCE: McKinsey Global Institute analysis

In cases where the bulk of the benefits are non-financial or when there are large externalities, governments need to evaluate projects using consistent, comparable, and transparent metrics. As Arthur Grimes, a senior researcher at New Zealand's Motu Economic and Public Policy Research institute, points out, traditional cost-benefit analyses are often flawed, consistently failing to consider network effects, option values, or appropriate discount rates.[47] Conversely, in some cases, the reports and metrics used are too complex to enable a productive debate among decision makers. Good cost-benefit analyses are comprehensive in their definition and quantification of key inputs, and standardize costs and benefits across projects by asset class. Metrics must go beyond the purely financial and operational to include long-term economic, social, and environmental effects. France, for instance, has developed standard values for the time saved by commuters in urban, intercity road, intercity rail, and intercity air traffic as well as for "social" outcomes such as lost lives, injuries, and noise. Chile employs a "social discount rate" in its analyses that represents the opportunity cost for the country when it uses its resources to finance infrastructure projects.

Reference-class forecasting should be used to validate cost-benefit analyses. This involves a selection of similar projects in the past, developing a probability distribution for the parameter that is being forecast (typically project costs and timelines), and comparing the proposed project with the reference-class

47 Arthur Grimes, *The economics of infrastructure investment: Beyond simple cost benefit analysis*, Motu working paper number 10-05, Motu Economic and Public Policy Research, August 2010.

distribution to establish the most likely outcome.[48] Reference-class forecasting effectively increases the number of potential hypotheses for a projected outcome and helps overcomes confirmation bias by including "failures," forcing decision makers to consider cases that don't simply justify the preferred course of action. The approach has been officially endorsed by the American Planning Association (in addition to traditional techniques), particularly for "non-routine projects such as stadiums, museums, exhibit centers, and other local one-off projects." Similarly, the United Kingdom's Department of Transport has recommended its use since August 2004, responding to a Treasury directive that future large public works allocations need to have cost, benefit, and duration estimates adjusted for optimism.[49] As a prerequisite, decision makers need to establish transparency and high-quality databases of infrastructure projects.

Review by independent experts can supplement cost-benefit analyses and reference-class forecasting. In Mexico, for instance, validation by external academics or experts is required for all technical, economic, and environmental feasibility analyses of projects valued at more than $50 million. Making all calculations, projections, plans, and outcomes publicly available can drive improved accuracy through increased accountability. The Department of Transportation in the US state of Washington, for instance, publishes a comprehensive performance report, the *Gray Notebook*, and provides detailed information on transport plans and progress to legislators and the public each quarter.[50] Finally, there should ideally be a system in place to check how projects actually perform relative to predictions—a first step toward breaking the cycle of routine inaccuracy.

Prioritize projects at the portfolio level using fact-based, transparent decision making

Governments need to make decisions at a portfolio level, evaluating projects as part of a system rather than in isolation, and considering potential network effects. In the US state of Georgia, for instance, Metro Atlanta evaluated a range of "de-bottlenecking" alternatives using different portfolio options with distinct asset compositions; each portfolio was analyzed for its overall impact on performance and for its cost-benefit ratio, taking into account network effects. It is also important to note that some projects that governments may view as important for broader socioeconomic reasons may not be positive from a narrow cost-benefit standpoint. The result of such an analysis will inevitably be a very different infrastructure investment portfolio with an integrated set of initiatives, rather than a list of individual projects each with their estimated costs and benefits.

In all cases, the process for selecting projects and infrastructure portfolios needs to be fact-based and transparent to ensure public accountability and to avoid arbitrary, and therefore potentially wasteful, decisions. South Korea's PIMAC

48 See also Dan Lovallo and Daniel Kahneman, "Delusions of success – How optimism undermines executives' decisions," *Harvard Business Review*, July 2003.

49 Bent Flyvbjerg, Massimo Garbuio, and Dan Lovallo, "Delusion and deception in large infrastructure projects: Two models for explaining and preventing executive disaster," *California Management Review*, volume 51, number 2, winter 2009; International Transport Forum, *Improving the practice of cost benefit analysis in transport*, discussion paper number 2011–01, summary and conclusions of the roundtable on improving the practice of cost benefit analysis in transport, Queretaro, Mexico, October 21–22, 2010.

50 Washington State Department of Transportation, *Gray Notebook*.

assesses all major infrastructure projects using a detailed "preliminary feasibility study" (PFS) methodology, and drawing on a multidisciplinary PFS team that involves three or more organizations to help sustain objectivity, consistency, and transparency. Chile publishes criteria and evaluations in an online project information system (see Box 4, "Chile's National Public Investment System has a consistent and transparent approach to selecting and evaluating projects").

Box 4. Chile's National Public Investment System has a consistent and transparent approach to selecting and evaluating projects

For several years, Chile has delivered above-average infrastructure outcomes (for a country at its stage of development), measured using its infrastructure quality rating by the World Economic Forum.[1] Chile's high score is due largely to the quality of its national planning institutions. These include the National Public Investment System, which the Latin American and Caribbean Institute for Economic and Social Planning acknowledges for its "real contribution to improving resource allocation."[2]

Chile follows three tenets of effective strategy and planning: projects are based on socioeconomic objectives; an independent body evaluates those projects; and a fact-based process is used to prioritize projects. Chile's Ministry of Planning, which oversees the planning, construction, development, and operation of infrastructure, has laid out an Infrastructure Master Plan based on politically established priorities and objectives.[3] All proposed projects go to the ministry's National Public Investment System, which uses standard forms, procedures, and metrics to evaluate each project, rejecting 25 to 35 percent of them. Its cost-benefit analyses include social prices such as the cost of travel time and a social discount rate that represents the opportunity cost for the country when it uses its resources to finance infrastructure projects. The final decision on a project lies with the Ministry of Finance, which allocates funding based on a combination of the cost-benefit analysis and national goals. All this information, as well as historical data on project performance, is available to the public.[4]

Chile has also implemented other mechanisms to ensure its success on infrastructure projects. These include a formal system for private-sector companies to propose projects that the government is currently not considering, as long as these schemes are in line with the overall national strategy, and a well-developed sovereign wealth fund (based on earnings from copper mining) that provides a reliable pool of capital for infrastructure investment.

1 *The global competitiveness report 2011–2012*, World Economic Forum, September 2011.

2 E. Contreras, F. Cartes, and J. F. Pacheco, *Los SNIP de América Latina y el Caribe: Historia, evolución y lecciones aprendidas*, 2010, quoted in Andrés Gómez-Lobo, "Institutional safeguards for cost-benefit analysis," *Journal of Benefit-Cost Analysis*, volume 3, issue 1, January 2012.

3 *Infrastructure master plan*, Ministry of Public Works, Chile.

4 *Appraisal of public investment: Chile*, World Bank knowledge brief, December 2006.

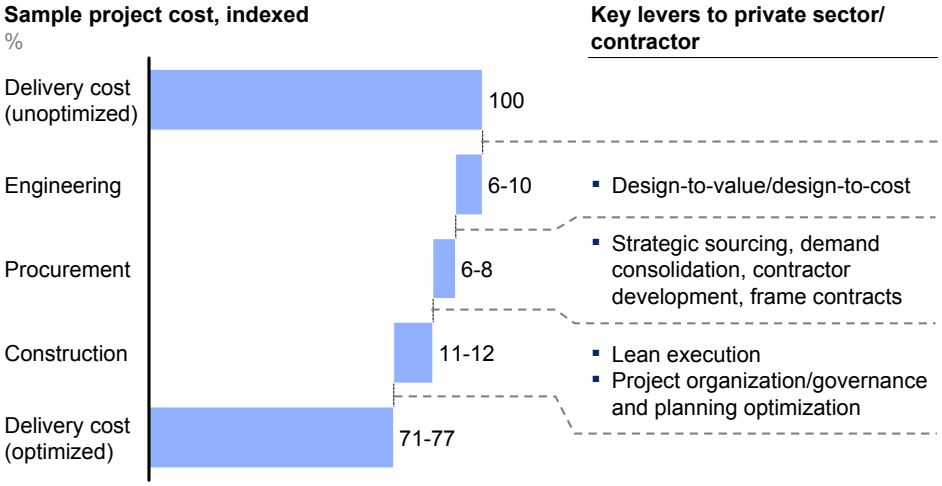
OPPORTUNITY 2: STREAMLINING PROJECT DELIVERY

More efficient delivery can generate savings of as much as 25 percent on new projects, or 15 percent savings on total infrastructure investment (assuming that some productivity levers also apply, to a limited extent, to investment in maintenance), according to McKinsey's experience in large capital projects.[51] The savings come from efficiency gains in approval, engineering, procurement, and construction (Exhibit 19).

Exhibit 19

McKinsey & Company's experience suggests potential productivity gains averaging 25 percent in infrastructure delivery

Typical capital expense reduction potential = 23 to 29 percent of total project cost[1]



1 Based on ~40 capital productivity studies from 1994 to 2012.
SOURCE: McKinsey Global Institute analysis

In addition, speeding up project delivery generates other financial and non-financial benefits not included in these estimates. There is no shortage of examples of the profound socioeconomic impact of delayed infrastructure projects. Six years after India approved a new suspension bridge, the residents of Suraitota in the mountainous Uttarakhand Province are still waiting for work to commence. The construction of a US-Mexico border bridge aimed at relieving congested cargo traffic lanes between El Paso and Ciudad Juárez had started in Texas at the time of writing but not in Chihuahua. As a consequence, trucks entering the United States still have to wait for up to two hours at the border.

To achieve these savings, governments and infrastructure authorities can use five main strategies: streamline permit approvals and land acquisition; adopt sophisticated procurement, contracting, and tendering methods; use best-practice project planning, design-to-cost, and lean construction methods; strengthen cooperation with contractors; and foster construction sector capabilities and productivity. We discuss each of these in turn.

51 This projection is based on two equal sources of savings: more efficient delivery of new projects (25 to 30 percent savings) and 50 percent discounted savings on capitalized maintenance and renewal.

Streamline permit approvals and land acquisition without compromising the quality of outcomes

Securing regulatory approvals usually consumes a significant portion of a project timeline—often many years and, not infrequently, longer than the time it takes to actually construct a piece of infrastructure. The necessary involvement of various stakeholders such as environmental interest groups, local communities, and businesses and property owners can further slow down already complex government procedures. Effective management of stakeholders is therefore important (see Chapter 3). Nevertheless, these processes can be shortened significantly. Best practice in issuing permits involves the rigorous prioritization of projects, clear roles and responsibilities, transparency on performance, and time-bound process steps (including time limits on public review). Providing "one-stop-shop" permitting lowers the burden on applicants. By applying these approaches, New South Wales, in Australia, cut its average time to grant a permit by 11 percent (see Box 5, "New South Wales has improved its permitting processes") although private companies would argue that a lot remains to be done. In England and Wales, a one-stop shop grants permits for power industry infrastructure in nine to 12 months, compared with an average of four years in Europe. Even in cases where accelerating approvals is not a critical priority from a pure impact perspective, the improved process and timeline predictability is often greatly valued by the stakeholders involved, and may therefore be justified on these grounds alone.

Streamlining permitting helps to complete projects more quickly and generate savings that can be used sooner for other purposes such as mitigating environmental effects. To achieve these and other efficiency gains, some governments are making a concerted effort to deploy lean principles inspired by the private sector in their operations (see Box 6, "How public-sector lean practices are working in Scandinavia").

Box 5. New South Wales has improved its permitting processes

The state of New South Wales in Australia cut the time required to secure a construction permit for infrastructure projects by 11 percent in one year by streamlining processes. It did so by defining decision rights more clearly, prioritizing projects, harmonizing processes, and focusing on performance.

The first step was for the national government to shift the power to make final decisions on permits to the state, rather than cities, and give all agencies involved clear roles and guidelines to avoid duplication. The federal government itself played a role only in special cases. Elevating decisions from the city to the state level helped clarify the prioritization process. A dedicated unit of the state government with expert specialists helped speed up decision making and identify projects to fast-track.

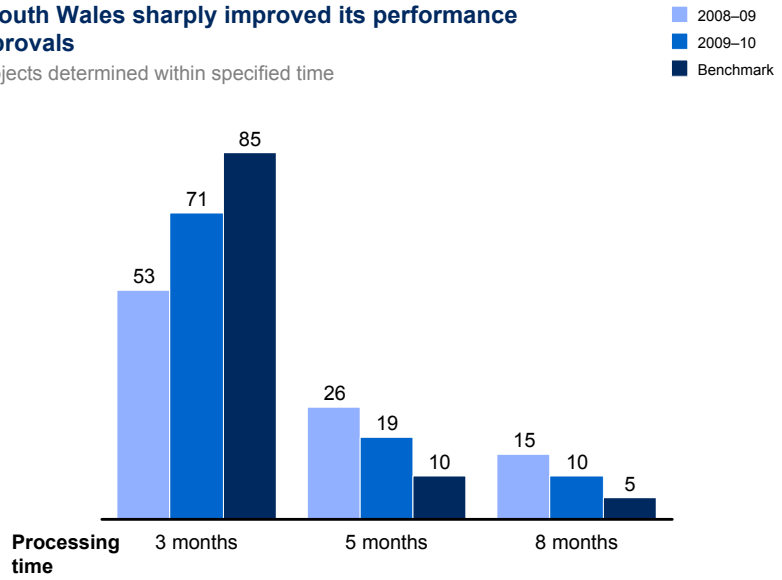
New South Wales also harmonized processes across agencies and tiers of government by adopting an integrated planning and permitting system. To account for the cross-jurisdictional nature of infrastructure projects, it negotiated bilateral agreements with other state governments. Finally, the government specified metrics, benchmarks, and performance monitoring to track approval times, creating accountability, ensuring reliability of service, and reducing uncertainty for applicants. To further increase accountability and transparency, data on the status of projects were published.

After a year, more than 70 percent of approvals were being processed within three months (Exhibit 20).

Exhibit 20

New South Wales sharply improved its performance on approvals

% of projects determined within specified time



SOURCE: New South Wales Department of Planning; McKinsey Global Institute analysis

Box 6. How public-sector lean practices are working in Scandinavia

Public-sector organizations in Sweden and Denmark are increasingly relying on lean practices to improve the efficiency of administrative processes at both the local and national levels. While construction permits are to a large extent regulated by law and much effort is made to simplify legal frameworks at the national level, the approval process is handled locally by municipalities. This is where the application of lean practices is most relevant. In a 2011 survey by the Swedish Association of Local Authorities and Regions, 88 percent of all county councils and 33 percent of all municipalities said they were working with lean practices. In those municipalities where lean has been introduced, 21 percent applied it to city planning, which includes construction.

Interest in lean is also growing among central government agencies. The Swedish National Council for Innovation and Quality in the Public Sector describes its mission as "studying public sector organizations adopting the management philosophy known as 'lean,' looking at research into the use of lean in public-sector organizations and, if deemed appropriate, supporting those public organizations that want to implement lean." The council has published several studies on lean in the public sector, noting vast potential from its implementation at all levels (e.g., in construction permitting). The agency in which these efforts have arguably gained the most traction is the National Financial Management Authority, which is responsible for financial management, reporting, and forecasting on behalf of national agencies.

While most lean projects started only recently, the first success stories are already emerging in the area of construction permitting. For example, Sweden's Kungsbacka municipality reduced handling times for real estate construction permits from nine weeks to seven within a year. Denmark's Stevns municipality was able to reduce handling times for the same process from 26 weeks to an average of four to six weeks.

Land acquisition is another time-consuming process. In India, for instance, 70 to 90 percent of road projects suffer a 15 to 20 percent delay due to challenges in acquiring land.[52] In the United Kingdom and Australia, fast-track courts have been set up to speed up the adjudication of land disputes relating to infrastructure and construction projects. Juries include judges and industry experts. Projects can also be designed to reduce time-consuming land battles. In the United States, Virginia moved ahead with a controversial plan to widen the I-495 interstate after a private design company came up with a route that eliminated the need to remove hundreds of homes. The plan also reduced the project cost from about $3 billion to around $1 billion.[53] Finally, some nations

52 McKinsey Infrastructure Practice, *Building India: Accelerating infrastructure projects*, July 2009.

53 Robert Poole and Peter Samuel, "The return of private toll roads," *Public Roads*, volume 69, number 5, March/April 2006. The article stated: "The original VDOT [Virginia Department of Transportation] proposal was more standard, featuring barriers separating the toll lanes, four sets of breakdown shoulder lanes, and high-speed ramps at all the interchanges. The private company proposed the same widening scheme—from 8 travel lanes to 12—but eliminated a pair of breakdown lanes. The company also proposed deferring some interchange improvements."

are standardizing land acquisition procedures. In the United Kingdom, a new process allows construction to start as soon as a permit is available by effectively deferring negotiations for compensation to landowners. While such solutions might not be applicable everywhere, it is important that, as with streamlined approval processes, land acquisition procedures should be time-bound to reduce unexpected delays and increase predictability.

Adopt sophisticated procurement, contracting, and tendering methods

Public-sector infrastructure operators are often constrained by rigid bidding formats and skill shortages such as limited contract-writing expertise. In addition, public-sector specifications tend to be highly prescriptive and not based on performance, which, in turn, limits innovation that could lower procurement costs. In our experience, these shortcomings result in an average cost premium of 17 percentage points over the results achieved by comparable private-sector organizations. To narrow this gap, public-sector entities can do the following:

- **Take a more strategic approach to sourcing.** Owners can use a range of approaches, including demand consolidation, global sourcing, and the long-term development of suppliers to attract the most competitive bids. Using such approaches in a coordinated roads procurement program, for instance, Australia realized savings of 20 percent.

- **Use both quality and cost as a basis for contractor section.** The selection of the contracting model needs to align with the characteristics of a project, including its complexity, as well as the objectives and capabilities of its owners. To ensure that high-quality engineering consultants and engineering, procurement, and construction (EPC) contractors are engaged, a quality- and capability-focused approach, rather than a purely cost-based assessment, needs to be used in the selection process. The McKinsey Operations Practice calls this "tendering for excellence." The financial and technical aspects of a proposal need to be considered separately. A set proportion of the technical score should be determined by a contractor's ability to deliver against expectations. The remainder should require a demonstration of excellence or innovation beyond simply "meeting the bar." Japan's Ministry of Land, Infrastructure, Transport, and Tourism, for instance, cut the average project delivery time by 16 percent by moving to best-value tendering. In Canada, Ontario's Ministry of Transportation assigns only a 10 percent weight to the bid price when evaluating an engineering proposal, compared with 40 percent on consultants' technical ratings and 50 percent on their performance ratings. Similarly, most US states' departments of transportation use technical ratings as an integral part of selection procedures. A central database of the performance of engineering consultants and EPC contractors can also be a powerful tool to help governments in the selection of quality contractors.

- **Create contract structures that make the most of contractors' capabilities.** Contracts need to encourage private-sector innovation in design and execution. In design, this can be achieved by inviting alternative design concepts, allowing proposals to be refined during tendering (for example, via multi-round bidding) and using design-build (DB) contracting, where design and construction responsibilities are handled by a single entity. This approach can also reduce risk for the project owner, cut down on delivery time by overlapping design and construction phases, and save on transaction costs

by avoiding having to issue two separate tenders.[54] In execution, incentive structures tied to cost, schedule, and other key drivers of value can encourage faster or more cost-effective project delivery—or both—through the application of the lean construction principles and advanced construction techniques that we have described. Unlocking the benefits from such innovation often depends on breaking traditional contract boundaries to enable the adequate sharing of benefits and risks among stakeholders.

Use best-practice project planning, design-to-cost, and lean construction methods

The delivery of infrastructure projects is enhanced when there is significant investment in up-front planning and design, when design-to-cost principles are emphasized, and when the use of lean and advanced construction techniques are maximized. Much of this may ultimately be in the hands of private-sector contractors, but governments need to be aware of best practice and ensure that contracts create incentives for its adoption. Best practice includes:

- **Investing heavily in up-front planning and design.** This is critical to controlling cost and time over-runs later in delivery, which is especially effective in cutting waste since the costs of design changes rise rapidly as a project advances. McKinsey & Company's experience with rail operators, for instance, suggests that more than 60 percent of cost over-runs in rail megaprojects can be attributed to changes in project owner or contractor requirements, or changes resulting from reworking inadequate feasibility studies. Similarly, in India's construction sector we found that inadequate investment in detailed project reports—driven mainly by the practice of selecting engineering consultants almost purely on cost—is one of the root causes for high cost over-runs. The project reports accounted for only 2 percent of total project costs, but the over-runs averaged 24 percent. A cross-functional approach involving all key delivery stakeholders and early collaboration with contractors (potentially even before tendering starts) can improve outcomes, but it requires cost savings to be shared among these stakeholders to be most effective.

- **A strong emphasis on design-to-cost principles and standardization.** This involves creating specifications for an asset that address its specific functional requirements and performance needs, rather than "over-speccing." Specifications should be performance-based rather than technical so that they do not stifle innovation and drive up costs. Owners need to structure contracts to encourage design innovation and the development of "minimal technical solutions"—the lowest-cost means of achieving the desired outcome (adjusting the thickness of road surfaces to usage patterns, for instance). Reducing costs will often entail maximizing the use of standardization and modular construction, and therefore minimizing the need to "reinvent the wheel" for similar projects (see Box 7, "A bridge in a weekend: The promise of accelerated construction techniques").

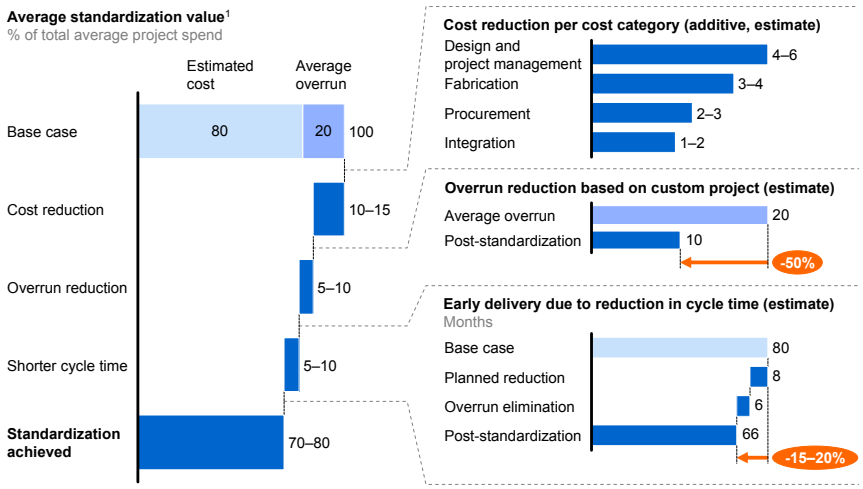
54 "DB with its single point responsibility carries the clearest contractual remedies for the clients because the DB contractor will be responsible for all of the work on the project, regardless of the nature of the fault," according to one study. See John Murdoch and Will Hughes, *Construction contracts: Law and management*, 4th edition, Taylor & Francis E-library, 2007.

Box 7. A bridge in a weekend: The promise of accelerated construction techniques

Accelerated construction techniques such as modularization and prefabrication can significantly reduce the time it takes to construct an infrastructure asset, minimize inconveniences and bottlenecks, and bring forward the benefits associated with that capacity (Exhibit 21). A small pre-cast and pre-stressed bridge, for instance, can be installed in a single weekend. In 2011, the US state of Massachusetts replaced 14 bridges on its I-93 highway over the course of just 10 weekends. Victor M. Mendez, head of the US Federal Highway Administration, said in an interview with the *New York Times* that this kind of accelerated approach would be the new normal.[1]

Exhibit 21

An oil company used standardization and prefabrication to significantly reduce costs on a major construction project



1 Industry average project based on total costs of $2 billion; total estimated time from discovery to first oil date of seven years. Includes about 25 percent cost and schedule overrun for full custom projects.

SOURCE: McKinsey Operations Practice; McKinsey Global Institute analysis

1 John Schwartz, "Did someone order an instant bridge?" *New York Times*, April 17, 2012.

- **Applying lean manufacturing concepts to construction.** This can significantly improve delivery outcomes (Exhibit 22). McKinsey & Company's experience suggests that there are typically four main sources of improvement potential:
  - **Construction logic.** Re-thinking the sequence of activities, including taking activities off the critical path (that is, distinguishing between those activities which if delayed will make the project take longer, and those activities which, if delayed, will not affect the overall project timeline), and externalizing or running some construction processes in parallel.
  - **Preparation.** Ensuring synchronization between related tasks and ensuring adequate preparation prior to executing tasks.

— **Resource deployment.** Defining resource needs and balancing those resources based on the different workloads at the construction site.

— **Equipment effectiveness.** Optimizing the utilization and performance of critical equipment, which requires a sound understanding of failures, reduced speed, maintenance time, and other issues.

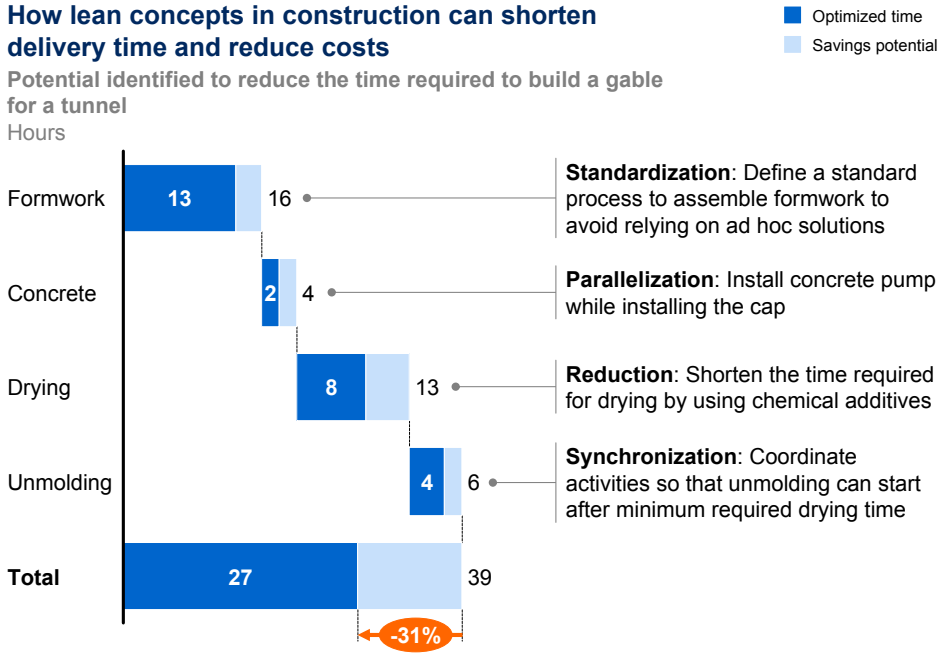
These concepts are particularly applicable to repetitive actions, which, despite the specificity and complexities of many infrastructure projects, typically comprise 80 percent or more of total activity. Close observation of these activities in the construction yard is typically necessary to identify how to improve future cycles. The capacity that is subsequently freed up can be invested in important non-repetitive activities where the focus needs to be on a sound up-front diagnostic that helps ensure that the one-time execution of the activity occurs as efficiently as possible.

Exhibit 22

How lean concepts in construction can shorten delivery time and reduce costs

Potential identified to reduce the time required to build a gable for a tunnel

Hours



SOURCE: McKinsey Operations Practice

Strengthen cooperation with contractors

The delivery of a project ultimately hinges on the performance of a contractor—either the EPC company or the EPC management (EPCM) company (EPCM contractors do not construct the project, but rather manage all the suppliers and contractors). Governments can exert influence in a variety of ways to allow—and encourage—these contractors to do their best. These measures include:

- **A well-defined stage-gate process.** This prevents projects from advancing to the next phase before sufficient progress has been achieved, avoiding unforeseen changes and potentially significant rework further down the line. For example, NASA, the US space agency, uses a project definition rating index (PDRI) to predict the performance of projects at stages along the process. The US Army Corps of Engineers declared the use of PDRI mandatory for all 2011 projects. Many private-sector players, particularly those

in the oil and gas industry, use stage-gating processes to better control their project delivery.

- **Active monitoring and management of contractors.** Management methods such as earned value management (EVM) enable owners to assess the status of a project (i.e., earned value) against schedule and budget goals (i.e., planned value). EVM can be very effective for forecasting problems in the performance of a project; it also enables stringent management of change orders (i.e., deviations from the original plan) and helps control cost and time over-runs. The successful adoption of EVM requires frequent interaction on the construction site and at least weekly reviews of physical progress. The Indian state of Jammu and Kashmir, for instance, set up a "project-acceleration cell" to oversee power distribution projects that employed this approach to speed up the mobilization of construction labor by a factor of three to four, and overall delivery by a factor of five to seven.

  While close integration between project owners and contractors is important regardless of the situation, the owner's capability requirements can change significantly depending on the choice of contracting model. For example, managing an EPC contractor typically requires a strong presence on site, which implies that the owner needs to have a sizable project management organization. However, only a small number of project managers from the owner might be required to work with an EPCM. Since EPCM contractors often take on little of the risk of cost escalation by subcontractors, which the project owner typically pays directly, the quality of the owner's small team of project managers is very important. That team must be capable of anticipating and minimizing changes and delays, rather than simply responding after issues arise.

- **Well-defined processes for dispute settlement.** Finally, any disputes between the owner and contractor—whether EPC or EPCM—can be settled efficiently and effectively. Various levels of escalation should be established and worked through before resorting to arbitration, which should be based on well-established international law. Dedicated construction tribunals can handle the arbitration to prevent cases from becoming bogged down in slow court systems. Governments can also issue policy guidelines to help deter frivolous litigation.

Foster construction sector capabilities and productivity

As we have noted, productivity of construction has been flat or has declined over the past 20 years in many advanced economies. However, governments can adopt measures to boost the sector's productivity.

- **Promotion and cultivation of industry best practice.** Dedicated, subsidized demonstration projects can help make the case for using cutting-edge tools and methods. These efforts were a major success in the United Kingdom in the 1990s, for instance, with demonstration projects considerably outperforming the industry average. As a result, the country achieved one of the highest rates of construction productivity growth in Europe between 1995 and 2005—1.7 percent per annum. Standardization of practices could also be encouraged by increased coordination and standardization of public-sector projects across states, regions, and municipalities, through a government-sponsored center of excellence, for instance. The Netherlands has adopted

an amalgam of the two approaches in a program called Vinex that uses pilot projects to facilitate the exchange of knowledge among central and local governments, market partners, designers, and interest groups.

- **Directly incentivize the use of productivity-enhancing tools, materials, and practices.** Singapore's productivity and capability fund, for instance, supports private-sector investment in productivity enhancements such as building information modeling systems that improve collaboration between owners and contractors. A more prescriptive approach could involve contractors being required to provide evidence for the use of cost-effective techniques. To do this without stifling innovation and flexibility would require the thoughtful definition and monitoring of productivity indicators—the use of prefabricated components and labor productivity, for instance.

- **Increasing transparency around the performance of contractors.** The United Kingdom, for example, provides online information on standard contract terms and the performance of contractors.

- **Improving the quality of education in the sector.** This is a slower-acting but powerful approach. Singapore, for instance, gives scholarships for construction-related degrees and continuing education. In the United Kingdom, CITB-ConstructionSkills is dedicated to providing training to construction professionals, with investment including the development of relevant university courses.

- **Attracting international competition.** A fifth approach, pertinent in relatively closed markets, involves making a concerted effort to attract international suppliers of both construction services and building materials. For example, prior to tendering out its rail signaling overhaul program, Banedanmark, which is responsible for maintenance and traffic control on most of Denmark's railway network, opened a dialogue with a number of potential bidders around the world, developing the tender material in a way that encouraged the bidders to bring their best knowledge and people to the deal. As a result, six major international companies set up substantial operations in Denmark to prepare their bids.

- **Enforcement and anti-corruption measures.** Informality (for instance, avoiding taxes, using an undocumented workforce, or corruption that allows some companies to stay competitive at lower productivity levels) lies at the root of the construction sector productivity challenge in many countries, and needs to be managed. We do not address the issue of corruption in detail in this report, so interested readers should refer to the literature on this issue.[55]

Finally, to select and coordinate the most effective mix of measures, countries could consider developing an integrated development strategy for the construction sector. Malaysia, for instance, produced a construction industry master plan in 2005 that has revitalized growth in the sector—the sector's growth contracted before 2005 but grew at annual rate of 4 percent in 2007.

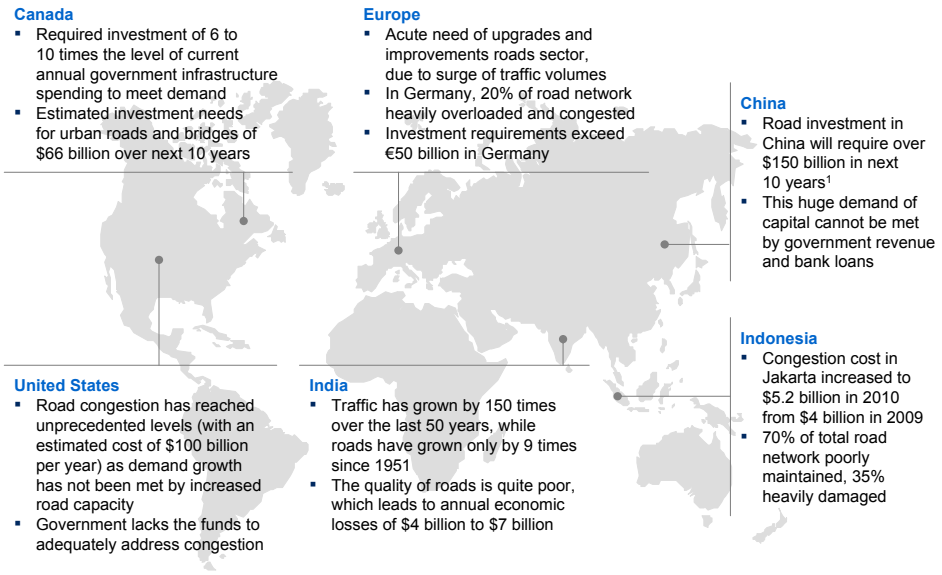
55 See, for instance, C. Kenny, *Construction, corruption, and developing countries*, World Bank Policy Research working paper, June 2007; or *Deterring corruption and improving governance in road construction and maintenance*, World Bank Policy Research working paper, September 2009.

OPPORTUNITY 3: MAKING THE MOST OF EXISTING INFRASTRUCTURE

Getting the most out of existing assets is becoming a critical imperative as many forms of infrastructure hit capacity constraints that cannot be resolved simply by building more. In the United States, demand for roads is 43 percent higher than capacity, and, according to the Department of Transportation, 15 percent of roads are in "unacceptable" condition.[56] Road congestion costs the country an estimated $101 billion a year in time and fuel.[57] Many countries face similar road capacity challenges (Exhibit 23). Increasingly, transport planners recognize that adding or expanding roads quickly induces additional demand, providing only temporary relief from congestion. It is estimated that a 1 percent saving in travel time will generate a 0.5 percent increase in traffic within the first year, rising to a total of 1 percent over the longer term.[58] In the case of power, projected annual demand will double between 2000 and 2030, outstripping the anticipated addition of new generating capacity.[59] In the case of water, the world's needs are set to outstrip accessible, reliable supply by 40 percent, or 2,800 billion cubic meters annually, by 2030.[60] Yet there is no measurement of water use in 40 percent of the world's households.[61] In some instances, adding capacity is simply not possible. For instance, it may not be an option to expand roads in a dense city center or build a new power plant in an ecologically sensitive area.

Exhibit 23

The growing global challenge to meet expected road demand



1 As of 2006.

SOURCE: World Bank; American Society of Civil Engineers; McGill University; Project Finance; A&L Goodbody Consulting; Railpage Australia; Business New Zealand; Government of India; McKinsey Global Institute analysis

56 *2006 status of the nation's highways, bridges, and transit: Conditions and performance*, US Department of Transportation, 2006.

57 David Schrank, Tim Lomax, and Bill Eisele, *2011 urban mobility report*, Texas Transportation Institute, September 2011.

58 Phil B. Goodwin, "Empirical evidence on induced traffic," *Transportation*, volume 23, issue 1, 1996.

59 *Addressing the electricity access gap*, background paper prepared for the World Bank Group Energy Sector Strategy, 2010.

60 *Charting our water future: Economic frameworks to inform decision-making*, 2030 Water Resources Group, 2009.

61 *World water meter report & database, 7th edition*, ABS Energy Research, 2009.

Even when building more is a viable long-term solution, it is typically much more expensive than investment that enables better use of existing assets. Deploying an intelligent transportation system, for instance, is often a much more cost-effective choice than expanding a road. Upgrading water distribution infrastructure to reduce leaks can be one-thirtieth as expensive as adding new production capacity that would deliver the same results.

For these reasons, policy makers need to start thinking of more efficient asset utilization, and optimized maintenance and demand management, as solutions of first, rather than last, resort. They need to initiate the political debate on demand management and engage with stakeholders on the benefits.

Our analysis suggests that making better use of existing assets potentially could reduce the global investment required for infrastructure by 15 percent. There are three main levers that can help achieve this: improved asset utilization; optimized maintenance; and more extensive use of demand-management techniques. We now discuss each of these.

Improved asset utilization

McKinsey & Company's work with asset operators around the world has consistently demonstrated the potential for operational improvements to extract more capacity from existing assets, particularly in transport. More efficient use of rolling stock can boost the capacity of rail freight operations by 10 to 20 percent, for instance. More efficient terminal operations can increase the traffic capacity of seaports by 20 to 30 percent. Advanced air traffic control technology is allowing more take-offs and landings without adding runways at airports such as London's Heathrow. By contrast, air transport in Africa is limited not by the amount or quality of physical infrastructure, but primarily by the way it is operated—air traffic control and ground-to-air communications are inadequate in much of the region (South Africa and Kenya are exceptions). Addis Ababa, for example, has no civilian radar, forcing extra distance and time separation between aircraft. Aircraft commonly fly more than an hour over parts of the continent with no ground contact. Even where the equipment exists, radar procedures (and radar separation) are not always implemented.[62]

Intelligent transportation systems (ITS) for roads, rail, airports, and ports can double or triple asset utilization. ITS include a range of technologies that monitor the flow of vehicles. The United Kingdom, for instance, achieved reductions of 25 percent in journey times, 50 percent in accidents, 10 percent in pollution, and 4 percent in fuel consumption on the M42 motorway by implementing an ITS solution that directs and controls traffic flow. The potential to implement ITS more broadly is huge. In the United States, for instance, the Information Technology and Innovation Foundation recommends increasing annual federal funding for ITS to between $2.5 billion and $3 billion and focusing these funds on implementation. Currently the US government spends $100 million annually on ITS, primarily on research and development.

62 African Development Bank Group, www.infrastructureafrica.org/aicd/sectors/air-transport.

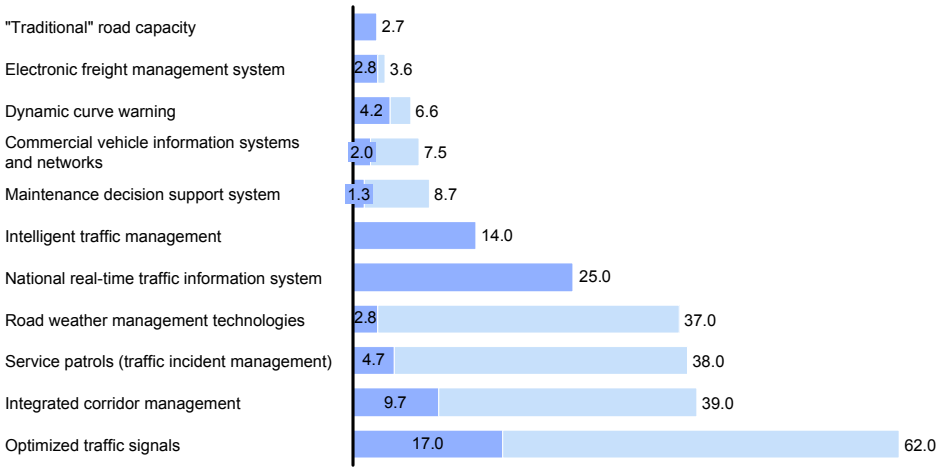
There is a wide range of ITS choices whose costs vary widely, making detailed cost-benefit analysis necessary. In most analyses, we find that ITS offer a superior option to the addition of physical road capacity (Exhibit 24). The United Kingdom's M42 motorway ITS, for instance, cost $150 million and took two years to implement. Widening the road to produce the same outcome would have taken ten years and cost $800 million.

Exhibit 24

Many types of intelligent traffic systems offer a superior benefit-to-cost ratio than the physical expansion of roads

Comparison of returns for different road investments

Average benefit-to-cost ratios



SOURCE: *Intelligent transportation systems*, Capitol Research, Council of State Governments, April 2010; Transport for London, 2007; *Intelligent transportation systems benefits, costs, deployment, and lessons learned desk reference: 2011 update*, US Department of Transportation, September 2011; *Urban mobility plan*, Seattle Department of Transportation, January 2008; McKinsey Global Institute analysis

While the greatest potential for improved asset utilization lies in transport, it can also help in other types of infrastructure. Smart grids, for instance, could help the United States avoid $2 billion to $6 billion a year in power infrastructure costs and also help reduce the likelihood of outages that cost the economy tens of billions of dollars per event.[63] Italy's ENEL Telegestore Project made a €2.1 billion investment in smart grids that produced savings of €500 million a year and improved service at the same time.[64] The Indian government has relied on renovation and modernization of existing power plants to deliver more electricity—at a lower cost than by building new plants (see Box 8, "Getting more out of Indian power plants").

63 National Energy Technology Laboratory, *Modern grid benefits*, US Department of Energy Office of Electricity Delivery and Energy Reliability, August 2007.

64 Ibid.

Box 8. Getting more out of Indian power plants

For decades, power demand in India has grown faster than supply, leaving the nation with negative reserve margins. To try to narrow the gap, the government has drawn up consecutive five-year National Action Plans for Renovation and Modernization (R&M). The focus of these plans is mainly on older, inefficient units, particularly coal-fired power stations that have deteriorated over time.

The decision to renovate and modernize an existing plant rather than building a new-generation unit is based on a standard process involving detailed cost-benefit analysis. First, potential target plants are evaluated in terms of remaining life, using a residual life assessment study. Plants whose economic life could be extended by 15 to 20 years are candidates for upgrades, but the costs of R&M cannot exceed 50 percent of building a new plant with comparable capacity. Finally, an investment decision is made based on a detailed cost-benefit analysis involving technical and economic considerations as well as sensitivity analysis.

Another major opportunity for stretching the capacity of power and water systems lies in reducing transmission and distribution losses. In some countries, these losses can be as high as 40 to 70 percent of the water supply (Exhibits 25 and 26). Some of these losses arise from "non-revenue" water—unmetered supplies that are a tacit subsidy for low-income communities. One study has shown that these "non-technical losses" are higher in election years, which suggests that they might not be reduced without raising political challenges.[65] However, governments and utilities have had some good results by making the reduction of these losses part of a comprehensive reform program that includes increasing access. In Cambodia, Phnom Penh's Water Supply Authority increased its number of connections sevenfold while reducing non-revenue water from 72 percent to less than 6 percent. Focusing on reducing losses can be extremely valuable: our analysis suggests that mitigating technical losses in water can cost less than 3 percent of what it would cost to build new capacity and can be accomplished significantly more quickly. In Latin America and India, similar programs in electric power have produced savings of 7 to 38 percent.[66] A World Bank analysis has previously suggested that $1 million spent to reduce line losses in Africa could have produced the equivalent of $12 million in power-generation capacity.[67]

65 Miriam Golden and Brian Min, *Theft and loss of electricity in an Indian state*, working paper number 12/0060, International Growth Centre, London School of Economics and Political Science, February 2012.

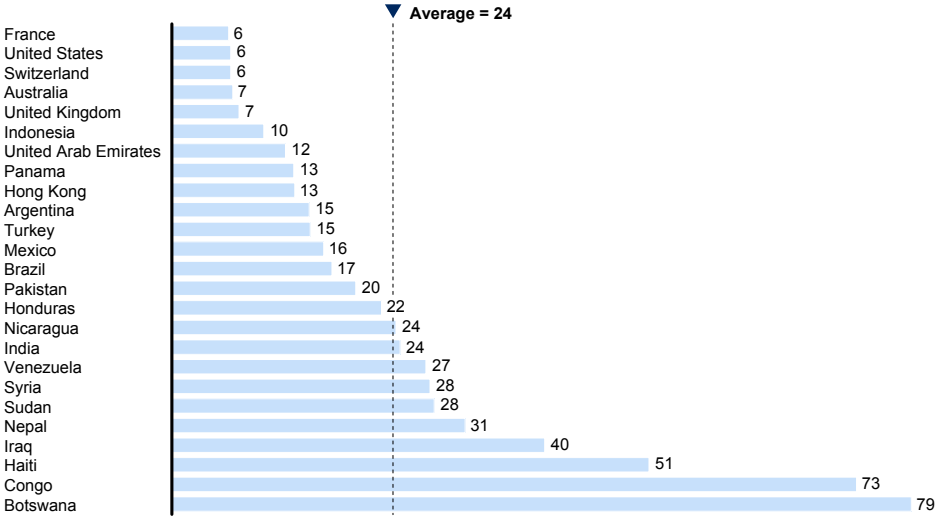
66 *Reducing technical and non-technical losses in the power sector*, background paper for the World Bank Group Energy Sector Strategy, July 2009.

67 *World development report 1994: Infrastructure for development*, World Bank, June 1994.

Exhibit 25

Non-revenue power is common and can account for more than 50 percent of consumption in some developing economies

Non-revenue power (unmetered or stolen usage) (%)

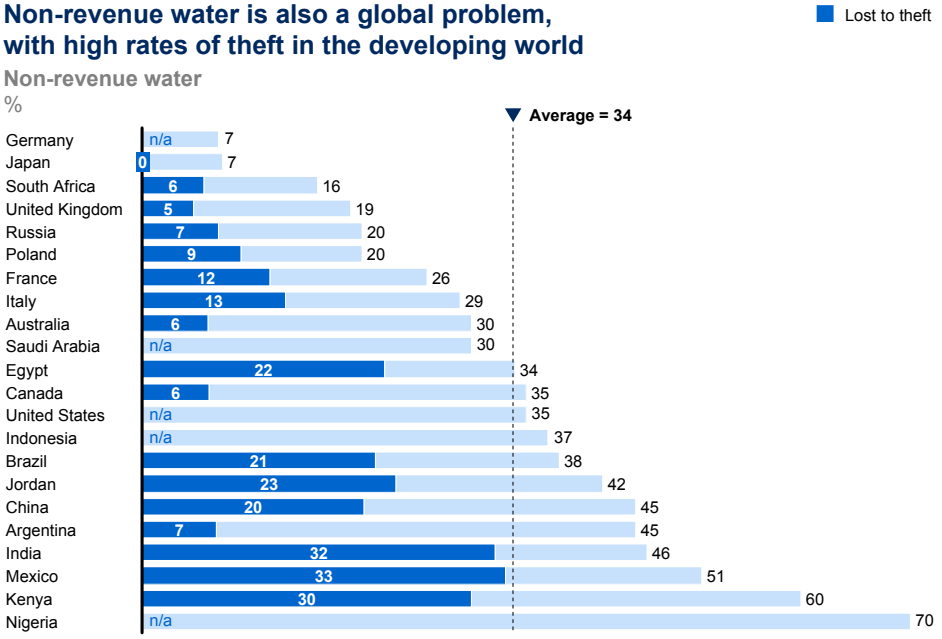


SOURCE: World Bank Development Indicators 2009; *Resource revolution: Meeting the world's energy, materials, food and water needs*, McKinsey Global Institute and McKinsey Sustainability & Resource Productivity Practice, November 2011; McKinsey Global Institute analysis

Exhibit 26

Non-revenue water is also a global problem, with high rates of theft in the developing world

Non-revenue water
%



SOURCE: National statistic yearbook market report 2010; GW) 2010 dataset; World Bank Development Indicators 2010; McKinsey Global Institute analysis

Optimized maintenance

Optimizing maintenance serves two purposes. Less frequent or extensive maintenance-related service interruptions can, in effect, raise capacity. Fewer interruptions of rail traffic, for instance, can increase average speeds and reduce safety buffers between trains. This effect is achieved through both better scheduling of maintenance operations and reducing the number of incidents that result from use of infrastructure that is in need of repair. There is also significant potential to achieve savings from optimizing operational as well as capitalized maintenance spending. Across the world, we see under-investment in maintenance or "maintenance deficits" that is likely to lead to deteriorating stock and translate into higher long-term costs. In Africa, for instance, it is estimated that road maintenance expenditure of $12 billion in the 1990s could have saved $45 billion in reconstruction costs.[68] To avoid such losses and capture savings from improved maintenance operations, infrastructure authorities could do four things:

- **Regularly assess and catalog the condition of infrastructure.** Using these data, operators can model the rate of deterioration and assess the costs of asset conditions. The Public Sector Accounting Board in Canada, for instance, requires municipalities and utilities to report all tangible capital assets in their financial statements, including valuation and amortization, and to develop plans for replacement and renewal that overcome infrastructure funding deficits. The City of London uses a pavement deterioration model to develop a 15- to 20-year investment program for roads.

- **Use a total cost of ownership (TCO) approach to allocating maintenance budgets.** A TCO approach between major asset renewals and day-to-day maintenance will minimize costs over the course of the asset life. Denmark, for instance, reduced its road maintenance costs by 10 to 20 percent using a TCO approach (see Box 9, "A TCO approach in Scandinavian road and rail helped determine the optimal funding for maintenance"). Brisbane in Australia uses life-cycle costing and scenario analysis of the condition of pavements to develop four-year funding programs for the operation, maintenance, and rehabilitation of road infrastructure.

- **Tailor maintenance strategies and policies to individual asset objectives and needs.** A major European rail operator, for instance, managed to improve returns on maintenance spend by up to 40 percent by moving from one standard maintenance policy applied across all its assets to adjusting maintenance plans based on the state and performance levels of each of those assets. Similarly, to support such prioritization, one central European road authority has established distinct standards for the maintenance activities and quality levels of the different assets that it oversees.

68 *World development report 1994: Infrastructure for development*, World Bank, June 1994.

- **Dedicate some proportion of funds for maintenance.** South Africa, where 80 percent of roads have passed their expected 20-year life spans, plans to create a dedicated Road Infrastructure Maintenance Fund to deal with local and provincial maintenance backlogs. Canada has set aside $3 billion in fuel tax revenue to enable fund infrastructure maintenance and upgrades in municipalities. Dedicated funding paired with "fix-it-now" policies can ensure that spending for preventive maintenance and repair is properly prioritized. Governments could set maintenance level targets and enforce execution, while ensuring sufficient funding is available. The US state of New Jersey issued a "fix-it-first" mandate in 2000, setting a five-year target to reduce the amount of deteriorated infrastructure by half.

Box 9. A TCO approach in Scandinavian road and rail helped determine the optimal funding for maintenance

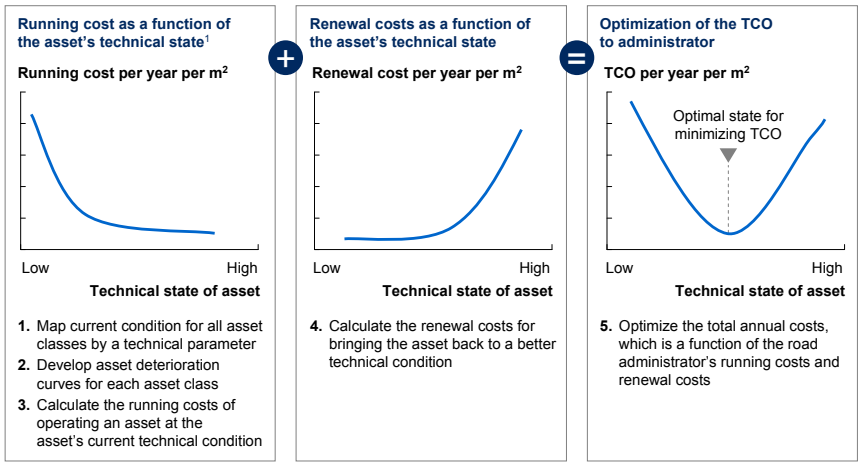
An effective trade-off between day-to-day preventive maintenance and less-frequent capital renewals can reduce the long-term cost of maintaining an infrastructure asset. TCO analysis of the relationship between the technical state of the asset and the cost of maintenance can identify the "optimal" asset state that minimizes long-term costs (Exhibit 27).

A TCO approach helped Denmark reduce the cost of maintaining its roads by between 10 and 20 percent. This approach also increased transparency on the state of the country's stock of roads and provided an objective means to determine optimal maintenance funding. This meant that the authorities were able to increase their budget allocation to road maintenance and operations with the aim of reducing the maintenance backlog by 70 percent within five years. In a similar fashion, Sweden used a TCO approach to reduce its rail maintenance backlog and cut delays by an expected 15 to 20 percent.

Exhibit 27

Optimizing maintenance strategies requires the use of rigorous TCO analysis of infrastructure assets

Road agencies could reduce maintenance cost by 10 to 20 percent



1 For example, noise, speed limitations, and environmental costs as a function of the technical condition of the asset.
SOURCE: McKinsey Operations Practice; McKinsey Global Institute analysis

To help enable implementation of the four measures that we have described, governments should foster awareness on the important topic of maintenance and, more broadly, asset management. Sweden's National Road and Transport Research Institute, for instance, has established infrastructure maintenance as one of its key research areas. In many developed countries, asset owners and operators are being incentivized to introduce more sophisticated asset-management systems and procedures. In Canada, for instance, the city of Hamilton, Ontario, is monitoring service levels, life-cycle trends and deterioration models to plan and develop an integrated three- to five-year budget, 20-year capital budget, and 100-year financial forecast of infrastructure investment. In Australia, a study of 15 wastewater agencies from 1990 to 2001 found that implementing more sophisticated asset-management processes and practices resulted in asset life-cycle cost savings of 15 to 40 percent.

To ensure improved alignment among stakeholders as well as the more effective allocation of spending, governments are focusing increasingly on creating public awareness and involving the public in making asset maintenance-related decisions. For example, prior to distribution of national funds, New Zealand mandates involvement by citizens and businesses in choosing levels of affordable service. Asset inventory, condition, and defined risks associated with various funding levels inform the discussion.

While optimizing maintenance has a significant financial payoff for the infrastructure owner, it can also bring much broader benefits. In the starkest cases, it can avert loss of life (from collapsing bridges and washed-out roads, for instance). It can also mean avoiding massive economic losses. Nepal loses more than 4 percent of industrial output (nearly 0.5 percent of GDP) every year due to unreliable power.[69] Power outages in Bangladesh have been found to reduce GDP growth by 0.5 percentage points. In both cases, operational inefficiencies—many linked to maintenance—have been cited as the leading cause of the problem.

More extensive use of demand-management measures

Because demand-management measures often entail restricting access or imposing user fees, there can be political and public challenges to their broader adoption. A proposal for London-style congestion pricing in New York City failed after it met with strong opposition and deep public skepticism that the city would make good on its promise to invest the new revenue in the public transit system. In countries with large water or power subsidies, including India, any discussion of reducing them tends to be greeted with intense political and public opposition. The effective engagement of stakeholders therefore often spells the difference between successful and unsuccessful implementation—and can be equally critical for infrastructure planning, delivery, and operation more broadly (see section on trust-based stakeholder engagement in Chapter 3). Another key to public acceptance is tying the introduction of demand-management measures directly to new facilities or service improvements. It is considerably more difficult to introduce user fees on an existing facility that commuters feel they have already paid for through their taxes, or when the facility is in bad condition or is poorly managed.

69 Nexant SARI/Energy, *Economic impact of poor power quality on industry: Nepal*, prepared for United States Agency for International Development (USAID), October 2003.

Despite these challenges, advances in technology are broadening the range and improving the effectiveness of demand-management tools. These advancements, together with growing recognition that simply adding infrastructure will never adequately address needs, suggests that demand-management solutions will find more consistent use around the world.

To fully capture the potential of demand management, governments will need to take a comprehensive approach and use all available tools. The city of Seoul, for example, is dealing with congestion by combining improved bus operations, access restrictions, and electronic fare collection with an integrated traffic-management system. Congestion pricing, widely regarded as the most effective measure for reducing congestion and decreasing the need for capacity additions, especially in advanced economies, can be paired with ITS solutions for even greater benefits. Australia approached water shortages with a multidimensional program combining regulation, pricing, and trading. California promoted energy efficiency through a combination of education programs and pricing schemes that penalized overconsumption and discouraged consumption during peak demand periods. The result was a reduction in the state's per capita energy use to 40 percent of the US average (see Box 10, "California employs a range of demand-management measures to lower electricity consumption").[70]

A comprehensive view of demand management can also help planners avoid an all-or-nothing approach and adopt more incremental strategies, which can help overcome public acceptance or feasibility challenges. Rather than going immediately to congestion pricing, for example, a city could implement smaller-scale solutions such as smart parking meters that dynamically adjust parking prices based on demand, or real-time traffic information that allows drivers to make better choices about when to take to the road.

70 Adrienne Kandel, Margaret Sheridan, and Patrick McAuliffe, *A comparison of per capita electricity consumption in the United States and California*, California Energy Commission paper presented at the 2008 ACEEE summer study on energy efficiency in buildings, Pacific Grove, California, August 17–22, 2009.

Box 10. California employs a range of demand-management measures to lower electricity consumption

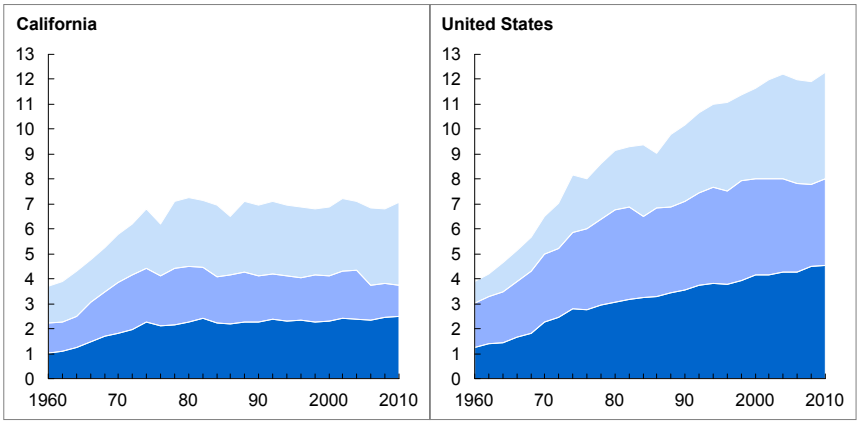
After the 1974 oil shock, Californian policy makers started using demand management to reduce electricity consumption. The state introduced energy-efficiency standards for electrical appliances, set up community awareness programs to educate Californians about their energy consumption and promote energy efficiency, and adjusted regulated electricity prices to encourage greater efficiency. More recently, California adopted peak pricing as an additional measure to reduce consumption. As a result, total per capita electricity consumption has grown by only 9 percent since 1973, compared with a 52 percent increase in total US consumption. By 2006, California's per capita consumption was the lowest in the nation, and 43 percent lower than the US average (Exhibit 28).

Exhibit 28

With aggressive demand management, California cut electricity use to far below the US average

Per capita electricity consumption

Thousand kilowatt hours per person



SOURCE: Adrienne Kandel, Margaret Sheridan, and Patrick McAuliffe, *A comparison of per capita electricity consumption in the United States and California*, California Energy Commission paper presented at the 2008 ACEEE summer study on energy efficiency in buildings, Pacific Grove, California, August 17–22, 2008; McKinsey Global Institute analysis

Across infrastructure types, we find that there are three critical enablers of the effective deployment of demand-management measures:

- **Public education and consultation.** Focused marketing by Vienna resulted in a 35 percent increase in public transit use by the target audience in the Austrian capital in just six months. The rollout of congestion pricing in London was preceded by an extensive, 18-month public consultation that included publication of key documents throughout the development process. Stockholm used a similar approach to smooth the transition to congestion pricing (see Box 11, "Stockholm's focus on education, enforcement, and equity has made congestion pricing a success").

Box 11. Stockholm's focus on education, enforcement, and equity has made congestion charging a success

In 2006, policy makers in Stockholm gambled on a full-scale congestion pricing trial aimed at reducing traffic in Sweden's capital, increasing accessibility to the city, and improving the environment. Vehicles entering the city center paid a variable fee of $1.50 to $3.00 during the weekday rush hour. To educate the public about the benefits, Stockholm introduced the scheme as a trial, and then briefly revoked the program to demonstrate to citizens how traffic volumes would increase again in its absence. After that, Stockholm citizens voted to make the system permanent. To enforce the rules, the city set up 18 control points with laser detectors and optical character recognition technology that immediately identified vehicle registrations; this achieved a 96 percent compliance rate. To ensure access and equity, the city has reinvested a significant portion of the revenue raised in public transport.

The scheme has been highly successful. Congestion both inside and outside the cordon fell by 20 to 25 percent during the trial period, air quality improved within a year, and the city recouped its initial investment in less than four years. The overall net present value of the scheme is an estimated $1.2 billion with a benefit-to-cost ratio of 4:1.

- **Effective enforcement.** In London, the fact that cameras capture images of commuters entering the city and can read license plates with more than 90 percent accuracy has ensured the effectiveness of congestion pricing.[71] In Phnom Penh, transmission and distribution losses in water have dropped 92 percent due to automated billing and the enforcement of fines for illegal connections.[72]

- **Address concerns about access and equity.** These concerns often form the basis of opposition to the introduction of demand-management measures and can be mitigated by providing alternatives for those who are "priced out." In Oslo, for instance, more than 20 percent of revenue from congestion charges go directly to expanding public transport.[73] In India, the Karnataka government cut illegal diversion of water by providing rainwater harvesting systems at 24,000 schools, for instance, making them self-sufficient in water.[74] It is worth noting that the poor often pay higher prices for infrastructure services than the rich—to water vendors that charge more than utilities providing piped water, for instance, or in the form of battery power to use electrical appliances. The willingness of government to price these services is often critical to attracting investment and expanding access. According to Michael Klein, formerly of the World Bank, "access to water or power may cover several extra tens of percent of the population, if effective pricing schemes are implemented."

71 Transport for London (www.roadtraffic-technology.com/projects/congestion/).

72 Maria Christina Dueñas, *Ek Sonn Chan: Pulling the plug on nonrevenue water*, Knowledge Management Office, Asian Development Bank, 2006.

73 Astrid Fortun and Erik Furuseth, *Road tolling in Norway—a brief introduction*, Norwegian Public Roads Administration, January 2007.

74 "World's largest rainwater harvesting project in Karnataka," *Current Science*, volume 92, number 2, January 25, 2007.

> However, because the poor often buy so little, "it may not be economic to build out an infrastructure system." In these cases, Klein suggests the answer may lie in price discrimination (which serves as a cross-subsidy, with the rich paying for a portion of service delivery to the poor), provision of different service-quality mixes (where the poor get lower service quality, at lower cost), or effectively targeted subsidies.[75]

Where governments have limited control over the implementation of demand management (i.e., when infrastructure is privately owned), they need to set incentives to encourage private investment in demand-management measures. Australia has created a policy and regulatory framework for its power sector that allows demand-management proposals to compete with traditional power-generation options. The Australian state of New South Wales, for instance, uses an "O-factor" incentive scheme to permit rate increases to recover the cost of demand-management measures (for example, smart grids) that defer the need for additional generating capacity. The "virtual power plant" concept proposed for the US states of North Carolina and South Carolina is similar, rewarding utilities for the savings achieved via energy-efficiency measures. Shared savings programs allow supply-side cost savings to be split between the utilities and consumers. Bonus return-on-equity agreements, such as the one implemented in the US state of Nevada, increase the authorized rate of return on capital related to energy efficiency in a utility's rate base, creating an incentive for these types of investment.

□ □ □

Governments, the private sector, and other stakeholders can take myriad practical steps to transform the productivity of how they handle infrastructure. The measures and approaches that we have discussed are not radical innovations. The task at hand is to take the many examples of best practice found throughout the world and to replicate them on a global scale. Doing so would transform the infrastructure challenge. The reason why these measures have not been more widely adopted lies in the lack of adequate infrastructure systems. How to put this right is the subject of Chapter 3.

75 Ibid. Michael Klein, *Infrastructure policy: Basic design options*, World Bank policy research working paper number 6274, November 2012.

3. Overhauling the infrastructure system

The effective delivery of services in many areas of economic and public life happens within a framework of well-defined systems. When health care, national security, or finance systems function well, they boast effective coordination between the critical actors such as health-care providers and insurance companies ("payors"); a clear division of labor between policy and execution, as in civilian oversight of the military; and clarity on the roles of the public and private sectors—in financial services, between central banks and private financial institutions, for instance. When such systems lack these characteristics, they become dysfunctional and unproductive.

In the case of infrastructure, the system often functions poorly. Indeed, too few people in the public and private sectors regard infrastructure as a system at all but rather think in terms of single projects. We believe that this is at the root of the sector's weak productivity. Upgrading the infrastructure system is all the more vital given the special characteristics of the sector (see Box 12, "Infrastructure's unique characteristics demand special attention from policy makers").

Until sound infrastructure systems are in place, countries will continue to fund the wrong projects, place priorities in the wrong areas, and fail to meet the needs of their people. In this chapter we describe how effective governance structures and processes can foster the systematic approach that will allow governments to identify and meet their infrastructure needs and implement the productivity measures that will enable them to do so at the lowest possible cost.

Box 12. Infrastructure's unique characteristics demand special attention from policy makers

Infrastructure has several characteristics that suggest the need for closer, more strategic policy attention than many other areas of the economy.

First, investment in infrastructure tend to be "lumpy" (i.e., projects are large and spaced apart) and the life of infrastructure assets can often exceed 40 years. The fact that investors realize returns over long periods makes infrastructure more difficult to finance than other assets; only a relatively small subset of investors is content to accept such investment horizons. And, while infrastructure investment is long term in nature, public officials have to also focus on election cycles. This encourages high-visibility new construction projects over more sustainable, longer-term solutions that seek to balance supply and demand and reduce maintenance and renewal costs over an asset's complete life. It also makes it difficult to build up, over time, the capabilities required to oversee such large investments.

Second, infrastructure assets form interconnected networks with powerful cross-cutting effects—an unreliable power grid, for instance, can severely hamper a transport network. These assets therefore need to be thought of, and managed, as large, partially integrated systems. But today responsibilities for infrastructure tend to be scattered across local, regional, and national jurisdictions and across a range of infrastructure authorities that administer different asset classes.

Third, many infrastructure assets are natural monopolies and have significant positive and negative externalities. A positive externality could be the fact that good airport infrastructure encourages more foreign direct investment or that upgraded telecommunications networks boost online business. A negative externality includes greater congestion and pollution following road expansions. Managing these characteristics requires a complex interface between the public and the private sectors, comprising thoughtful regulation and, in the case of beneficial but financially non-viable projects, government support. When the regulatory bodies are not up to the task, substantial friction can result.

Recognizing these unique characteristics is an essential prerequisite for policy makers to develop an end-to-end (from planning through delivery and operations), long-term, network perspective across multiple asset classes.

Effective infrastructure governance systems share six traits

We find that effective infrastructure governance systems share six traits:

- Close coordination between infrastructure institutions
- Clear separation of political and technical responsibilities
- Effective engagement between the public and private sectors
- Trust-based stakeholder engagement
- Robust information upon which to base decision making
- Strong capabilities across the infrastructure value chain

We now discuss each in turn.

CLOSE COORDINATION BETWEEN INFRASTRUCTURE INSTITUTIONS

Effective infrastructure governance aligns the incentives of the various authorities or agencies covering different infrastructure assets: roads, rail, ports, power, and water. All these organizations should share a common understanding of the socioeconomic goals that the government and citizens have for infrastructure. These goals should guide their actions and should be enforced with formal mechanisms, including those that ensure that these organizations interact effectively.

Infrastructure governance (like infrastructure productivity) has not advanced in many places. Among the few exceptions are Singapore's Urban Redevelopment Authority, Land Transport Authority, and Development Planning Committee that work together seamlessly to translate national priorities into plans, goals, and individual projects that are entirely consistent with one another. Another exceptional case is Switzerland's Department of the Environment, Transport, Energy and Communications, a single agency that incorporates national goals established by the Federal Council into an infrastructure strategy that unifies sector-specific approaches such as the country's air travel policy, information society strategy, spatial development plan, transport plan, and energy strategy.

Some developing economies, which are not as encumbered by legacy systems, boast well-coordinated infrastructure governance. Rwanda's Ministry of Infrastructure, for example, coordinates the activities of other ministries and public agencies, ensuring that infrastructure strategies are in line with the East African Community's regional integration plans, as well as monitoring downstream delivery and operations.

CLEAR SEPARATION OF POLITICAL AND TECHNICAL RESPONSIBILITIES

Well-functioning infrastructure governance systems ensure that there is clear separation of technical and political responsibilities—the balance between politicians and technocrats needs to be right. Policy makers should set overall aspirations and the strategic direction—making the call between investment

in roads rather than hospitals, or vice versa; or choosing to emphasize urban transport over rural connectivity; or focusing on the development of certain industries or regions. Experts need to determine how best to meet those overarching goals, and evaluate, as well as execute, the projects. Leaving delivery to independent institutions tends to be much more successful.

This separation can take different forms. Hong Kong's Mass Transit Railway Corporation and Infrastructure Ontario in Canada both have organizational autonomy, while Singapore's Land Transport Authority relies on a very clear delineation of roles.

It is important to note that while technical responsibilities such as planning, engineering, and delivery require independence, overall decision making must remain accountable to the public and to political leadership. The independent UK Infrastructure Planning Commission was closed in 2010 in the wake of criticism that it was unresponsive to public concerns. The UK government's infrastructure plans now are put before Parliament for ratification.

EFFECTIVE ENGAGEMENT BETWEEN THE PUBLIC AND PRIVATE SECTORS

With the mix of public and private ownership in infrastructure, players must have clear roles and expectations (for a framework for how policy makers can think about the roles of the public and private sectors, see Box 13, "First decide the market structure; the rest follows").

Often, governments think about the private sector as a supplier that provides financing, and plans, executes, and manages assets. PPP is effectively a form of procurement and is treated like one. Real cooperation between the public and the private sectors would be more effective for both sides. This means finding ways to get the private sector involved along more of the infrastructure value chain including in identifying projects and planning portfolios. For example, Chile, the Philippines, South Africa, South Korea, and Taiwan are developing frameworks that facilitate a greater role for private players in project and portfolio planning. The frameworks accommodate the growing number of unsolicited proposals these nations are receiving from private contractors and typically include bonus opportunities or special procurement processes that reward the proposer for laying the groundwork—examples include "Swiss challenge" and "best-and-final offer" systems.[76] Creating a mechanism for the private sector to make proposals outside the customary bidding process has the potential to increase the quantity and quality of projects under consideration and foster greater interest, innovation, and competition among potential contractors.

76 In the Swiss challenge system, the original proponent is granted the right to counter-match the best offer and secure the contract. The best-and-final offer system is similar to the Swiss challenge in approach, but merely grants the original proponent the advantage of automatically competing in the final tendering round. See John T. Hodges and Georgina Dellacha, *Unsolicited infrastructure proposals: How some countries introduce competition and transparency*, Public-Private Infrastructure Advisory Facility working paper number 1, 2007.

Box 13. First decide the market structure; the rest follows

Michael Klein, former vice president of financial and private-sector development of the World Bank Group, formulated guidelines for thinking about markets structure, pricing, and ownership issues from which we highlight and adapt the ones we consider most relevant in this context.[1]

Market structure. Policy makers need to consider the competition and pricing models they want in their markets. In some infrastructure classes, such as mobile phone networks, there is free competition and the market is responsible for setting prices. However, assets with monopoly characteristics such as electric power or water utilities may require price regulation and highly competent regulatory bodies. Unregulated monopolies also can provide social benefits. For example, allowing regional providers to build non-utility-grade electricity or water networks may improve access in cases where alternatives—generators or a long walk to a well—are even less attractive than monopoly prices.

Pricing and subsidies. If market competition is not feasible, prices must be set at a rate that covers the cost of infrastructure. Certain subsidies may be justified (see below) but only if prices plus sustained subsidies cover the cost of building, operating, and expanding the infrastructure asset. Pricing rules can focus on the efficiency of investment and operations by creating a pricing cap, as is the case in the United Kingdom, or show commitment to sustaining the business and continued investment while limiting the maximum rate of return, as is common in the United States. The legal and contractual framework that governs pricing can be based on law, a regulatory statute, a license, or a contract. The choice signals different levels of commitment to the pricing rules and gives operators planning stability and certainty on the viability of their investments. The organizational structure and procedural arrangements that administer regulations and contracts should provide the regulatory body with protection from undue political influence, flexibility to adapt the rules to changing situations, and clear means to deal with under-performing firms. Where subsidies are necessary, it is important to calibrate them so that they expand access to infrastructure rather than support those who already have access to a service and are able to pay for it. Subsidies can be funded via either price discrimination (that is, richer, heavier users of infrastructure are charged more, while poorer, lighter users are charged less) or general tax revenue. When subsidies are implemented effectively, they can have a powerful effect on expanding access. Chile, for instance, increased the number of rural electricity users from half the population in 1994 to more than 92 percent by the end of 2006 by liberalizing the power market and providing targeted subsidies to firms willing to invest in rural areas.

Ownership and finance. Once market structure and pricing frameworks have been established, policy makers need to consider whether they want private firms, state-owned firms, or a public-private partnership. In competitive markets, private companies generally deliver innovation and efficiency. In regulated monopolies, there is limited evidence that private players outperform public ones systematically. If it is certain that costs are covered and ownership has been determined, the choice of financing comes down to technical considerations related to the capacity to raise debt, risk profiles, and the related cost of capital (for more detail, see the section on finance in Chapter 1).

1 Michael Klein, *Infrastructure policy: Basic design options*, World Bank policy research working paper number 6274, November 2012.

TRUST-BASED STAKEHOLDER ENGAGEMENT

Even if each idea in the previous chapter were followed to the letter, the planning, delivery, and operation of infrastructure could still fail if stakeholders are not engaged effectively. For example, Brazil plans to construct the world's third-largest dam on the Xingu River in the Amazon to increase the nation's energy independence, but 15 lawsuits have been filed against the proposal since 2004 (the courts have not yet made a final ruling on the issue). In another instance, the government in Rockland County, New York, responded to a petition signed by 24,000 residents opposed to a proposed desalination plant on the Hudson River by extending the period for public consultation and adding many public hearings to the original plan. These examples demonstrate that without support from all stakeholders there can be long delays in executing a project. But what constitutes effective good stakeholder engagement? Drawing from best practice around the world, we find that there are five elements:

- **Transparency.** Trust is the key to managing stakeholders, and a critical element of this is transparency. Citizens should be able easily to obtain information on a proposed project and its effects. In Sweden, for example, private nuclear-waste management companies provided residents with tours to nearby nuclear storage research sites, resulting in residents agreeing to geological testing for nuclear-waste sites.

- **Education.** Another aspect of transparency is for governments, designers, and builders to hold forums that educate citizens on proposed projects, which is often the key to winning public acceptance of a project. In La Plata, Argentina, for instance, the city authorities selected 62 people at random to participate in a forum to discuss traffic issues in the city. As a result of that forum, opposition to bike lanes dropped by more than 20 percentage points from 71 percent to 50 percent, and opposition to bus lanes fell even more sharply, from 74 percent to 45 percent.

- **Participation.** It is important to ensure that stakeholders are able to participate in the process in a meaningful way. In the United States, for instance, Texas held forums that brought together residents, regulators, and utilities that paved the wave to the construction of more than 1,000 megawatts of renewable energy capacity. This was the first time regulators and utilities were confident that residents both wanted this capacity and were willing to pay for it. In some cases, participation goes beyond allowing residents to have some influence over outcomes to actually determining the outcomes. In Switzerland, for example, voters determine most major infrastructure-related decisions, including car parking fees, public transport funding, and even increases in the number of bicycle lanes. The public feels responsible for outcomes and therefore make more informed decisions.

- **Compensation**. Communities directly affected by infrastructure projects can receive immediate, tangible benefits to offset the costs that they bear. When the Walt Disney Company decided to build a new theme park in the US state of Florida, it created an area of wetlands equal to the area displaced by the new park. Returning to the Swedish nuclear-waste example we cited, another key to the acceptance of citizens was that they received various forms of compensation from the waste-storage companies involved in return for permission to locate the storage sites near the communities.

ROBUST INFORMATION UPON WHICH TO BASE DECISION MAKING

All systems need high-quality, timely information to enable the effective planning and delivery of services or products and efficient operations and public scrutiny—and infrastructure systems are no exception. Indeed, there is a particular need for improved financial data on infrastructure, given that this information is hampered by short-term cash accounting, rather than balance-sheet accounting, standards. Developing a balance-sheet perspective that focuses on the financial metrics that really matter—assets, equity, and liabilities for maintenance backlogs, for instance, and operational metrics focused on delivery and operations—could enable a much more effective policy dialogue (for one potentially useful approach, see Box 14, "National infrastructure 'balance sheets' can help overcome the data challenge").[77]

Box 14. National infrastructure "balance sheets" can help overcome the data challenge

Only limited types of infrastructure data are generally available, and these usually pertain to physical stock or a particular asset class. Country-level data are rare; in most nations, it is difficult to find even an accounting of annual infrastructure spending. We found robust spending data for fewer than half of the 84 countries we looked at across asset classes; less than 10 percent of low-income countries had good-quality spending data.

Two related measures can help. The first is to develop national infrastructure balance sheets that contain both recent snapshot and trend data on infrastructure spending by asset class for new investment, maintenance, and operational expenditure. Dashboard data should also include revenue by source—i.e., federal, state, and private, as well as capital stock and maintenance backlog data. The second is moving ahead on the Global Infrastructure Benchmarking Initiative proposed by the MDB (Multilateral Development Bank) Working Group on Infrastructure. This initiative includes ideas about how countries can establish objective baselines for the performance of infrastructure and regular reporting of data on global infrastructure.[1]

1 Members of the MDB (Multilateral Development Bank) Working Group on Infrastructure are the African Development Bank, Asian Development Bank, EIB, Inter-American Development Bank, Islamic Development Bank, and the World Bank Group.

77 *Infrastructure to 2030: Telecom, land transport, water and electricity*, OECD, June 2006.

STRONG CAPABILITIES ACROSS THE INFRASTRUCTURE VALUE CHAIN

The effective planning, delivery, and operation of infrastructure requires people with the right skills and capabilities at each step in the value chain: urban planners to conduct feasibility assessments and manage stakeholder involvement; financial and technical analysts to create cost-benefit analyses; engineers to scope and design projects; project managers to oversee EPC or EPCM firms; lawyers to manage contracting; and bankers to advise on financing. Over the course of our research, we found concerns about capabilities and capacity everywhere we looked. As long as governments under-invest in these capabilities, the outcome in a competitive market for talent is predictable—poor oversight of projects and assets that commonly cost billions of dollars.

The specific number of staff required by infrastructure authorities varies greatly depending on organizational models and the size and scope of projects. Organizations should be designed based on circumstances, existing capabilities, and specific needs. For example, a $5 billion project could require 20 full-time employees if the owner organization manages only finance and oversight. If that organization also oversees design, engineering, quality assurance, finance, and all aspects except the construction itself, the number of full-time staff may need to expand to 400.

South Korea's PIMAC, Canada's Infrastructure Ontario, and Singapore's LTA are all capable infrastructure organizations that can provide a model for others to emulate. In some cases, governments or agencies can develop the necessary capabilities internally. For instance, Singapore's civil service recruits top talent through educational sponsorships and by offering attractive salaries. In other instances, governments can access skills from organizations offering technical assistance such as multilateral or bilateral development agencies. Necessary skills can also be "bought" or "borrowed" as necessary. Governments can bring in third-party contractors and consultants or can outsource functions entirely. In either case, it makes sense to incorporate these costs into the total project budget rather than the overall budget of the organization. Resources can also be borrowed from sponsoring agencies or even project funders. For instance, the EIB's Joint Assistance to Support Projects in European Regions program deploys technical, economic, and financial capabilities to EIB-financed projects through the concept, feasibility analysis, design, documentation, application, and legal compliance phases. Whenever an agency engages outside resources, it should take the opportunity to use these resources for capability building and knowledge transfer by integrating these experts with local teams where possible.

Developing new skills and capabilities takes time and requires substantial investment. When governments are resource- or capability-constrained, or need to proceed with high-priority projects before they can put in place a systematic program to improve skills and capabilities, governments may want to assemble dedicated delivery units. These are tightly focused, cross-functional teams that help carry out near-term priorities and implement specific measures. They also can serve as a model and help establish a performance culture within government organizations (see Box 15, "Delivery units can help resource-constrained countries drive infrastructure priorities").

Box 15. Delivery units can help resource-constrained countries drive infrastructure priorities

A delivery unit is typically a small body of highly skilled and talented professionals reporting to the highest executive authority in the infrastructure agency. The unit needs to have experienced and influential leadership and a narrow focus on a few (three to six) key priorities. The unit is not responsible for implementation or decision making, but serves as a facilitation agent, removing bottlenecks and obstacles, providing analytical and technical assistance, promoting smooth coordination among departments, and increasing internal and external transparency.

Successful delivery units have an unrelenting focus on performance, pursuing a handful of important targets; their progress is constantly monitored and reported both internally and externally. Malaysia's Performance Management Delivery Unit, for example, has overseen significant infrastructure improvements including projects to add capacity for 10 million more people to use the subway, the construction of nearly 1,800 kilometers of roads, and the connection of more than 100,000 households to a clean water supply. The recently established President's Delivery Unit in Chile has achieved progress on many social initiatives including a 22 percent reduction in street crime, the creation of more than 500,000 new jobs, and a 50 percent increase in the number of top students choosing teaching as a profession.

Finally, infrastructure authorities need skilled organizational leadership. There are a few shining examples; Elatuvalapil Sreedharan, for instance, oversaw construction of India's Delhi metro on time and under budget by building a handpicked organization from the ground up and fixing the processes and timeline.[78] During his tenure as mayor of the Brazilian city of Curitiba, Jaime Lerner was the driving force behind a sophisticated new bus transit system, pedestrian-only streets, new parks, and recycling systems.[79] Attracting, retaining, and developing such leadership potential has to be a high priority for the effective governance of infrastructure. As in any endeavor, and as Sreedharan and Lerner have demonstrated, leadership can make all the difference in infrastructure planning, delivery, and operation, ensuring success even where few other conditions of success are met.

78 V. G. Narayanan and Saloni Chaturvedi, *Delhi Metro Rail Corporation*, Harvard Business School case study, April 27, 2012; Amy Yee, "Delhi's subway builder," *Forbes Magazine*, May 11, 2009.

79 Hiroaki Suzuki, Arish Dastur, Sebastian Moffatt, Nanae Yabuki, and Hinako Maruyama, *Eco² cities: Ecological cities as economic cities*, World Bank, 2010; Jared Green, "Interview with Jaime Lerner," *The Dirt*, American Society of Landscape Architects, July 3, 2011.

Companies can play an important role in boosting productivity and reap significant benefits

Pressures on public budgets and bank finance will put a premium on improving the productivity of infrastructure. Companies that are proactive in seeking to improve the productivity of their infrastructure planning, delivery, and operations have a significant opportunity to defend their core markets, capture incremental business, and potentially change their business models so that they capture a share of the generated savings. We see three major imperatives for companies seeking higher productivity in the infrastructure sphere.

DRIVE PRODUCTIVITY WITHIN COMPANY OPERATIONS

Many of the levers that we discussed in Chapter 2 apply to private-sector businesses. Companies that build and operate entire infrastructure networks like many utilities or rail infrastructure providers (including those that are state-owned) are responsible for much of the planning and operation function but contract out much of the delivery. They can benefit from more investment in up-front planning, sophisticated procurement, and tendering processes that favor innovation and value engineering while bringing down the cost of materials and services, and advanced contract management with effective oversight and stringent claims management. Many companies engaged in rail, ports, or airports have room to improve operational throughput of their assets. In power and water, companies have scope to reduce transmission losses. Businesses across infrastructure asset classes can optimize the TCO by making trade-offs between up-front investment and ongoing cost by analyzing maintenance schedules. Construction contractors, in particular, should seek to embrace lean methods to the fullest possible degree, improve their procurement of materials, and develop standardized, modular, prefabricated solutions. They can also tap opportunities in value engineering including investment in R&D for innovative solutions. Value-based selling capabilities will help them persuade owners to invest in TCO optimization and relax specifications in order to achieve more cost-effective solutions.

ENGAGE IN A PRODUCTIVE DIALOGUE AT INDUSTRY LEVEL WITH PUBLIC-SECTOR STAKEHOLDERS

Infrastructure companies—or their industry-level associations—should strive to remove current frictions with public-sector stakeholders and engage in a constructive dialogue. They can highlight deficiencies and global best practice in procurement, tendering, and contracting schemes, and, by quantifying the impact of these shortcomings on their operations, make the case for change at government level. They can also collaborate with the public sector on removing the barriers to, and building the enablers for, a high-performing construction sector. Initiatives could include: joint investment in R&D centers; the development of educational facilities with industry-designed curricula and on-the-job training; demonstration projects for sharing and showcasing best practice; and proposing changes to construction standards or labor regulation.

DEVELOP NEW BUSINESS AND CONTRACTING MODELS

Looked at from a different angle, every inefficiency is a business opportunity. EPC firms can identify and propose additional infrastructure investments or invest in capabilities that tend to be scarce among owners, and provide even more owner-incentivized planning, engineering, procurement, and contract management services. We are already beginning to see a broadening out into such activities through EPCM companies. Global companies can play a role in the transfer of best practice. Accounting firms can support the development of national infrastructure balance sheets. Educational institutions can build targeted courses. Operators can propose business models and amendments to regulation that would allow them to capture the benefits of demand management whether through the immediate effect of higher prices or through more complex incentive structures.

□ □ □

It is easy to think of infrastructure in dry or abstract terms as a collection of assets and financial obligations—pavement and power plants, leverage ratios, and risk allocation. But infrastructure has real impact on people's lives and livelihoods, whether it is the all-weather road that saves a five-mile walk to school, the mobile connection that helps a farmer find the best price for his crop, the safe water that prevents a life-threatening case of diarrheal disease, the uncongested highway that helps a company get its goods to market, or the uninterrupted power supply that makes the difference between a small business that is viable and one that is bankrupt. There is, in short, a moral imperative to make productive use of the huge resources that are committed to infrastructure.

We recognize that governments and businesses face difficult choices about where to spend their available funds, and that infrastructure, albeit important, is just one item of spending among others. We are not arguing for the diversion of precious resources from other important uses, but to collectively improve the quality and productivity of infrastructure investment. Decisions can be more effective, construction can happen more efficiently and more quickly, and governments and businesses can make the most of what they have. There are many examples from around the world that offer inspiration and guidance. Learning from them is an urgent global priority.

Technical appendix

This appendix lays out key points of our methodology in the following areas:

1. Data challenges
2. Historical spending
3. Infrastructure stock
4. Estimates of need
5. Impact quantification

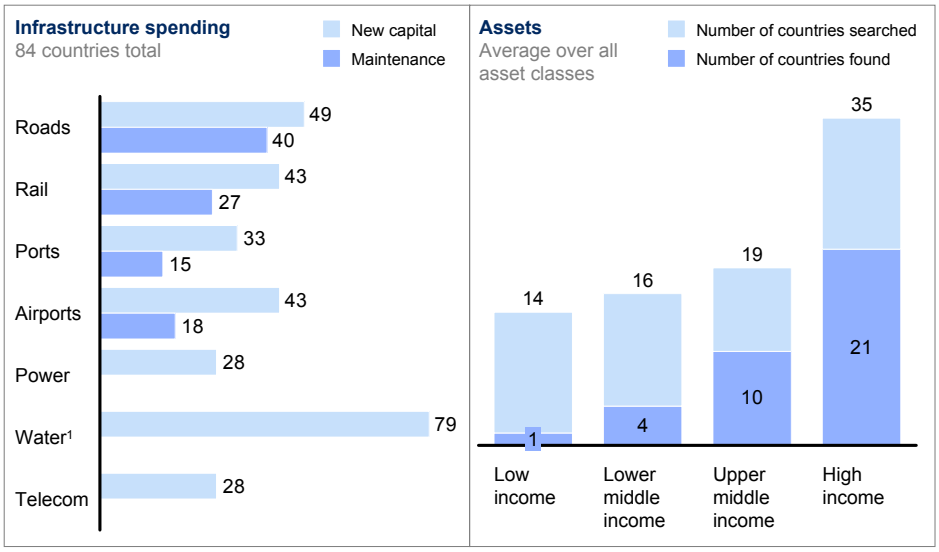
1. Data challenges

Our intention has been to obtain the most comprehensive data possible to allow comparisons among economies and serve as a basis for our analyses and models. We set out to construct a database of annual infrastructure spending from 1992 to 2011 for 84 countries that account for more than 90 percent of the world's GDP. To do this, we examined a range of global databases as well as national sources that report both public and private spending on infrastructure. With the exception of a few national sources for transportation data, we used International Transport Forum (ITF) data for road, rail, port, and airport spending; IHS Global Insight for power and telecommunications spending; and Global Water Intelligence (GWI) for spending on water and sanitation.[80] These were the most comprehensive sources available. However, there were significant gaps in the data. Fewer than half of the selected countries had information for the past ten years in most asset classes; data for low-income countries were particularly difficult to find (Exhibit A1).

Exhibit A1

Data on infrastructure spending and assets are scarce

Countries with ≥5 years of data from 2001 to 2010



1 Water data examined for at least five data points between 2007 and 2011.
SOURCE: McKinsey Global Institute analysis

80 We used national account data for transport asset classes for Brazil, Nigeria, and South Africa since the data were not available from ITF. We also used data from the African Development Bank for African countries for 2005 (the only year available).

2. Historical spending

We chose the following sources in constructing our database on historical spending, which we used to check our estimate of need based on historical spending as a share of GDP:

- **Roads.** Road data came from the ITF, which defines a "road" as a public thoroughfare primarily for the use of road motor vehicles; included are paved roads and other roads with a stabilized base (e.g., gravel roads).[81] Roads include streets, bridges, and tunnels, supporting structures, junctions, crossings, and interchanges. Toll roads are also included.[82]

- **Rail.** We sourced rail data from the ITF.[83] The ITF defines "rail" as all railways in a given area but does not include stretches of road or water (e.g., cargo conveyed on ferries). The ITF excludes lines exclusively for tourism and railways constructed solely to serve mines, forests, or other industrial or agricultural undertakings that are not open to public traffic. However, the ITF includes metro lines/subways and light rail lines (we are uncertain if it includes tram lines).

- **Ports.** We sourced data from the ITF.[84] The ITF defines "port" for maritime transport as "a place having facilities for merchant ships to moor and to load or unload cargo or to disembark or embark passengers to or from vessels, usually directly to a pier" and inland waterway transport as "a place for vessels to moor and to load or unload cargo or to disembark or embark passengers to or from vessels, usually directly to a pier."

- **Airports.** We sourced data from the ITF.[85] The ITF defines "airport" as "a defined area of land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft and open for commercial air transport operations."

- **Power.** We used IHS Global Insight data on capital expenditure for "electricity, gas, steam and hot water supply," which includes the "production, collection and distribution of electricity, manufacture of gas, distribution of gaseous fuels through mains, steam and hot water supply." Hot water is separate from water supply. Note that capital expenditure data in this sector include spending on equipment such as computers that would typically not be considered infrastructure.

- **Water.** We used GWI data on the infrastructure investment needed for municipal and industrial water and wastewater systems, which include anticipated expenditure on related equipment. Irrigation is not included in these data.

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81 *Illustrated glossary for transport statistics*, 4th edition, ITF, Eurostat, and Economic Commission for Europe, 2009.

82 As with the rail data, it is not clear whether tram lines are counted, but we believe this does not have a material impact.

83 *Illustrated glossary for transport statistics*, 4th edition, ITF, Eurostat, and Economic Commission for Europe, 2009.

84 Ibid

85 Ibid.

- **Telecommunications.** We used IHS Global Insight capital expenditure data for the telecommunications sector—that is, cables, broadcasting, relay or satellite, telephone, telegraph, and telex infrastructure used for communications. Data include the cost of maintaining the networks. As with the power sector, the data include items that would not necessarily be considered infrastructure such as capital expenditure related to headquarter or back-office activities.

Since African data were particularly difficult to obtain, we used data from the African Development Bank for these countries for 2005 (the only year for which data were available). We also used government data for the transportation asset classes (roads, rail, ports, and airports) for Brazil, Nigeria, and South Africa.

3. Infrastructure stock

While countries usually have detailed records on their physical infrastructure assets (e.g., kilometers of roads and railways or number of airport runways), the financial value of that stock is more difficult to obtain. As a result, we built a model that would provide a rough estimate of the financial value of a country's infrastructure stock. To do so, we took the following steps:

- **Method.** We applied a perpetual inventory model, which takes investment spending over a number of years, back-casts that information to generate a sufficiently long timeline, and applies a depreciation rate to calculate the value of installed stock.

- **Data.** We populated the model with data from our infrastructure spending database. Except in the case of water, we used data only from countries that had at least 15 years of data between 1992 and 2011 across each asset class, with the exception of water.[86] The sample includes Brazil, Canada, China, Germany, India, Italy, Japan, Poland, South Africa, Spain, the United Kingdom, and the United States. For years in which data were not available, we multiplied the weighted average of that country's spending for that asset class by its GDP as an approximation for what the country had probably spent. We used the same approach for back-casting, assuming that a country historically had spent the same share of GDP on infrastructure as in the 15 to 19 years of data that were available. This is admittedly a simplification. To obtain real values of infrastructure investment in 2010 currency, we inflated historical spending data using construction-sector deflators for each country.

- **Depreciation.** We applied a depreciation rate of 2.5 percent and made GDP growth assumptions using GDP data available from IHS Global Insight.

86 The GWI database contains data only from 2007 onward.

4. Estimates of need

We calculated the estimate of $57 trillion for global infrastructure need through 2030 by compiling projections of demand in different infrastructure categories. We then "sense-checked" these estimates by analyzing historical spending patterns and the value of the infrastructure stock. We used the following sources for our $57 trillion projection of need by infrastructure type:

- **Roads.** We assumed that future needs will follow historical spending as a percentage of GDP. The OECD has published comprehensive investment need estimates for roads, but these estimates equate to only 40 percent of what countries have spent historically. We think it is unlikely that countries will reduce road investment by 60 percent. Therefore, we applied the 1 percent of GDP that countries have historically spent for this purpose to projected GDP growth, which gave us a figure of $16.6 trillion for road needs between 2013 and 2030.

- **Rail.** For rail investment needs between 2009 and 2030, we used OECD estimates published in 2012.[87] We created the estimates using a combination of inputs: current stock of rail infrastructure, GDP growth, and recent and anticipated policy changes. This gave us a figure of around $4.5 trillion for rail investment needs between 2013 and 2030.

- **Ports.** In 2012, the OECD published estimates for port investment needs between 2009 and 2030, which included projections for China, India, and the United States. We used the United States as a proxy for advanced economies and China and India as proxies for the developing world. Scaling these estimates to global levels gave us a figure of around $0.7 trillion between 2013 and 2030 for port investment needs.

- **Airports.** We used OECD estimates for airport investment needs between 2009 and 2030, also published in 2012. We calculated these estimates using a combination of air traffic growth projections, capital spending surveys, and identification of planned capital projects. This gave us an estimate of airport investment needs of around $2 trillion between 2013 and 2030.

- **Power.** We used 2011 International Energy Agency (IEA) estimates for investment needs in power generation, transmission, and distribution between 2011 and 2035. The IEA calculated these estimates by reviewing macroeconomic conditions, population growth, energy prices, government policies, and technology. This gave us a figure of around $12.2 trillion for investment in power infrastructure between 2013 and 2030.

- **Water.** GWI has projected needs for water and sanitation and related equipment (not including for irrigation) through 2016. These appear to be straight-line projections based on historical spending, and we simply extended them through 2030. This gave us a figure of around $11.7 trillion between 2013 and 2030.

87 OECD uses ITF data and definitions. Rail lines exclude those used solely for tourism and those built solely to serve mines, forests, or other industrial or agricultural activities. Metro lines, subways, and light rail are included. Tram lines are not included in ITF definitions of road and rail, and it is unclear if they are counted; we believe this does not make a material difference to investment need analyses.

- **Telecommunications.** In 2006, the OECD published estimates for spending on mobile, fixed-line, and broadband infrastructure between 2005 and 2030. They cover OECD countries plus Brazil, China, and India. We converted these estimates to a percentage of GDP and then applied them on a global basis. Based on this approach, we estimate the world will spend almost $9.5 trillion on telecommunications infrastructure between 2013 and 2030.

5. Impact quantification

Our quantification of impact for productivity-improvement levers aggregated actual or forecast cost savings in representative case studies and extrapolated this potential to a global level. For each lever, we first determined which investment need it applied to. We then differentiated between the investment needed for new infrastructure assets and capacity versus maintenance. We estimated that capital expenditure for maintenance is, on average, about half of national infrastructure spending across asset classes and geographies.[88] We applied savings from improved project selection and planning to anticipated investments in new capacity. We split savings from improved delivery procedures between new capacity and maintenance across asset classes. We applied savings from maintenance optimization to road and rail maintenance costs. We applied savings from operating improvements and demand management to new capacity, and we did not fully scale case examples globally due to different starting positions and applicability across countries.

To extrapolate the potential impact figures for each lever (expressed as a percentage of potential savings), we first calculated the average and range of impact from the relevant case data, where we used some case examples in an asset-class specific way, and others across asset classes, depending on applicability. We then scaled up the savings potential to global spend, adjusting for differences in geographies where needed. They are provided in the following subsections.

CALCULATION OF SAVINGS POTENTIAL FROM ELIMINATING WASTEFUL PROJECTS

We estimate a 15 to 20 percent savings opportunity on new capital investments, based on 18 case examples (half each in public- and private-sector infrastructure) and “sense testing” with experts. The public-sector cases suggested an improvement potential of 10 to 35 percent, and the private-sector cases suggested a potential of 10 to 30 percent. Experts, and a review of published academic research, suggested a potential of 15 to 20 percent. We applied the 15 to 20 percent figure across geographical regions and assets, as our data set does not provide any support for further differentiation.

88 Our global estimate comes from triangulating historical data from our country sources (where the desired split is available) with literature estimates. Note that the split can vary greatly across cases, both by asset class and country development stage.

CALCULATION OF SAVINGS POTENTIAL FROM STREAMLINING DELIVERY

The impact from streamlined delivery group can be broken down into two parts. First, we estimate a 23 to 29 percent savings opportunity on new capital investment, based on results from 40 McKinsey & Company cases on the optimization of infrastructure project delivery. These savings can come through value engineering (6 to 8 percent), more effective procurement processes (6 to 10 percent), and the use of less costly construction techniques (11 to 12 percent). The same levers can be applied to renewal projects, but we estimate that the impact will be about half of what we expect in new construction, yielding potential savings of 12 to 15 percent. We do not have sufficient data to break down the impact of streamlined delivery by geography or asset class.

CALCULATION OF SAVINGS POTENTIAL FROM MAKING THE MOST OF EXISTING ASSETS

We considered three levers.

Improved operational efficiency

For water, we considered the mitigation of losses and operational efficiency improvements separately. In the case of loss mitigation, we assumed that technical mitigation reduces the need for adding capacity until 2030 by 110 cubic kilometers, which translates into $1.35 trillion of savings over 18 years.[89] For operational improvements, based on expert input and the experience demonstrated in our analysis of case studies, we estimate that, by combining pumping schedule optimization and storage optimization, water system operators can reduce peak consumption by 5 to 7.5 percent in developed economies and 10 to 15 percent in developing economies. We assumed that half of the savings from peak reduction translates into lower need for new investment, resulting in a global capital investment reduction potential of 4 to 6 percent.

We based estimates of loss mitigation in power on the use of more extensive metering, consumer education, and technical loss mitigation (e.g., reducing transmission losses). We used nine case examples from India and Latin America to obtain a loss reduction potential ranging from 10 to 40 percent. We discounted this potential by 30 percent, based on individual countries' transmission and distribution loss statistics, and applied the savings only to emerging economies. Using a discounted cash flow model, we estimated the new investment savings potential at 11 to 31 percent.[90] We considered loss mitigation implementation costs negligible given that they are offset by operational savings.

89 *Resource revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and McKinsey Sustainability & Resource Productivity Practice, November 2011.

90 We first translated the increase in capacity into the equivalent decrease in consumption and then used a discounted cash flow model to compare the investment required under two different scenarios (business as usual and one-time drop). Both use the same growth rate, but the one-time-drop model starts from a lower level of demand.

For airports, we considered the capacity improvement potential, in terms of additional movements per runway, from levers such as improved scheduling that require no capital investment.[91] We estimated the potential to improve runway throughput using case data and expert analysis of various European airports, yielding an average improvement potential of 10 to 30 percent. We scaled this figure based on applicability to individual geographical regions, obtaining an average capacity improvement potential of 15 to 40 percent globally. The scale is based on the European benchmark, which we placed toward the high end of the operational sophistication of these facilities. This improvement potential translates into a 9 to 27 percent spending reduction potential.[92] We applied this potential to the share of airport investment that is related to new runway capacity, which we estimate at 50 percent of total investment.

For rail, we followed a similar approach as for airports, taking into account levers such as streamlining operations and optimizing infrastructure parameters that require little or no capital investment. Our cases, covering both freight and mixed passenger-freight systems, suggested a productivity improvement potential of between 10 and 30 percent, with most of that coming in freight systems through better operations at terminals, for example. We scaled this potential by country development stage and then applied the result to new investment spending, excluding those in high-speed rail (which are estimated at around 15 percent of new investment).[93]

For ports, we used case studies and expert interviews to derive an estimated capacity improvement potential of 10 to 15 percent. The applicable levers include optimized cooperation throughout the supply chain, improvement of resource usage (e.g., berths and ship efficiency), and optimization of information management. We applied this savings potential to the share of investment in new capacity, which we estimate at 75 percent.

Optimized maintenance

More strategic maintenance planning can drive down the TCO of assets by carefully balancing larger capitalized and more frequent operational maintenance spending. Based on case examples and expert interviews, we estimate that, for road and rail asset classes, optimized maintenance can achieve 10 to 15 percent TCO savings. Note that optimization can reduce either capitalized or operational maintenance spending, but we apply the full potential to capitalized spending since we assume that operators don't mind where the savings arise.

91 Examples of relevant levers include the introduction of mixed-mode operations and air traffic control procedures to improve the sequencing of aircraft.

92 The capacity improvement formula is $Y=1-(1/(1+X))$, where X is capacity improvement and Y is cost reduction.

93 We expect operational improvements from high-speed rail to be negligible.

More extensive use of demand management

We considered demand management for transportation, water, and power separately. For water, we collected 13 cases spanning all geographic regions and involving measures such as consumer education programs, consumer pricing moves, better metering, and municipal water efficiency efforts. Combined, these cases suggest a potential for consumption reduction ranging from 15 to 40 percent. We discounted this reduction rate by 40 percent, based on a mix of an expert country-by-country feasibility rating and country per capita consumption numbers. We then assumed a one-time drop in consumption and used a discounted cash flow model to compute the implied potential reduction in capital investment compared with a business-as-usual demand growth scenario. This resulted in a savings potential of 14 to 29 percent. We applied this savings rate only to the new investment related to water production (as opposed to distribution), the assumption being that water demand has a much more limited effect on distribution networks. We did not explicitly consider lever implementation costs in our analysis since these measures are often capital-expenditure-neutral or paid for through operating efficiencies.

For power, we followed the same approach used for water. Case examples of pricing, regulation, and community awareness measures in California, Europe, and Russia suggest that consumption can be reduced by 15 to 40 percent. We reduced this range by 40 percent before scaling globally based on three analyses: per capita consumption, country-by-country feasibility assessments, and country-by-country energy-efficiency analyses. We arrived at a potential savings rate of 14 to 29 percent, which we applied only to the new investment in power generation. We did not take into account capital investment required to implement these saving levers, since we assumed investments were smaller than operational savings, typically producing net present value-positive results in less than five years.

For road transportation, we focused on congestion charging as the main form of demand management. We estimated that implementing congestion charging across the world's highways could result in savings of 14 to 19 percent of total road investments.[94] This result is based on a 28 to 38 percent savings potential estimated for US-wide deployment of congestion charging, which we discounted by 50 percent to account for differences in applicability (for example, urbanization, population density, and congestion levels). We applied the resulting 14 to 19 percent savings to the share of highway-related capital expenditure that the US Department of Transportation estimates to be 80 percent of total road investment.

94 We based this estimate on the US Department of Transportation 2008 conditions and performance report. Considering two scenarios (with and without congestion charging), we obtained the cost savings potential by comparing the investment required to maintain the same level of service. We applied congestion charging only to national and interstate highways. These categories account for 77 percent of the total.

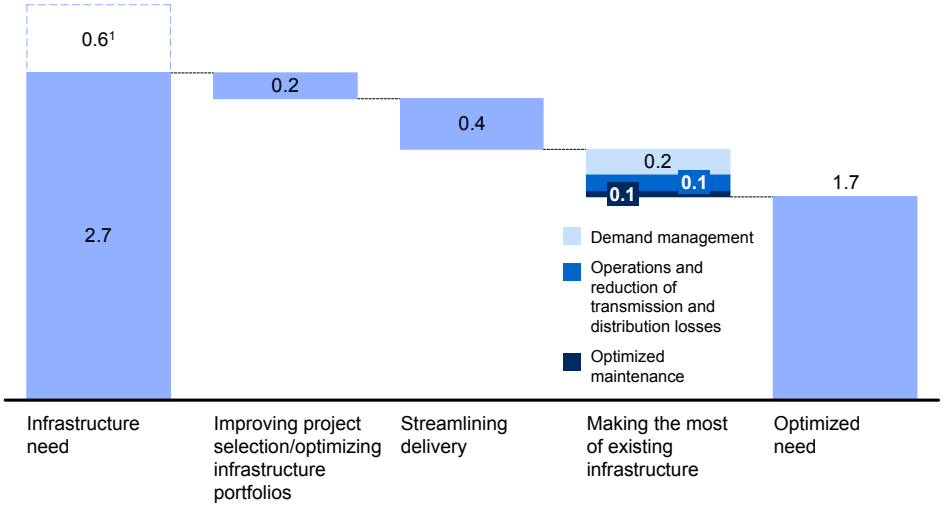
DERIVING THE GLOBAL IMPACT FIGURES

To arrive at a global impact figure, we assumed that all levers are implemented to their full extent and aggregated the results (Exhibit A2).

Exhibit A2

The $1 trillion-a-year infrastructure productivity opportunity

Global infrastructure investment need and how it could be reduced
Yearly average, 2013–30
$ trillion, constant 2010 dollars



1 Telecom investment need beyond the scope of this paper.
SOURCE: McKinsey Global Institute analysis

For aggregation, we assumed a sequence of demand management, operational improvements (including loss mitigation), planning optimization, delivery optimization, and maintenance optimization, and applied the savings potential at each step only to the already optimized spending level of the previous step.

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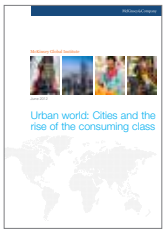
Related MGI and McKinsey Infrastructure Practice publications

Investing in growth: Europe's next challenge (MGI, December 2012)

Private investment was the hardest-hit component of Europe's GDP between 2007 and 2011—but it can also be a major driver of the region's recovery. Even in the face of weak demand and high uncertainty, some investors would start spending again if governments took bold measures to remove barriers that now stand in the way.



Urban world: Cities and the rise of the consuming class (MGI, June 2012)

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Meeting the world's resource supply and productivity challenges will be far from easy—only 20 percent of the potential is readily achievable and 40 percent will be hard to capture. There are many barriers, including the fact that the capital needed each year to create a resource revolution will rise from roughly $2 trillion today to more than $3 trillion.

Keeping Britain moving: The United Kingdom's transport infrastructure needs (McKinsey Infrastructure Practice, March 2011)

The United Kingdom's strategic roads, railways and airports are some of the most congested in the world and demand is set to increase significantly. The nation therefore faces a period of unprecedented investment to maintain and enhance the quality of its transport assets. McKinsey & Company estimates that the cost of maintaining, renewing and expanding the United Kingdom's transport infrastructure will be around £350 billion over the next two decades– a 45 percent increase on average annual spending since the turn of the 21st century.

Releasing the pressure on road agencies (McKinsey Infrastructure Practice, February 2011)

Road agencies will have trouble meeting rising demand. However, adopting new tools and processes can produce big improvements in capital productivity and operating cost efficiency.

Building India: Accelerating infrastructure projects (McKinsey Infrastructure Practice, July 2009)

If past infrastructure investment trends continued between 2008 and 2017, India could suffer a GDP loss of $200 billion or around 10 per cent of GDP in fiscal year 2017. Inefficiencies in implementing infrastructure projects exist at all stages in the process but there are a few key initiatives could help address bottlenecks and reduce the time taken and costs incurred in infrastructure projects.

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