

The infrastructure moment

Investing in the expanding foundations of modern society

Authors

Alastair Green

Ishaan Nangia

Nicola Sandri

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Foreword

The mention of infrastructure conjures images of traditional elements—constructs like roads, bridges, water lines, and ports. While these foundations remain essential at every level, they no longer encompass the full implications of the word.

Indeed, the very definition of infrastructure has changed—and continues to evolve. Across the globe, from the most advanced industrial nations to developing economies, the concept has transformed to include elements that didn't even exist in tangible form as recently as a few decades ago.

Today, infrastructure refers as much to the digital networks that enable our information economy as the power plants that keep the lights on. It also includes the services and systems that ensure these assets are reliable, resilient, and equitably accessed.

At the same time, infrastructure verticals are increasingly interdependent—technically, operationally, and financially. One prominent example arises at the intersection of energy, water, and digital in the form of skyrocketing demand for sustainable energy to power the increasing use of AI and water to cool data center servers.

Despite this remarkable evolution, many traditional challenges remain the same: maintenance, renewal, and adaptation to meet changing needs. We've entitled this report *The infrastructure moment* because it truly captures this inflection point in our global society. It's a time when new elements of infrastructure are converging with traditional ones across multiple verticals, presenting new challenges and opportunities alike.

At a moment like this, it's clear that today's stakeholders—policymakers, investors, and industry operators—will make decisions that shape the future for generations to come. This moment demands a shift in mindset about infrastructure coupled with a commitment to act on that new mindset for the good of the world.



Alastair Green

Senior partner and
global co-leader of
McKinsey's Infrastructure
Special Initiative

Washington, DC



Ishaan Nangia

Senior partner and
global co-leader of
McKinsey's Infrastructure
Special Initiative

Melbourne



Nicola Sandri

Senior partner and
global co-leader of
McKinsey's Infrastructure
Special Initiative

Milan

Executive summary

Infrastructure is a critical enabler of long-term global economic growth, supporting prosperous societies, elevated standards of living, and every modern industry. But the ongoing expansion and evolution of what infrastructure comprises has transformed its definition, demanding a fundamental mindset shift among governments, investors, and industry operators about how to fund, build, use, and maintain it. Even as infrastructure verticals are evolving individually, their new intersections form another aspect of evolution.

McKinsey estimates that a cumulative \$106 trillion in investment will be necessary through 2040 to meet the need for new and updated infrastructure. The required investment spans seven critical infrastructure verticals, with transport and logistics requiring the largest share (\$36 trillion), followed by energy and power (\$23 trillion), digital (\$19 trillion), social (\$16 trillion), waste and water infrastructure (\$6 trillion), agriculture (\$5 trillion), and defense (\$2 trillion).¹

A confluence of global forces is accelerating the need for infrastructure investment. Outdated assets, rapid urbanization, geopolitical shifts, and technological advancements are exposing the limitations of yesterday's infrastructure.

These forces are also changing the very definition of infrastructure. Traditionally, the term has been synonymous with assets such as power grids, roads, ports, and bridges. More recently, advances in technology have meant that newer assets such as fiber-optic networks, hyperscale data centers, and electric-vehicle charging stations are increasingly vital. These modern types of infrastructure share traits with "traditional" infrastructure, including long lifespans, significant initial investment, predictable and resilient cash flows, and critical economic roles.

A supporting layer of specialized services—maintenance, inspection, compliance, and remote monitoring—ensures these assets remain operational and are increasingly considered to be infrastructure as well. Governments and investors must fund these supporting services alongside critical assets.

At the same time, the boundaries between infrastructure verticals are blurring. Many of today's most critical needs—such as infrastructure to support the deployment of artificial intelligence and the energy transition—exist at the intersections of the verticals. This report explores these intersections in depth and reveals why a siloed approach to infrastructure planning and investment may no longer be viable. Governments, investors, and operators will want to reflect on these interconnections and pursue integrated strategies that best deliver the mix of infrastructure that society needs to prosper.

Private capital is playing an increasingly important role in delivering infrastructure that sits at these intersections and within verticals. Private infrastructure assets under management surged from about \$500 billion in 2016 to \$1.5 trillion in 2024, reflecting its new position as the most desired asset class for increased investment. Investments will focus within and at the intersection of seven critical verticals, which this report explores in depth: energy, power, and resources; transportation and logistics; agriculture; digital and communications; waste and water; social; and defense.

¹ Adding these figures does not total to \$106 trillion, due to rounding.

To mobilize capital at the required scale, stakeholders can adopt clear, practical, and novel strategies. Policymakers can consider meeting the moment and strategically prioritizing verticals by creating frameworks to attract private capital, streamlining regulatory processes and repurposing underused assets. Investors can broaden their scope by embracing cross-vertical plays and thematic investment opportunities while considering new financing structures that align with long-term asset performance. Finally, infrastructure operators should strive for efficiency gains and improved asset resilience by integrating technology solutions.

The next decade will be a defining one for global infrastructure. Those who act decisively today will shape the future of connectivity, economic growth, and societal well-being for generations to come.

Chapter 1

‘New’ infrastructure means new investment potential

The world will need massive investment in infrastructure—\$106 trillion by 2040, according to our projections. Alongside these accelerating investment needs, the very definition of infrastructure is changing and expanding across seven key verticals. This presents a remarkable coupling of challenge and opportunity for governments and investors alike.

Global population growth, economic development, and technological advances are creating massive demand for infrastructure across the world—not only more of the familiar elements but also new kinds altogether. The very definition of infrastructure is expanding and evolving, shaped both by changes within individual infrastructure verticals and by the new and exciting ways they intersect.

Traditionally, infrastructure has referred to the physical assets that have underpinned societies throughout history, from the fundamentals like roads, ports, and bridges to later developments such as power grids. Those assets remain important, and they require significant investment to support every sector of the global economy while continuing to improve living standards (Exhibit 1).

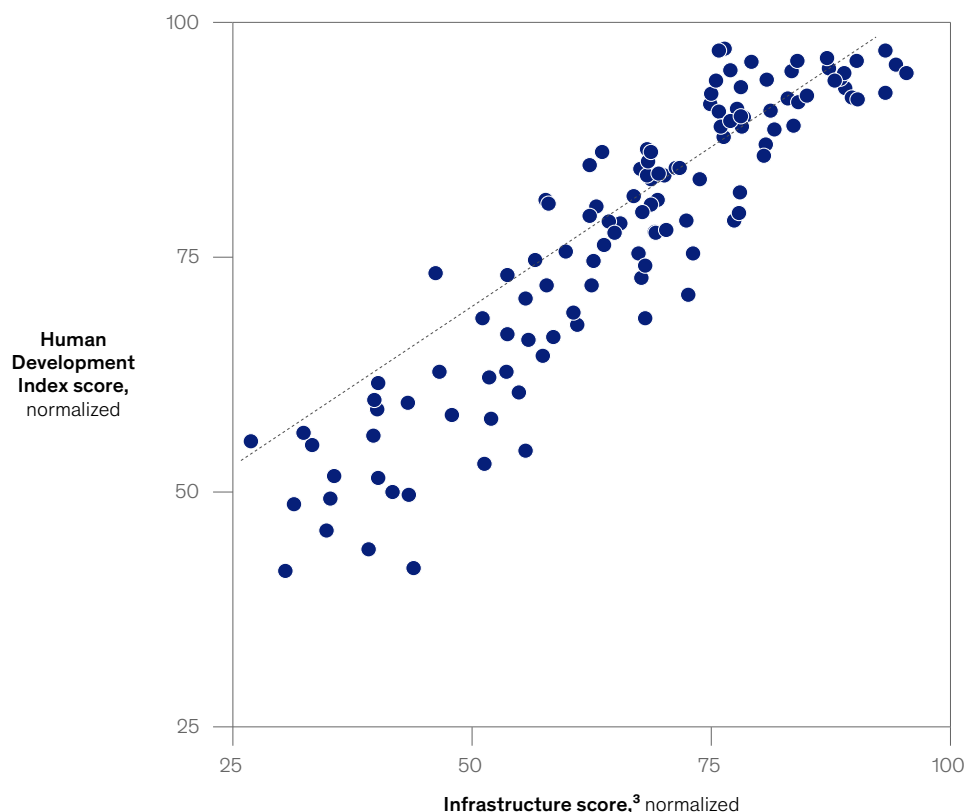
However, infrastructure now includes elements that enable newer assets, services, and technologies such as artificial intelligence, renewables, and electric vehicles. In many cases, these new elements of infrastructure integrate with established ones. For example, fiber-optic networks, electric-vehicle charging stations, and AI- and Internet of Things (IoT)–powered predictive maintenance systems now operate in conjunction with traditional concrete and steel structures.

This fundamental redefinition calls for a substantial mindset shift among three stakeholder groups: governments, investors, and industry operators. Only with an evolved understanding of what infrastructure means today can these stakeholders build to meet the needs of tomorrow. That presents challenges but also introduces a range of compelling opportunities for those willing to act in innovative, forward-thinking ways.

Exhibit 1

Human development and infrastructure expansion are highly correlated.

Country-level relationship¹ between infrastructure and Human Development Index²



¹ $R^2 = 0.85$.

²The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: having a long and healthy life (life expectancy), being knowledgeable (mean of years of schooling), and having a decent standard of living (gross national income per capita). The HDI is the geometric mean of normalized indexes for each of the 3 dimensions. The data shown is from 2023.

³The Infrastructure score from the World Economic Forum is part of the Global Competitiveness Index "Infrastructure" pillar, which aggregates multiple indicators (eg, quality of roads, ports, rail, electricity supply) to form a single score per each country. The data shown is from 2019.

Source: Human Development Index, UN Development Programme, 2023; Klaus Schwab, ed., The Global Competitiveness Report, World Economic Forum, 2019

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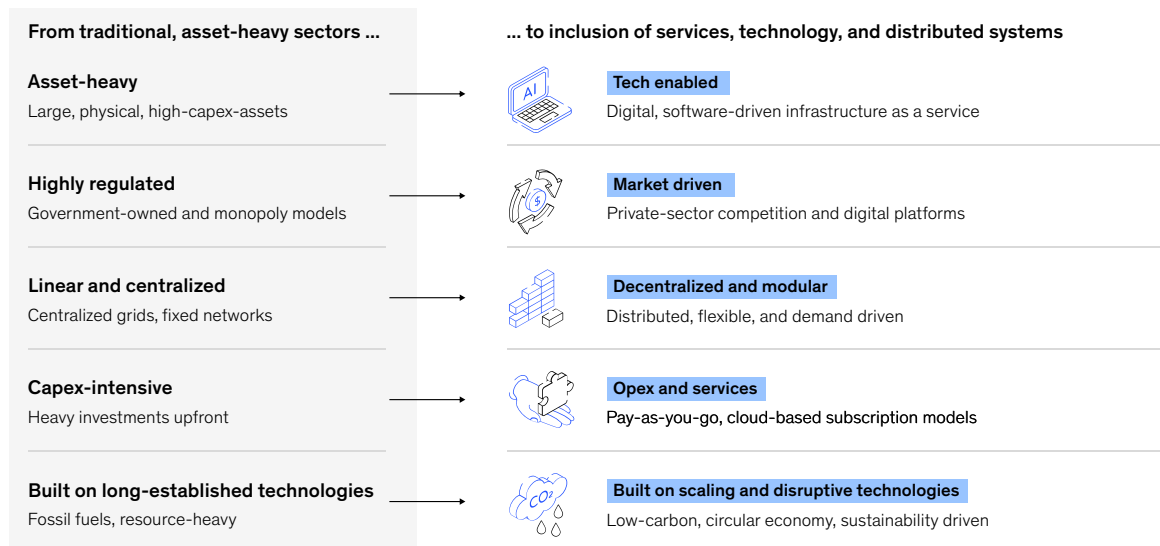
Traditional infrastructure is defined by several characteristics (Exhibit 2):

- **Asset-heavy and capital-intensive.** The definition of infrastructure calls to mind large, physical structures such as dams, highways, and airports that require high upfront capital expenditures and long construction timelines.
- **Highly regulated and often government controlled.** Many infrastructure assets are owned or operated by a single or few public entities.
- **Linear and centralized.** Traditional infrastructure is built around one-way flows (for example, power flowing from grid to user or water running from reservoir to tap) and large-scale systems, such as national power grids that distribute electricity from a few central plants to millions of homes and businesses.

- **Capital-expenditure-intensive.** Acquiring traditional infrastructure requires a significant initial investment in physical assets, as well as long development cycles, complex financing, and multiyear payback horizons.
- **Built on long-established technologies.** Much of the infrastructure that fits in traditional categories has been built on mature, often fossil-fuel-based systems and incorporates relatively little integrated digital technology.

Exhibit 2

The definition of infrastructure is evolving to meet future needs.



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That definition is rapidly changing and expanding. Modern infrastructure increasingly has the following characteristics (Exhibit 3):

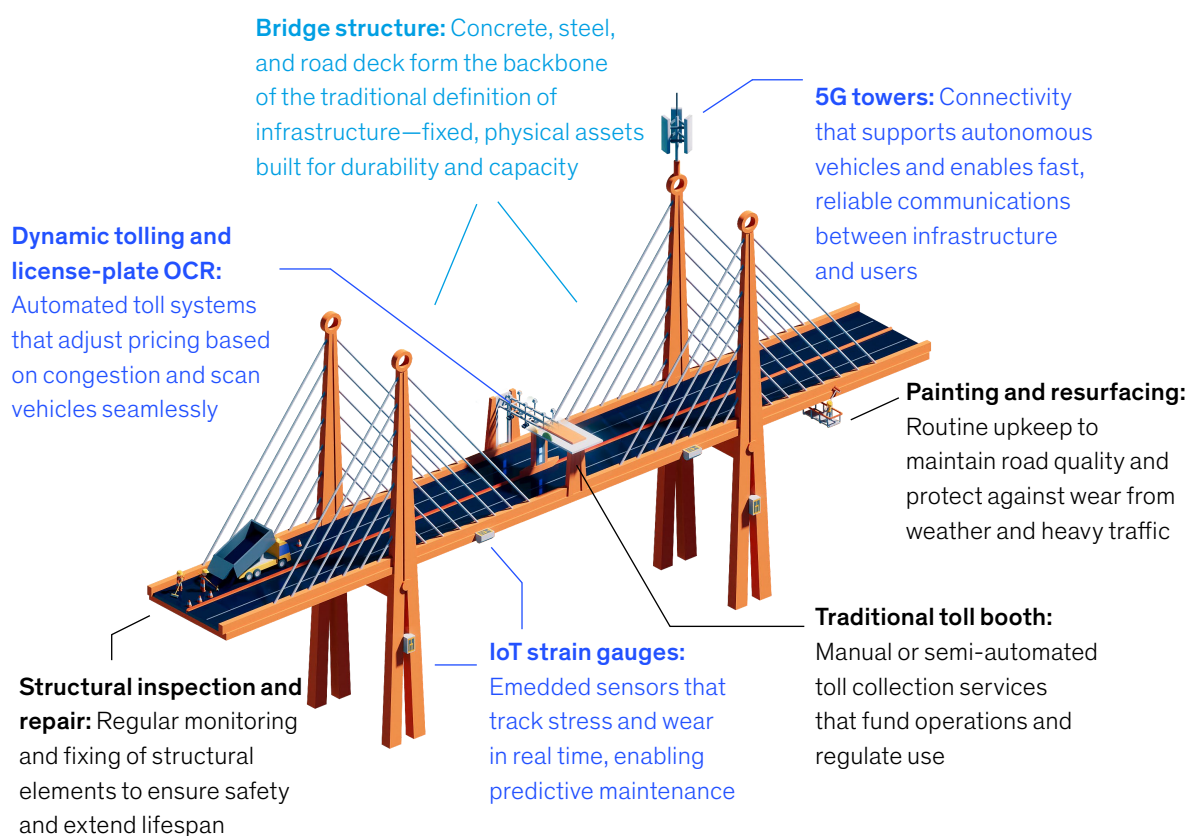
- **Tech-enabled.** Digital platforms, sensors, and AI enable capabilities such as real-time monitoring (for example, IoT-powered water management), predictive maintenance (AI-supported rail system diagnostics), and advanced network optimization (smart traffic systems).
- **Market-driven.** Infrastructure is increasingly shaped by private capital flows, user demand, and competitive forces. For example, AI demand is driving accelerated data center development and private investment.
- **Decentralized and modular.** Nimble networks of smaller, self-contained units are faster to deploy, easier to upgrade, and more resilient to disruption than legacy infrastructure. For example, segments of the energy sector are moving from centralized power plants to a modular model where multiple smaller power sources (such as microgrids that generate solar and offer battery storage and backup power) are aggregated by a centrally managed platform, or “virtual power plant.”
- **Operating-expense oriented and service based.** A growing share of value can be captured through models such as asset-as-a-service offerings (where the customer pays for uptime or output rather than buying or leasing an asset), which often include bundled maintenance services, as well as stand-alone third-party operations and maintenance contracts. Both models are increasingly enabled by monitoring technologies and aim to deliver superior uptime and efficiency over the long term.

- **Built on scaling and disruptive technologies.** Infrastructure may be designed with the goal of limiting life cycle emissions, incorporating energy-efficient systems and circular-economy practices.

This expanded definition of infrastructure manifests in seven main infrastructure verticals, many of which blend physical assets, new technologies, and ongoing services (see table in Appendix).

Exhibit 3

Beyond the bridge: How the definition of infrastructure is expanding



1: Traditional infrastructure

Infrastructure begins with physical assets—durable, capital-intensive structures like bridges, roads, and tunnels, valued for their capacity and reliability.

2: Infrastructure with services

The definition expands to include operations and maintenance—toll collection, inspection, repair, and resurfacing—highlighting infrastructure as an ongoing service system, not just a one-time construction project.

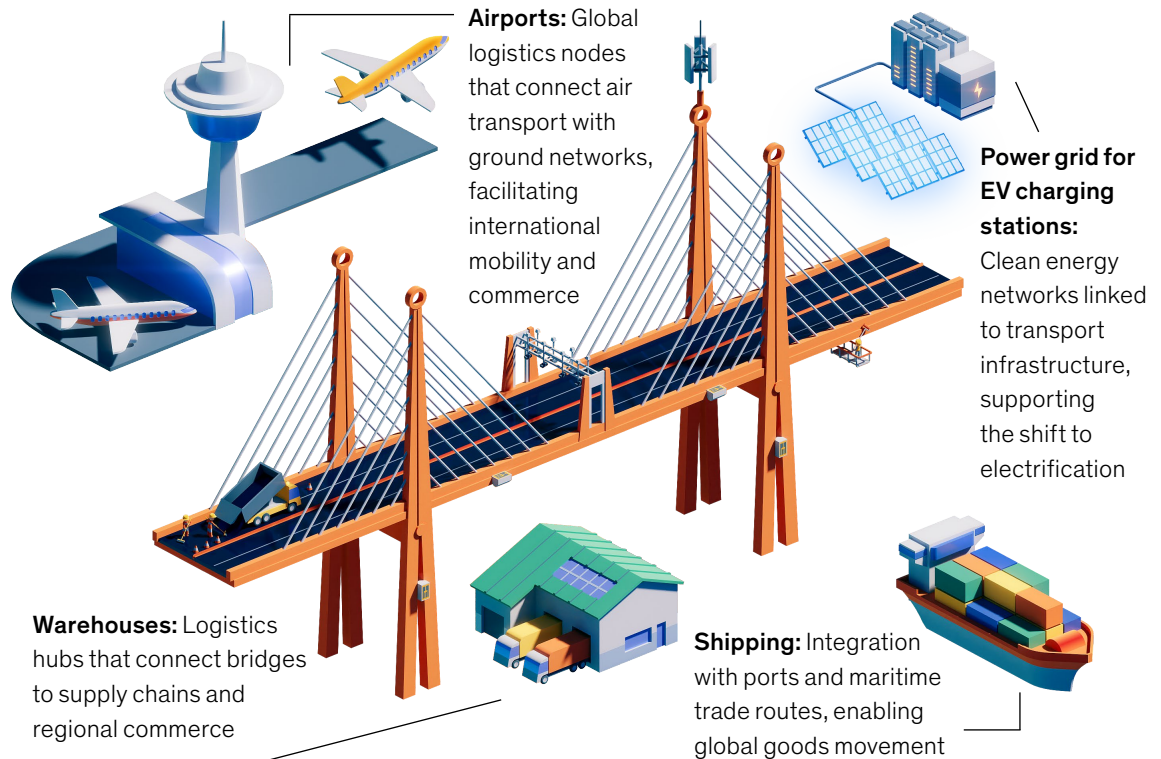
3: Infrastructure with technology

With digital layers, infrastructure becomes “smart.” Sensors, automation, and connectivity enable predictive maintenance, dynamic tolling, and advanced mobility use cases such as autonomous vehicles. Infrastructure begins to generate data and intelligence.

Exhibit 3 continued

4: Infrastructure ecosystem

Finally, infrastructure is seen as part of an integrated ecosystem. The bridge links to renewable energy systems, electric vehicle charging, logistics hubs, ports, and airports. Infrastructure now underpins entire networks of energy, mobility, and commerce.



Infrastructure verticals are getting more interdependent

Infrastructure systems are more interconnected than ever, so when governments, investors, and private-sector operators plan investment strategies, they are learning to shift their mindsets to “cross-vertical” thinking. It’s not enough to take a compartmentalized approach. Electric-vehicle corridors, for example, require coordination among power utilities (energy), highway authorities (transportation), and payment platforms for charging stations (digital).

Other verticals are blending as well. As data center clusters expand to facilitate AI, they draw heavily on the grid for power and water for cooling, bringing together digital, energy, and water infrastructure. Waste, agriculture, and energy are increasingly interconnected now that farm waste such as livestock manure and food scraps can be converted into renewable natural gas to feed electricity back to the grid and power on-site equipment.² These overlaps are sparking new business models that pull together different types of infrastructure to create more flexible, resilient ways to deliver infrastructure services.

² “Biomass explained: Landfill gas and biogas,” US Energy Information Administration, updated November 19, 2024; “Project profile: Ruckman Farm,” AgSTAR, US Environmental Protection Agency, updated May 7, 2025.

In fact, in many cases, full value from assets in different verticals can be realized only when they operate as an integrated whole. Lagging development among the assets of a single vertical can create bottlenecks across the system. Insufficient electricity production, for example, hampers the construction of data centers. This interconnectedness—and interdependence—is prompting investors to target cross-vertical opportunities at increasing levels. From the second half of 2023 through the first half of 2024, cross-vertical strategies attracted 75 percent of the infrastructure capital raised.³ Antin Infrastructure Partners' latest €10.2 billion flagship Fund V, for example, explicitly targets opportunities that bridge energy transition, digital infrastructure, transportation, and social infrastructure across Europe and North America.⁴ Similarly, EQT's Infrastructure VI, which closed at €21.5 billion, aims to invest in themes across digital infrastructure, energy storage and distribution, electrification of transport, and decarbonization.⁵

New infrastructure's \$106 trillion opportunity

Sectors of the economy are no longer isolated, so how and where capital flows to one sector has an increasing influence on investment in others. Thus, the emergence of this more expansive, interconnected infrastructure ecosystem is creating substantial opportunities and increasing infrastructure investment needs compared to previous decades. According to McKinsey estimates, addressing the global need for new and improved infrastructure will require roughly \$106 trillion in investment across the seven main verticals by 2040 (Exhibit 4; see sidebar "About the research" for our methodology).

³ *Funds and Investors Report*, IJInvestor, H1 2024.

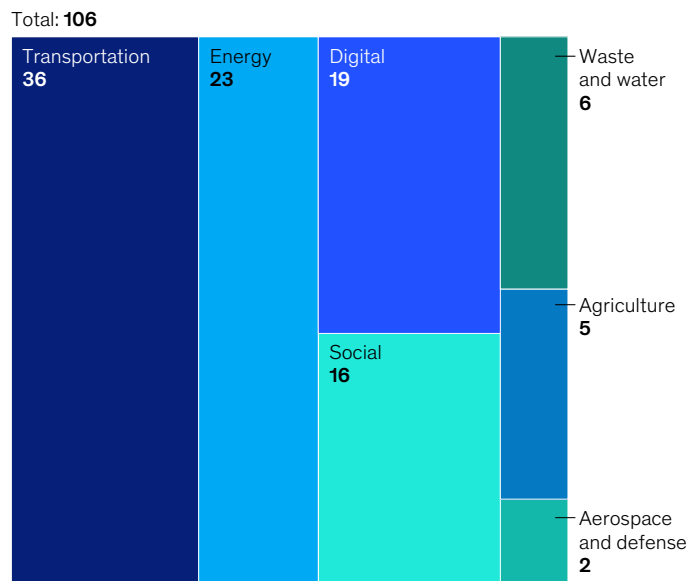
⁴ Emily Lai, "Antin Infrastructure secures €10B for latest flagship fund," PitchBook, December 19, 2024.

⁵ "EQT Infrastructure VI holds final close at its hard-cap, raising EUR 21.5 billion in total commitments," EQT, March 28, 2025.

Exhibit 4

Cumulative infrastructure investment is expected to reach as high as \$106 trillion by 2040.

Total infrastructure investment projected through 2040, by sector, \$ trillion



Note: Figures do not sum, because of rounding.

Source: Food and Agriculture Organization; Global Infrastructure Hub; International Energy Agency; International Monetary Fund; Organisation for Economic Co-operation and Development; Prequin; United Nations; World Bank; World Economic Forum; McKinsey

About the research

Our analysis of future infrastructure investment draws on a combination of empirical data, economic modeling, and proprietary McKinsey research. We began with established 2017 investment baselines by region and vertical, using data from the Global Infrastructure Outlook and Preqin. Where data coverage was limited—such as data centers (part of digital infrastructure), waste, agriculture, social infrastructure, and defense—we supplemented with modeled estimates using capital investment trends (including US government documents on military infrastructure spending), vertical-specific indicators, and other McKinsey publications, such as the recent 2025 article, “The cost of compute.”¹

To project future investment needs, we extrapolated growth by infrastructure vertical and geography based on the historical relationship between capital investment growth and GDP growth, using data from the Organisation for Economic Co-operation and Development (OECD) and the International Monetary

Fund (IMF). Countries were grouped into five global regions—Africa, Americas, Asia, Europe, and Oceania—aligned with McKinsey’s GDP projections and the Oxford Economics baseline. These regional growth trajectories were then extended through 2034 under a scenario in which there are no real disruptions—that is, current conditions continue, with moderate inflation and stable trade terms.

After 2034, investment growth converges to the 2060 baseline forecast from Oxford Economics.

To determine the required investment breakdown by vertical, we estimated public and private shares, using data from the Global Infrastructure Outlook and Preqin. Growth rates were adjusted based on sectoral alignment with GDP projections through 2040, applying differentiated multipliers to reflect vertical-specific capital intensity and expected demand shifts.

¹ “The cost of compute: A \$7 trillion race to scale data centers,” McKinsey, April 28, 2025.

Projected investment needs by vertical

Chapter 3 of this report includes a focused look at how the seven verticals intersect and explores the investment opportunities that arise from these evolving connections. But first, it’s vital to understand the projected investment needs for each vertical.

The leader is transportation and logistics, with \$36 trillion in projected investment. This substantial figure reflects the scale of unmet demand across the world: many countries are grappling with aging roads, congested ports, and strained public transit systems while trying to decarbonize freight, aviation, and passenger mobility.

Energy ranks second at \$23 trillion, driven by the global push to expand clean generation, upgrade aging grids, and meet electrification demand from industries and end users.

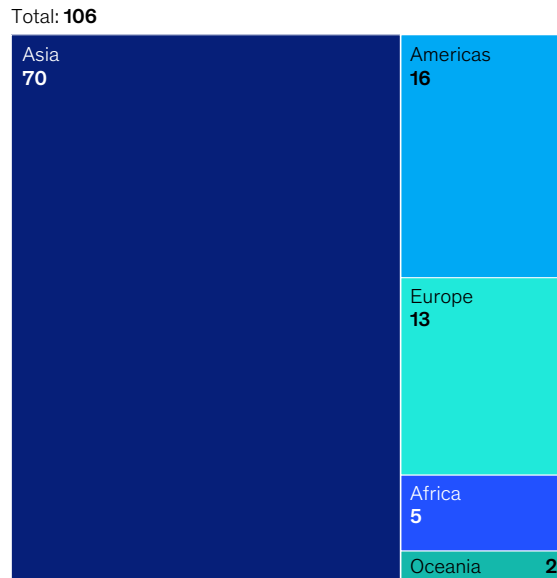
Digital infrastructure is estimated to require \$19 trillion of investment. While this figure is lower than that needed for several other verticals, digital’s role as a catalyst for them means it will see the most growth from today’s level of investment. Fiber, towers, satellites, and data centers form the backbone of business, cities, digital services, and AI-powered systems across all other verticals.

Agriculture and waste and water, while smaller in dollar terms (\$5 trillion and \$6 trillion, respectively), are essential for food security, resource conservation, emissions reduction, and, increasingly, supplying clean fuels and circular inputs to other verticals.

Exhibit 5

Asia could receive two-thirds of the total infrastructure investment through 2040.

Total infrastructure investment projected through 2040, by region, \$ trillion



Source: Food and Agriculture Organization; Global Infrastructure Hub; International Energy Agency; International Monetary Fund; Organisation for Economic Co-operation and Development; Prequin; United Nations; World Bank; World Economic Forum; McKinsey

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Projected investment varies considerably by region, with Asia alone accounting for more than two-thirds at \$70 trillion (Exhibit 5). This substantial majority reflects Asia's rapid urbanization, population growth, and continued industrial expansion. Much of this capital will go to transportation, energy, and digital connectivity to support rising demand in megacities and industrial zones.

We project the Americas will attract approximately \$16 trillion in investment, split between three opportunities. One is modernizing legacy infrastructure, such as transportation systems. A second is expanding new digital infrastructure, including data center growth. The third involves scaling infrastructure in fast-growing Latin American cities such as Lima and Medellín.

Europe is expected to follow, with roughly \$13 trillion in investment. Much of this will focus on renewal of aging infrastructure—from roads, bridges, and railways built decades ago to the upgrading of digital networks. Europe tends to have the world's most ambitious climate targets; meeting them will require considerable renewable-energy projects and grid modernization.

Clearly, the infrastructure moment has arrived—and with it, tremendous opportunity. Our next chapter will examine the powerful forces driving the evolution of infrastructure, including seven macro trends, including the age of physical assets, emerging technologies, and geopolitical and labor market factors.

Chapter 2

What's driving the infrastructure shift

The redefinition of infrastructure isn't happening in a vacuum. It's being shaped and accelerated by a set of global forces—such as urbanization, geopolitical shifts, and skilled labor shortages—that are changing how infrastructure is planned, financed, and executed while also increasing investment needs. At the same time, the energy transition and emerging technologies are creating new avenues for growth while adding complexity to investment strategies.

This chapter explores how seven macro trends could influence the direction of global infrastructure development and investment over the next decade:

1. Infrastructure globally is aging and unable to meet society's demands, requiring upgrades.
2. Urbanization and demographic shifts are adding to the pressure on existing infrastructure.
3. Digital technology, particularly AI, is the major driver of technological advancement in infrastructure.
4. The global transition to cleaner energy is progressing but at varied speeds in different markets.
5. Over the past decade, private investors have emerged as a pivotal force in infrastructure financing, but they face challenges, including high interest rates and longer exit timelines.
6. Infrastructure investment has become a strategic tool in global politics, with countries using large-scale projects to extend influence, secure resources, and reshape trade networks.
7. Labor shortages are causing substantial delays and cost increases among infrastructure projects, during both construction and operations.

Later in this report, we'll consider how these trends could change stakeholder decision making. But first, let's take a close look at how each is playing a role in reshaping the infrastructure landscape.

Infrastructure must be refreshed or upgraded around the world

Infrastructure systems around the globe are becoming increasingly inadequate to meet the demands of the 21st century. In some regions, assets built decades ago are nearing the end of their intended functional lifespan. Elsewhere, infrastructure is relatively new but already strained by rapid urbanization, climate volatility, or technological disruption. Regardless of context, many systems are insufficient for the pressures of today's economy, population dynamics, and sustainability goals.

Much of the core infrastructure in the United States—roads, bridges, water systems, and the electrical grid—was built in the mid-20th century and has been affected by decades of underinvestment. The American Society of Civil Engineers (ASCE) estimates that failing to modernize this infrastructure could cost the US economy \$10 trillion in lost GDP by 2039.⁶

⁶ "Failing infrastructure costing families \$3,300 a year, new ASCE report says," American Society of Civil Engineers, February 1, 2021.

Most of China's infrastructure was built more recently, but the scale of the build-out has outpaced maintenance budgets in many regions. Some earlier-generation projects from the 1980s and the 1990s, such as sewage systems, are already showing signs of deterioration. Some newer assets—from high-speed rail to metro systems—have faced profitability challenges and growing debt, due in part to high maintenance costs and low ridership.⁷

Urbanization and demographic shifts are adding to the pressure on infrastructure

Compounding the age factor, rapid urbanization and demographic changes are also exerting unprecedented pressure on infrastructure systems. United Nations projections indicate that by 2050, as much as 70 percent of the world's population will reside in urban areas.⁸

Urbanization is creating exceptionally high demand for infrastructure development in Africa and South Asia, including public transit systems, utilities, and digital connectivity. For example, Lagos, Nigeria, is home to 27 million people, a population that has grown about 3 percent annually since 2010.⁹ To keep pace, the city has been rolling out major infrastructure projects. These include ongoing efforts to increase the water supply—which began in the late 1990s and have more than doubled treated water output and added at least 640 kilometers of new mains—as well as the Blue Line light rail, a 13-kilometer corridor already carrying an estimated 250,000 daily riders (phase one opened in 2023).¹⁰

Europe and the United States are facing a different challenge. Rather than expanding infrastructure for new urban centers, these regions must adjust their infrastructure to adapt to shifting demographic patterns, including an aging population and postpandemic relocations to rural and suburban areas.¹¹ Meanwhile, the slowing of China's economic boom is altering global infrastructure dynamics, affecting everything from commodity prices to the long-term viability of large-scale development projects dependent on China's growth.

Digital technology and AI are driving advances in infrastructure

Technology has always shaped supply and demand of infrastructure. Today, digital technology, particularly AI, is the major driver of technological advancement in the industry. AI is spurring massive demand for data centers and supporting infrastructure, for example. In 2025, Amazon, Google, Meta, and Microsoft will invest more than \$400 billion in capital spending, much of it in data center capacity to support AI.¹² Global demand for data center capacity could more than triple by 2030, forcing substantial upgrades to power, cooling, and network infrastructure.¹³

Consider the impact of AI and digital automation on just one infrastructure vertical—the transportation sector. In rail, early adopters in Europe and North America are using a mix of high-capacity fiber backhaul, edge data centers, and 5G to optimize crew planning, trimming labor costs by 10 to 15 percent. Proofs of

⁷ Dong Huang et al., "Current state and future perspectives of sewer networks in urban China," *Frontiers of Environmental Science & Engineering*, 2018, Volume 12, Number 3; "China's high-speed rail: A marvel of engineering facing a mountain of debt," *Asia Daily*, August 7, 2025.

⁸ "Sustainable cities and communities," chap. 11 of *The Sustainable Development Goals report 2023: Special edition*, UN Department of Economic and Social Affairs, July 2023.

⁹ *Lagos diagnostic study and pathway for transformation: A rapid multi-sector analytical review of the mega-city*, World Bank Group, June 2023.

¹⁰ *Implementation completion report: Federal Republic of Nigeria Lagos State water supply project (Loan 2985-UNI)*, report no. 17980, World Bank, May 21, 1998; Kunle Adeshina, "We will generate a combined 100M gallons per day water capacity soon—LASG," Lagos State Government, Ministry of the Environment and Water Resources, January 21, 2025; "CPCS sets Lagos Blue Line Rail up for success," CPCS, n.d.

¹¹ Mark Mather and Paola Scommegna, "Fact sheet: Aging in the United States," Population Reference Bureau, January 9, 2024; "U.S. Census Bureau releases 2018–2022 ACS 5-year estimates," US Census Bureau, December 7, 2023; Hamilton Lombard, "Since the pandemic, young adults have fueled the revival of small towns and rural areas," *StatChat* (University of Virginia Weldon Cooper Center for Public Service), September 17, 2024.

¹² Rolfe Winkler, Nate Rattner, and Sebastian Herrera, "Big Tech's \$400 billion AI spending spree just got Wall Street's blessing," *The Wall Street Journal*, July 31, 2025.

¹³ "AI power: Expanding data center capacity to meet growing demand," McKinsey, October 29, 2024.

concept in rail predictive maintenance have boosted fleet reliability by about 15 percent and lowered maintenance costs by roughly 20 percent.¹⁴ AI is also poised to facilitate the next wave of railroad evolution, including autonomous trains and AI-powered digital twins. Autonomous trains promise more efficient and continuous freight and passenger movement, while digital twins allow for real-time network optimization. Both of these developments have the potential to redefine how goods and people move in the coming decade.

The trucking industry could also see rapid change, as low-latency digital infrastructure could unlock autonomy in the coming years. The value chain for fully driverless heavy-duty fleets could generate about \$600 billion in revenue by 2035 across China, Europe, and the United States. In the United States, these vehicles could reduce shipping costs and shrink the projected shortfall of about 160,000 drivers by 2030. As 5G, edge data centers, and remote-operations control rooms mature, autonomous truck pilots can scale from short highway runs to full end-to-end distribution center runs.¹⁵

These examples illustrate a broader trend: across sectors of the economy, intelligent networks promise lower operating costs, higher asset utilization, and new revenue streams. But they also require significant capital, clean-energy sourcing, and public–private coordination. Any coordination between the public sector and investors will want to consider balancing the speed of rollout with security, sustainability, and long-term system resilience as the digital build-out accelerates.

The global transition to cleaner energy is progressing

The clean-energy transition is among the most substantial forces shaping infrastructure investment, with various cleantech deployments increasing notably from 2010 to 2023. Global installed terawatt capacity of wind and solar rose about 20 percent a year during that period, while the electric-vehicle fleet grew roughly 79 percent annually and the installed stock of heat pumps increased by about 6 percent a year.¹⁶

Net-zero pledges have also become more prevalent. Some 10,000 companies are members of the “Race to Zero” campaign to halve emissions by 2030, while two-thirds of Fortune 500 companies have made climate-related commitments.¹⁷ To meet global decarbonization targets, annual energy infrastructure investment will need to more than double by 2030, requiring large-scale funding for renewable energy generation, grid modernization, and energy storage.¹⁸ Innovation is advancing rapidly in key areas, including grid-scale battery storage, green steel production, next-generation nuclear power, and modular renewable energy systems such as distributed solar and hydrogen electrolyzers.

At the same time, varying regional policies are adding complexity. In the United States, for example, there is uncertainty around the longevity of both investment and production tax credits, along with unfolding tariff regimes on vital inputs such as solar modules and steel. These open questions may have played a role in the declines seen in first quarter 2025 renewable-finance volumes of about 40 percent for solar and 80 percent for energy storage compared with the prior year. Furthermore, some jurisdictions—most notably parts of Asia and Africa—continue to add gas- or coal-fired capacity or extend the life of existing plants to address immediate energy security concerns.¹⁹

Nevertheless, navigating the energy transition represents an economic opportunity, as countries and companies that invest early in next-generation energy systems could gain long-term competitive advantages.

¹⁴ Raphaëlle Chapuis, Leo Melnikov, and Nicola San, “The journey toward AI-enabled railway companies,” McKinsey, March 7, 2024.

¹⁵ “Will autonomy usher in the future of truck freight transportation?” McKinsey, September 25, 2024.

¹⁶ “The energy transition: Where are we, really?” McKinsey, August 27, 2024.

¹⁷ “The energy transition: Where are we, really?” McKinsey, August 27, 2024.

¹⁸ Cristen Hemingway, Jaynes, “IEA: Clean energy investment must reach \$4.5 trillion per year by 2030 to limit warming to 1.5°C,” World Economic Forum, September 28, 2023.

¹⁹ “China’s construction of coal-fired power plants reaches highest in a decade,” *Financial Times*, February 12, 2025; Malcolm Moore and Rob Rose, “A cautionary tale from south Africa’s ‘just energy transition,’” *Financial Times*, July 23, 2024.

Private capital has emerged as a key force in infrastructure financing but faces challenges

Over the past decade, private investors have played a pivotal role in infrastructure financing. Assets under management in dedicated infrastructure funds have tripled from roughly \$500 billion in 2016 to more than \$1.5 trillion today.²⁰ Although fundraising fell by 15 percent in 2024 compared with 2023, deal value rose 18 percent, making 2024 the second-highest year on record behind only 2022.²¹ Furthermore, nearly half (46 percent) of limited partners in a McKinsey survey expressed an intention to increase infrastructure allocations in the next year, attracted by infrastructure's predictable cash flows, inflation protection, and strategic alignment with digitalization and energy transition trends.²² Meanwhile, investors are committing large amounts of capital to single flagship funds, further evidence that limited partners are willing to back managers that can deploy capital at scale. That said, private capital still accounts for a minority share of total infrastructure investment, with the bulk of funding still derived from governments and public sources.

The mix of verticals seeing investments is changing, too, to reflect the new definition of infrastructure. The fastest-growing category is digital infrastructure, which has jumped to about 16 percent of global deal value as hyperscalers scramble for towers, fiber, and edge data center capacity. Renewables now account for roughly one-quarter of all transactions, cementing their place as a mainstream infrastructure allocation rather than a niche climate play. Traditional transport has shrunk from roughly 45 percent of deal value a decade ago to approximately 22 percent in 2024, while power and core energy hover in the low teens.²³ Investment across verticals—for example, at the nexus of energy and digital in the construction of data center campuses—has risen as well, due to increasing interdependencies.

However, private investors face challenges. Higher interest rates (which increase discount rates and compress returns), crowded auction processes, longer exit timelines, and evolving geopolitical dynamics are reshaping infrastructure valuations, fundraising momentum, and portfolio-level return expectations. At the same time, cross-border deals have been affected by evolving geopolitical relations and tightening investment controls in critical infrastructure verticals.

To ensure they capture the required returns for their limited partners, investors are experimenting with fresh ways to unlock value, particularly through value creation levers such as commercial excellence, platform roll-ups, and operational improvements. (Chapter 4 of this report will explore these levers in depth.)

The geopolitical landscape is upending investment decisions and trade

Infrastructure investment has become a strategic tool in global politics, with countries using large-scale projects to extend influence, secure resources, or reshape trade networks. One emerging example is the race to build national AI infrastructure—particularly sovereign data centers designed to keep sensitive data within borders, control access to compute resources, and assert digital autonomy.

In addition, resource security is playing a growing role as wealthier nations and corporations engage in land acquisitions in resource-rich regions, securing access to critical materials needed for energy, technology, and industrial production. Meanwhile, shifting global supply chains are driving investments in new trade corridors and transport infrastructure, particularly in Association of Southeast Asian Nations (ASEAN) manufacturing hubs and in industries linked to hydrogen-based energy and green ammonia production. As companies and nations seek to derisk supply chains, trends like nearshoring and friendshoring are reshaping global trade infrastructure, influencing where new investments are directed.

Meanwhile, global trade policy uncertainty has risen, due to increased tariffs. The World Trade Organization (WTO) estimated that higher tariffs could reduce global merchandise trade by roughly 1 percent next year.²⁴

²⁰ "Global Private Markets Report 2024: Private markets in a slower era," McKinsey, March 28, 2024.

²¹ "Global Private Markets Report 2025: Braced for shifting weather," McKinsey, May 20, 2025 (n = 333).

²² "Global Private Markets Report 2025: Braced for shifting weather," McKinsey, May 20, 2025 (n = 333).

²³ "Global Private Markets Report 2025: Braced for shifting weather," McKinsey, May 20, 2025 (n = 333).

²⁴ "WTO says tariffs could bring contraction of 1% in global merchandise trade volumes," Reuters, April 3, 2025.

At the same time, physical disruptions—including more than 100 shipping attacks near the Red Sea and drought-related restrictions in key waterways—have complicated trade logistics, extending supply routes and increasing transportation costs.²⁵

Ongoing labor shortages are affecting infrastructure projects

Labor shortages are causing major delays in infrastructure projects. More than half of construction firms in the United States report project delays due to worker shortages.²⁶ For example, high-profile investments such as Intel and TSMC's Arizona semiconductor fabrication facilities have cited skilled-labor gaps and cost overruns.²⁷ Projections for the United Kingdom indicate the need for more than 250,000 additional construction workers in the next five years.²⁸ A survey of construction companies in France found that labor shortages have been a leading factor limiting construction activities in recent years.²⁹

The gap is projected to grow in the coming years. Labor demand in the United States is forecast to peak in 2027–28, when infrastructure work could require about 350,000 additional workers in engineering, materials, and contracting.³⁰ Globally, the renewables sector alone must add about 2.8 million jobs by 2030 (1.1 million for construction and 1.7 million for operations and maintenance).³¹

Churn compounds the problem. Annual hiring for many craft roles far exceeds net job growth, inflating recruitment and training costs. Even with construction wages up more than 25 percent since early 2020 in the United States, employers struggle to attract talent because of lengthy training pipelines, waning interest among younger workers, and sharp regional imbalances.³²

Addressing these shortages will require several approaches, including achieving higher productivity through automation and modular methods, aggressive upskilling and retention programs, and expanded use of remote-operations technologies, such as tele-operated heavy machinery that allows skilled workers to manage equipment from centralized control centers. Investors and operators that tackle the talent gap early stand to gain cost, schedule, and reliability advantages.

This chapter has examined factors that have played a role in the fundamental redefinition of infrastructure—including some of the forces that introduce new challenges. With this context in place, we will next explore each of the seven infrastructure verticals in depth, both individually and at their intersections.

²⁵ Paulo Aguiar, "Houthis emerge from Red Sea crisis unscathed," *Geopolitical Monitor*, February 19, 2025; "Panama Canal traffic cut by more than a third because of drought," *Associated Press*, January 19, 2024.

²⁶ "2024 workforce survey analysis," *Associated General Contractors*, August 2024.

²⁷ Wen-Yee Lee, "TSMC's US plant unlikely to get latest chip tech before Taiwan, CEO says," *Reuters*, January 16, 2025; "Intel editorial: Intel addresses semiconductor workforce shortage," *Intel press release*, September 24, 2023.

²⁸ Mark Hillsdon, "Long on ambition, short on people: How the skills gap could scupper UK's bid to decarbonise buildings," *Reuters*, November 28, 2024.

²⁹ "Factors limiting building activity in France from 2005 to 2024, by type of constraint," *Statista*, January 29, 2025.

³⁰ "Will a labor crunch derail plans to upgrade US infrastructure?" *Recruiting News Network*, October 20, 2022.

³¹ "Renewable-energy development in a net-zero world: Overcoming talent gaps," *McKinsey*, November 4, 2022.

³² "Average hourly earnings of production and nonsupervisory employees, construction," *Federal Reserve Bank of St. Louis*, updated August 1, 2025; Ezra Greenberg, Erik Schaefer, and Brooke Weddle, "Tradespeople wanted: The need for critical trade skills in the US," *McKinsey*, April 9, 2024.

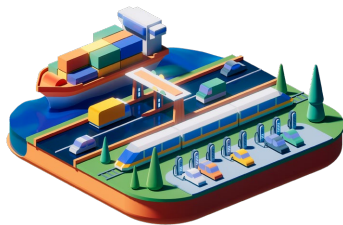
Chapter 3

A closer look at infrastructure verticals

While the trends reshaping infrastructure are apparent across verticals, they manifest differently depending on the context. When it comes to energy, for example, grid modernization and renewable integration are formative forces. Agriculture is affected by evolving global trade flows, technological innovation, and growing use of sustainable inputs and farming practices. This chapter examines how major trends and sector-specific developments are unfolding and where investment is flowing around seven foundational verticals: transportation and logistics; energy, power and resources; social infrastructure; digital infrastructure; agriculture; waste and water; and defense.

It also offers insights about the opportunities that exist where these verticals intersect. After all, with the evolving redefinition of infrastructure, these new intersections are where some of the most exciting innovations—and corresponding investment opportunities—are emerging.

Transportation and logistics



\$36T

estimated investment by 2040

Transportation and logistics consists of assets such as railways, highways, ports, airports, and canals, along with the systems that manage them.

Key takeaways

- Global transport infrastructure is straining under the weight of aging assets, rising demand, and evolving user expectations about technology.
- Climate regulation and operational benefits are pushing many governments and operators to shift capital to electrification, sustainable fuels, and infrastructure retrofits.

- Geopolitical risk and supply chain diversification are redrawing global trade routes, especially in Southeast Asia.
- Automation and AI are reshaping operations across ports, rail, and distribution hubs to boost productivity and address labor shortages.

Overview

The importance of the transportation and logistics vertical cannot be overstated. Consider, for example, that maritime transportation alone facilitates about 80 percent of global trade by volume.³³ This vertical consists of two interconnected layers: assets and the systems that manage them. Transportation assets—railways, highways, ports, airports, and canals—provide the physical capacity needed to move people and goods. Logistics systems, including terminal operators, customs corridors, third-party logistics providers (3-PLs), and digital freight platforms coordinate and optimize the utilization of the transportation assets.

Worldwide demand for transportation and logistics infrastructure exceeds capacity, due to population growth, rising construction costs, aging infrastructure, decarbonization targets, and the restructuring of global supply chains. Funding mechanisms in some countries have not kept pace with mounting infrastructure needs. Consider the US federal gas tax, which has remained fixed at 18.4 cents per gallon since 1993 even as construction costs and maintenance needs have grown. In inflation-adjusted terms, its real value has declined, reducing the funds available for public infrastructure.³⁴ We estimate that by 2040, cumulative investments needed to shore up transport infrastructure could reach \$36 trillion. Without this level of investment, regions could face more delays, higher shipping costs, and other barriers that make it harder and more expensive to move goods across borders, potentially slowing GDP growth.

Trends shaping transportation and logistics

Key trends in the transportation and logistics vertical involve aging infrastructure, decarbonization efforts, supply chain diversification, and increased deployment of automation and AI.

In many regions, existing infrastructure is deteriorating

Aging transportation infrastructure, often operating near or past its intended useful lifespan, presents significant safety and operational challenges. Roughly 43 percent of roads in the United States are in poor condition; likewise, 7.5 percent of bridges are structurally deficient.³⁵ The European Union faces similar challenges: one-third of French bridges maintained by the state need repairs,³⁶ while only about 65 percent of long-distance trains in Germany arrived on time in 2024, due in part to outdated and overloaded infrastructure.³⁷ To address these issues, mature economies are allocating more of their transportation capital spending to extend the lifespan of existing infrastructure.

Decarbonization goals require capital outlays but offer long-term benefits

The pressing need to modernize transportation infrastructure (and the desire to realize the advantages offered by the technology involved) coincides with aggressive global decarbonization targets that require low- or zero-emission transportation solutions. Shipping alone contributes 3 percent of global emissions,³⁸ prompting various responses. The European Union's FuelEU Maritime mandate calls for a 2 percent reduction in the greenhouse gas intensity of bunker fuel in 2025, which is further slated to become an 80

³³ *Review of maritime transport 2024: Navigating maritime chokepoints*, UNCTAD, October 22, 2024.

³⁴ "State gasoline taxes average about 30 cents per gallon," US Energy Information Administration, April 1, 2021.

³⁵ *2021 Report Card for America's infrastructure*, American Society of Civil Engineers, December 2020.

³⁶ Amy McLellan, "Urgent repairs needed to facilitate project moves," Breakbulk, April 2, 2019.

³⁷ Kieran Burke, "Over a third of Deutsche Bahn long-distance trains late," *DW* (Deutsche Welle), January 4, 2025.

³⁸ Mike Scott, "A sea-change for seafarers as the shipping industry gears up to decarbonise," Reuters, December 3, 2024.

percent reduction by 2050.³⁹ Similarly, the International Air Transport Association has committed to adopting sustainable aviation fuels to achieve net-zero emissions by 2050.⁴⁰

Transport operators face large capital outlays to adapt their fleets to emerging technologies such as sustainable aviation fuels, hydrogen propulsion, battery-electric solutions, and shore power that enables ships to shut off diesel engines when docked. Despite the cost of adaptation, each of these technologies also provides long-term operational benefits, including greater efficiency and reduced maintenance.

Supply chains are evolving as organizations seek diversification

Another trend has been the redrawing of global supply chains, driven by companies pursuing China-plus-one diversification and the need to address geopolitical and trade uncertainties. For example, Vietnam, together with Indonesia, attracted almost \$50 billion of greenfield manufacturing projects in 2023, which helped raise Southeast Asia's foreign direct investment in manufacturing by roughly 20 percent from 2019 levels.⁴¹ In response, Southeast Asian governments have announced investments of more than \$250 billion in ports and deep-water berths, rail, bonded logistics parks, and other transportation infrastructure to facilitate exports.⁴²

Automation and AI usage is increasing to address mounting operational pressures and labor shortages and to improve customer experience

Labor shortages are hitting the transportation and logistics vertical particularly hard, demonstrated by the shortage of roughly three million truck drivers across 36 countries in 2023⁴³ and a projected global shortage of about 90,000 seafarers projected by 2026.⁴⁴

Ports are responding by improving labor efficiency with automated guided vehicles to move containers and by increasing berth and yard productivity through advanced analytics and real-time planning. Many logistics and distribution hubs are employing digital signaling and robotic sorting. In rail, Deutsche Bahn has expanded digital maintenance efforts to speed up inspections, adopting AI-supported camera gates, robots, and measuring systems. The approach saves 20 hours of routine maintenance work per S-Bahn (metro) facility each day while reducing physically strenuous work.⁴⁵

Automation offers benefits beyond operational advantages for transportation systems. It also enhances the rider experience with smoother acceleration and braking patterns for more comfortable rides, and it enables shorter headways that allow for more frequent, convenient service. These benefits are now being realized at scale: Honolulu's Skyline became the first driverless urban rail system in the United States in 2023, and Riyadh launched the world's longest fully automated metro network in 2024.⁴⁶

³⁹ "Decarbonising maritime transport—FuelEU Maritime," European Commission, n.d.

⁴⁰ *Net zero 2050: Sustainable aviation fuels (SAF)*, fact sheet, International Air Transport Association, June 1, 2025.

⁴¹ "Diversifying global supply chains: Opportunities in Southeast Asia," McKinsey, September 5, 2024.

⁴² "Diversifying global supply chains: Opportunities in Southeast Asia," McKinsey, September 5, 2024.

⁴³ "Global truck driver shortage to double by 2028, says new IRU report," IRU, November 20, 2023.

⁴⁴ Lee Ying Shan, "The shipping industry is wrestling with one of its biggest challenges—seafarer shortages," CNBC, November 26, 2024.

⁴⁵ Karel Novak, "DB: AI overcomes shortage of skilled workers," *Rail Market News*, August 2, 2023.

⁴⁶ Adam Williams, "Saudi Arabia opens world's longest driverless transit system," *New Atlas*, December 2, 2024; "US' first fully autonomous urban railway system, built by Hitachi, opens in Honolulu," Hitachi news release, June 30, 2023.

Energy, power, and resources



\$23T

estimated investment by 2040

Power infrastructure consists of energy generation, transmission, and distribution assets.

Key takeaways

- Global energy needs are spiking, with developing countries accounting for 85 percent of new demand.
- Renewable projects are scaling rapidly and are poised to supply the majority of power generation.
- Stakeholders are focusing on fortifying vulnerable grids and investing heavily in new transmission infrastructure.
- Digital and decarbonization technologies are crossing into large-scale deployment, reshaping what is commercially viable in the next generation of power infrastructure.

Overview

Power infrastructure—including generation, transmission, and distribution assets—is expected to grow steadily, buoyed by a sustained acceleration of energy demand. This growing demand is driven by many factors, including the increasing electrification of households across the globe, construction of energy-thirsty hyperscale data centers, and broader industrial and economic growth in developing countries.

All told, energy demand is projected to increase by approximately 4 percent annually through 2027, with developing countries accounting for 85 percent of the figure.⁴⁷ Demand is rising even in developed countries, where consumption has been flat for nearly two decades. Consider the United States, where power demand—for decades near 3,800 terawatt-hours a year—is forecast to grow about 3.5 percent annually through 2040.⁴⁸ Our estimates suggest that meeting skyrocketing global needs will require 16.6 terawatts of generation and \$23 trillion or more of investment across transmission and distribution assets by 2040.

Trends shaping energy, power, and resources

Energy, power, and resources are seeing considerable impact from renewables, small modular reactors, and efforts to harden distribution networks for resilience. Other important drivers include investments in distribution infrastructure and increased commercial viability of new decarbonization and digital technologies.

Renewables like solar and wind are going mainstream

Low-carbon sources are poised to supply the majority of future power generation. Wind and solar already offer the lowest-cost greenfield generation in many regions, and other McKinsey research projects that clean electricity will account for 65 to 80 percent of global generation by 2050.⁴⁹ At the same time, corporate

⁴⁷ "Growth in global electricity demand is set to accelerate in the coming years as power-hungry sectors expand," IEA, February 14, 2025; Ben Geman, "Global electricity demand to rise 4% annually due to AI, other uses," *Axios*, February 14, 2025.

⁴⁸ Adam Barth, Humayun Tai, Ksenia Kaladiouk, Lawrence Heath, "Powering a new era of US energy demand," McKinsey, April 29, 2025.

⁴⁹ "Global Energy Perspective 2024," McKinsey, September 17, 2024.

buyers are currently locking in long-term power purchase agreements, and in many markets, unsubsidized rooftop solar now undercuts retail electricity prices for households.⁵⁰

Renewable projects—such as the Hollandse Kust Zuid in the Netherlands, the world’s first major subsidy-free offshore wind farm, delivering 1.5 gigawatts of power,⁵¹ and the 1.4 gigawatt Sofia wind farm in development in the UK North Sea—demonstrate how utility-scale renewables have moved from pilot to platform.⁵² These developments are not merely outliers; rather, they signal a systemic shift where next-generation renewables are being deployed at scale, financed by mainstream capital, and integrated into national grids. As this trend accelerates, the distinction between “traditional” and “renewable” power infrastructure is disappearing.

There’s momentum behind the construction of small modular reactors

Small modular reactors (SMRs) offer several advantages over traditional nuclear power plants. They can be deployed in locations without robust grid infrastructure and provide reliable, affordable, low-carbon power. Governments have been moving to take advantage of SMRs. Russia commissioned the world’s first commercial SMR in 2020.⁵³ China connected its high-temperature gas-cooled modular pebble bed reactor to the grid in 2023. In the United States, the Department of Energy recently relaunched a \$900 million funding initiative aimed at accelerating the deployment of SMRs.⁵⁴

The private sector is also leaning in, with major technology companies and investors exploring SMRs to meet rising demand for low-carbon, reliable energy. Amazon acquired a stake in X-energy, a US-based developer of SMRs in 2024,⁵⁵ while Kairos Power is building a test reactor in Tennessee with public-sector support from the Department of Energy (DOE) and the Tennessee Valley Authority.⁵⁶ These moves suggest growing confidence in SMRs as a future component of the clean energy mix.

Developed regions are hardening distribution networks for resilience

Low-voltage local distribution infrastructure is gaining focus and investment to ensure energy security and grid resilience. In developed regions, strengthening the grid has emerged as a priority in response to more frequent severe climate-related events.

Entergy Louisiana committed \$1.9 billion to bolster its distribution network by installing hardened utility poles and elevating substations, citing the increased frequency and intensity of storms.⁵⁷ Recent power outages at London Heathrow Airport and similar disruptions in Spain and Portugal further signal the urgency of upgrading distribution infrastructure.⁵⁸ Despite these pressing needs, critical grid investments often experience lengthy delays caused by regulatory hurdles and slow interconnection processes.

Stakeholders are investing heavily in new transmission infrastructure

As renewable generation grows rapidly in geographically dispersed locations, new high-voltage long-distance transmission infrastructure has become essential for delivering this energy to areas of demand. Enhanced transmission networks reduce grid congestion (which cost the United States, for example, an estimated \$20 billion in 2022),⁵⁹ minimize energy curtailment (the practice of reducing electricity output because of grid limitations), and enable cross-border electricity flows, improving grid reliability and energy security.

⁵⁰ “Residential solar: Down, not out,” McKinsey, February 3, 2025.

⁵¹ Philipp Roßkopf, “First power generated by Hollandse Kust Zuid offshore wind farm,” BASF news release, August 2, 2022.

⁵² “Vineyard Wind, America’s first large-scale offshore wind farm, delivers full power from 5 turbines to the New England grid,” State of Massachusetts press release, February 22, 2024; Sofia Offshore Wind Farm website.

⁵³ Juzel Lloyd, “The other nuclear race,” *Foreign Affairs*, April 28, 2025.

⁵⁴ “\$900 million available to unlock commercial deployment of American-made small modular reactors,” US Department of Energy press release, March 24, 2025.

⁵⁵ Neil Ford, “Big Tech contracts inject life into new nuclear,” Reuters, February 19, 2025.

⁵⁶ *Neutron Bytes*, “TVA to collaborate with Kairos Power on development of a 140 MWe advanced SMR,” blog post by djysrv, May 10, 2021.

⁵⁷ “Phase one of Entergy Louisiana’s comprehensive grid resilience plan approved by LPSC,” Entergy news release, April 20, 2024.

⁵⁸ Suman Naishadham and Joseph Wilson, “Spain says April blackout was caused by grid failures and poor planning, not a cyberattack,” Associated Press, June 17, 2025.

⁵⁹ Ethan Howland, “US grid congestion costs jumped 56% to \$20.8B in 2022: Report,” *Utility Dive*, July 14, 2023.

The United Kingdom has demonstrated how investments in the transmission grid can facilitate sustainable energy. Announced in March 2024, the National Grid Electricity System Operator's £58 billion plan would add a north-south high-voltage spine and subsea links intended to transmit more than 20 gigawatts of Scottish offshore wind to English users by 2035.⁶⁰ The move could reduce the amount of wasted energy that sources in Scotland were unable to transmit to end customers in England.

New decarbonization and digital technologies are increasingly commercially viable

Early-stage decarbonization ventures are now securing stable financing and moving beyond experimental phases toward large-scale, commercially viable operations. Occidental's Stratos project in Texas, one of the largest direct-air-capture plants to date, secured financing in 2023. It aims to remove 500,000 tons of CO₂ annually, supported by committed corporate offtake agreements with customers such as Microsoft.⁶¹

At the same time, digital technologies are enabling operators to become more efficient. Google and its Alphabet-backed Tapestry unit is partnering with PJM Interconnection to deploy generative AI tools that rapidly simulate thousands of grid scenarios, dynamically generating optimized scheduling plans and configurations. These technologies can accelerate grid planning and the integration of new renewable sources into the network.⁶²

Some operators are also turning to digital twins—real-time virtual replicas of transmission networks—to perform critical contingency studies in minutes, tasks that previously took days. Such advances help them manage complex grids, identify vulnerabilities quickly, and lower costs.

Digital infrastructure



\$19T

estimated investment by 2040

Digital infrastructure includes assets such as fiber networks, telecom towers, data centers, and satellites, as well as associated services like power supply management, cooling solutions, and maintenance services.

Key takeaways

- Digital infrastructure is now embedded in every other vertical and in varied sectors of the economy—including energy, transport, agriculture, and logistics—requiring integrated investment strategies.
- Demand for AI, video, and cloud services is fueling explosive growth in data centers, fiber, satellites, and subsea cables. Supply is struggling to keep pace.
- Power access is constraining data center construction, driving a wave of joint ventures at the intersection of energy and digital infrastructure.

⁶⁰ "ESO publishes 'Beyond 2030'—a £58bn investment plan in the future of Britain's energy system," National Energy System Operator, March 19, 2024.

⁶¹ "Microsoft agrees to purchase 500,000 tonnes of DAC carbon removal credits," 1PointFive press release, July 9, 2024; "Occidental and BlackRock form joint venture to develop STRATOS, the world's largest direct air capture plant," Occidental press release, November 7, 2023.

⁶² Laila Kearney, "Google deploys AI to speed up connections at PJM, largest US power grid," Reuters, April 10, 2025.

- Investments in data centers continue to grow, with private and public entities committing significant capital to expand compute capacity and meet rising demand.
- Governments and telecom operators are commissioning “sovereign-AI factories”—national GPU—cloud hubs that keep sensitive data and models within borders.

Overview

Digital infrastructure has become central to modern life. It includes assets such as fiber networks, telecom towers, data centers, and satellites, as well as infrastructure services like power supply management, cooling solutions, and maintenance services. These systems have transformed how society generates, processes, and shares information, democratizing education and knowledge access globally.

They are also critical to scaling next-generation technologies—such as generative AI, autonomous driving, and advanced computing—and to modernizing other infrastructure verticals. But today’s infrastructure is falling short of rising demand, with an estimated \$19 trillion in investment required by 2040 to meet these needs.

Trends shaping digital infrastructure

The digital infrastructure vertical is being shaped by accelerating AI data center construction and investment, boosted demand for fiber for data center expansion, rapidly expanding last-mile fiber optic infrastructure, and emerging subsea cable and satellite broadband infrastructure.

AI is accelerating data center construction—and investment

Artificial intelligence, especially gen AI, is driving a step change in demand for computing power, fueling a data center boom. As of mid-2024, 78 percent of organizations reported using AI in at least one business function, up from 55 percent in 2023. Gen AI adoption more than doubled from 33 percent to 71 percent in just over a year.⁶³ As organizations expand beyond text-based gen AI use cases into images, computer code, video, music, and more, data center capacity will need to scale.

Some of the incremental demand is explicitly earmarked for sovereign-AI workloads—tasks involving highly sensitive data that must remain within national borders for security, privacy, or regulatory reasons. A few examples:

- SoftBank is converting a former Sharp LCD plant in Osaka into a 150-megawatt AI-only facility that it will run with OpenAI, targeting Japanese public-sector and enterprise customers.⁶⁴
- Swisscom and Telenor have each launched NVIDIA-powered “AI factories” to let businesses train and host models entirely within national borders.⁶⁵
- G42 plans a five-gigawatt campus in Abu Dhabi that will host US hyperscalers and regional AI tenants,⁶⁶ while Saudi-backed HumAI is partnering with NVIDIA to build up to 500 megawatts of Blackwell-powered capacity as part of Vision 2030.⁶⁷

Significant private capital has been invested in data center capacity (approximately \$170 billion between 2020 and 2024), reflecting a shift in investors’ focus from other digital infrastructure asset classes such as towers and fiber. Data center deal value quintupled, from \$11 billion in 2020 to \$54 billion in 2024,

⁶³ “The State of AI: How organizations are rewiring to capture value,” McKinsey, March 12, 2025.

⁶⁴ Chris Penrose, “SoftBank and OpenAI to transform former Sharp LCD plant into major AI agent hub in Japan,” Nasdaq, March 13, 2025.

⁶⁵ “Leading European telcos build AI infrastructure with NVIDIA for regional enterprises,” NVIDIA, June 11, 2025.

⁶⁶ “G42 to lead a consortium with US partners to build 5GW UAE-US AI campus,” G42, May 15, 2025; “UAE and US presidents attend the unveiling of phase 1 of new 5GW AI campus in Abu Dhabi,” US Embassy and Consulate in the United Arab Emirates, May 17, 2025.

⁶⁷ “HumAI and NVIDIA announce strategic partnership to build AI factories of the future in Saudi Arabia,” NVIDIA, May 13, 2025.

representing an increase from a 16 percent share of total digital infrastructure investments to 47 percent over the same period.⁶⁸

Global data center demand is projected to more than triple by 2030, reaching anywhere from 171 gigawatts of IT power in a conservative projection to 298 gigawatts in an accelerated scenario.⁶⁹ Massive investments are already underway around the world:

- In India, the Adani Group plans to invest \$6 billion in data centers in the state of Maharashtra and \$10 billion in two additional one-gigawatt data centers.⁷⁰
- In Asia-Pacific, Blackstone-owned AirTrunk has invested billions of dollars to create data center locations across the region, with campuses already operational in Australia, Hong Kong, Japan, Malaysia, and Singapore.⁷¹
- In the United States, Microsoft is expected to invest approximately \$80 billion globally in data center development in 2025, with more than half of that allocated to US-based projects.⁷²

Rapid expansion of data centers in underserved metropolitan hubs is creating substantial new demand for fiber

Both hyperscale and co-location data centers are increasingly being developed in previously underserved metropolitan areas. As of December 2024, S&P estimated that roughly one-quarter of the 2,600 recently announced data centers globally will be built in cities currently lacking adequate connectivity.⁷³ This geographic shift is spurring substantial demand for high-capacity long-haul and metro fiber networks to connect these new data centers, ensuring the bandwidth and latency required for cloud computing, AI workloads, and other intensive digital applications.

Last-mile fiber-optic infrastructure is expanding rapidly to meet demand for high-bandwidth and low-latency services, but a connectivity gap remains

Services like video streaming, gaming, and AI depend heavily on fiber networks to deliver the high speeds and stable, low-latency connections required for seamless performance. Yet, as of 2024, an estimated 40 percent of the world's population still lacks access to fiber-based connectivity.⁷⁴

Investors and operators are creating vehicles to fund fiber, such as the Gigapower joint venture between AT&T and BlackRock launched in 2023.⁷⁵ The venture is aimed at expanding fiber access to about 1.5 million homes and businesses outside of the service areas that AT&T currently covers.⁷⁶

Nonetheless, hundreds of billions of dollars of additional investment will be needed to close the fiber connectivity gap globally, particularly in remote or economically developing regions where fiber economics struggle to scale.⁷⁷

Emerging subsea cable and satellite broadband infrastructure is extending global internet connectivity

More than 500 subsea cables already carry about 99 percent of international internet traffic, and subsea cables and satellite broadband infrastructure are expanding rapidly—particularly in underserved regions

⁶⁸ McKinsey Telecom Infrastructure Deals Engine (TIDE) asset.

⁶⁹ "AI power: Expanding data center capacity to meet growing demand," McKinsey, October 29, 2024.

⁷⁰ Matthew Gooding, "Adani could spend \$10bn on two data centers in India—report," Data Center Dynamics, April 23, 2025; Georgia Butler, "Adani Group to invest \$6bn in Indian data centers," Data Center Dynamics, January 18, 2024.

⁷¹ "Behind the deal: AirTrunk, data centers and Blackstone's digital infrastructure strategy," Blackstone, January 15, 2025.

⁷² *Microsoft on the Issues*, "The golden opportunity for American AI," blog post by Brad Smith, Microsoft, January 3, 2025.

⁷³ "AI infrastructure: a new growth avenue for telco operators," McKinsey, February 28, 2025; S&P Global Market Intelligence, accessed December 2024.

⁷⁴ Anton Lysenko, Tiago Silveira, and Manglam Tewari, "The keys to deploying fiber networks faster and cheaper," McKinsey, February 28, 2025.

⁷⁵ "Gigapower joint venture from AT&T and BlackRock launches, AT&T Fiber begins serving end-user customers through Gigapower's commercial wholesale open access platform," AT&T, May 11, 2023.

⁷⁶ Michael Soper, "AT&T-BlackRock fiber JV IDs initial wave of build markets," *Light Reading*, May 11, 2023.

⁷⁷ Gerardo de Geest, Lorraine Salazar, Eivind Tørstad, and Martin Wrulich, "Fiber opportunity: Four deal types for investors to consider," McKinsey, December 14, 2022.

such as Africa and Southeast Asia.⁷⁸ New large-scale builds are stretching farther and supporting more connectivity. The 2Africa cable, for example, will run about 45,000 kilometers and touch 33 countries, tripling Africa's bandwidth.⁷⁹ Project Waterworth, a planned 50,000-kilometer cable, aims to support both last-mile internet connectivity and AI-driven data center demand. It would link five continents and become the longest cable ever laid.⁸⁰

At the same time, low-Earth-orbit (LEO) satellite broadband is also gaining traction as a connectivity solution—not just for remote areas but increasingly as a viable alternative to fiber. SpaceX's Starlink constellation has launched over 8,000 operational satellites as of August 2025,⁸¹ and decreasing launch costs could facilitate mass deployment, especially in regions where terrestrial fiber remains economically impractical. In the United States, the National Telecommunications and Information Administration (NTIA) recently expanded its Broadband Equity, Access, and Deployment (BEAD) program to support not only fiber but also fixed wireless and LEO satellite technologies—reflecting a growing recognition of the role satellite will play in closing coverage gaps.⁸² In parts of Africa, Starlink is gaining traction in midsize cities, where fiber rollouts have lagged, emerging as an alternative to fixed broadband for urban, middle-class users seeking reliable connectivity.⁸³

⁷⁸ Elisabeth Braw, "Financial institutions should prepare for subsea cable sabotage," *Financial Times*, July 14, 2025.

⁷⁹ "2Africa," Submarine Cable Networks, accessed August 12, 2025; Najam Ahmad and Kevin Salvadori, "Building a transformative subsea cable to better connect Africa," *Engineering at Meta*, May 13, 2020.

⁸⁰ *Engineering at Meta*, "Unlocking global AI potential with next-generation subsea infrastructure," blog post by Gaya Nagarajan and Alex-Handrah Aimé, Meta, February 14, 2025.

⁸¹ Tereza Pultarova, "Starlink satellites: Facts, tracking and impact on astronomy," *Space.com*, August 1, 2025.

⁸² "Final guidance on BEAD funding for alternative broadband technology," US National Telecommunications and Information Administration, January 2, 2025.

⁸³ Manny Pham, "Satellites, Starlink and the race to connect Africa," *Developing Telecoms*, May 21, 2025; Emmanuel Nkansah, "Starlink faces overwhelming demand in African cities amid broadband shortages," *TechFocus24*, February 6, 2025.

Semiconductors as infrastructure

Powering the data centers that anchor today's digital infrastructure are semiconductors—tiny chips now being recognized as critical infrastructure in their own right. Once thought of as the engines of commercial products, they're now treated as strategic assets vital to national security, economic competitiveness, and technological sovereignty. That's because they serve as the enabling layer for almost every modern system, including defense, transport, energy grids, and industrial automation.

The COVID-era chip shortage and escalating geopolitical tensions exposed the fragility of global semiconductor supply chains and triggered a wave of national strategies to reshore production and scale domestic capacity. These include the US CHIPS and Science Act (featuring about \$53 billion in

incentives), the EU Chips Act (€43 billion),¹ and similar programs in India, Japan, and South Korea. Such efforts often involve direct subsidies for fabrication plants, long-term procurement guarantees, and co-investment in shared infrastructure such as clean energy, water treatment, and resources for workforce development.²

Semiconductor manufacturing also increasingly resembles infrastructure in both form and financing. Fabrication plants (fabs) require billions of dollars in up-front capital, rely on large-scale utilities like ultrapure water and stable electricity, and operate under long-term output contracts with anchor customers. In some cases, fabs are being delivered through leaseback or public–private partnership (PPP) models, blurring the line between industrial asset and public infrastructure.³

¹ Michelle Kurilla, "What Is the CHIPS Act?," Council on Foreign Relations, April 29, 2024; "European Chips Act," European Commission, July 23, 2025.

² Takaya Yamaguchi and Leika Kihara, "Japan unveils \$65 billion plan to aid domestic chip industry," *Reuters*, November 11, 2024; Heekyong Yang and Ju-min Park, "South Korea announces \$19 billion support package for chip industry," *Reuters*, May 23, 2024; Emily G. Blevins, Alice B. Grossman, and Karen M. Sutter, *Semiconductors and the CHIPS Act: The global context*, Congressional Research Service, September 28, 2023.

³ "Exploring new regions: The greenfield opportunity in semiconductors," McKinsey, January 29, 2024.

A common thread across all four trends is speed. Operators are racing to meet demand and stay ahead of the competition. AT&T, for example, has announced plans to double its US fiber footprint from 30 million today to 60 million in just five and a half years.⁸⁴ In today's market, the ability to build fast but smart is becoming as critical as capital itself.

Social infrastructure



\$16T

estimated investment by 2040

Social infrastructure includes essential facilities and services in four main categories: education, healthcare, civic facilities, and affordable housing.

Key takeaways

- Social infrastructure worldwide is aging, resulting in gaps between growing demand and existing capacity.
- Many governments are mandating stringent carbon reduction targets, spurring extensive retrofits and energy-efficient construction.
- Technological advancements in digital and modular construction present cost-effective solutions for budget-conscious governments.
- Fiscal constraints are compelling governments to adopt more innovative funding models, particularly public–private partnerships.

Overview

Social infrastructure comprises essential facilities and services that form the backbone of society. They affect citizens' daily lives across four main categories: education (schools and student housing), healthcare (hospitals, outpatient clinics, and care facilities), civic facilities (libraries, community centers, government offices, and stadiums), and affordable housing.

Many of these facilities worldwide are aging, creating gaps between growing demand and existing capacity. A May 2025 UN briefing estimated that 2.8 billion people globally live in inadequate housing conditions, and without decisive intervention, this figure could double by 2030.⁸⁵ At the intersection of housing and education, Europe alone has a shortfall of three million purpose-built student accommodation beds.⁸⁶

Rapid public infrastructure expansions in the Middle East ahead of major global events such as Expo 2020 Dubai have demonstrated how economic growth and infrastructure modernization can serve society

⁸⁴ "AT&T now reaches more than 30 million fiber locations," AT&T press release, June 10, 2025.

⁸⁵ "High-level dialogue on adequate housing for all: A focus on the next strategic plan of the United Nations Human Settlements Programme for the period 2026–2029," UN-Habitat, May 29, 2025.

⁸⁶ Nicole Sansom, "Europe's student housing shortage to reach 3.2 million over the next five years," JLL, June 7, 2024.

beyond basic needs. Conversely, numerous communities in Africa and Asia still lack access to essential infrastructure such as well-equipped schools and healthcare clinics. Even in the United Kingdom, hospitals are operating with outdated infrastructure and maintenance backlogs amounting to £13.8 billion.⁸⁷ Though the specific challenges are not uniform, every country is experiencing some level of social infrastructure need.

Trends shaping social infrastructure

Several trends are shaping this vertical, including aging infrastructure assets; supply constraints intensifying pressure on housing, healthcare, and education; the compelling impacts of climate change; increased public-private partnerships; and the use of digital and modular techniques in construction.

Aging infrastructure is prompting upgrades around the world

Aging physical assets essential to social infrastructure present serious safety and operational risks. Many educational, healthcare, and civic buildings constructed from the 1960s to the 1980s have exceeded their intended lifespans. The United Kingdom is actively replacing approximately 500 schools due to structural issues.⁸⁸ Similarly, Singapore's Ministry of Education has allocated substantial portions of its budget to upgrade school infrastructure.⁸⁹

Supply constraints intensify pressure on urban housing, healthcare, and educational infrastructure

Mass urbanization has increased pressure on housing, healthcare, and educational facilities. The United Nations estimates that 68 percent of people will reside in urban areas by 2050.⁹⁰ However, land scarcity in city centers, restrictive zoning laws, community opposition (known as “not in my backyard,” or NIMBY), cumbersome permitting processes, rising material and labor costs, and chronic shortages of skilled construction workers limit the supply of new facilities.

Meanwhile, aging populations with higher life expectancies are increasing demand for long-term care facilities and homes adapted for mobility. Additionally, smaller household sizes are boosting housing demand overall, even in the absence of population growth, in countries such as Japan and South Korea.⁹¹

Climate change is compelling governments to invest in more resilient infrastructure

Infrastructure investment for climate change adaptation is becoming increasingly critical as the scale and frequency of climate-driven disasters intensify. Since 1980, the United States alone has experienced 403 climate-related disasters causing more than \$1 billion each in damage, totaling over \$2.9 trillion (inflation-adjusted). Underscoring the accelerating threat, nearly half of these damages occurred within just the past decade (2015–2024).⁹² Globally, C40 estimates that by 2050, 800 million people could be living in cities exposed to sea-level rise exceeding half a meter, potentially causing annual economic losses of up to \$1 trillion from flooding alone.⁹³

Many governments worldwide are responding with mandatory measures to compel investment in resilient infrastructure. The state of Florida's stringent building codes for high-velocity hurricane zones require all new residential construction in vulnerable counties, such as Miami-Dade, to withstand wind speeds up to 156 to 186 mph, with mandatory use of impact-resistant glazing and reinforced structural elements.⁹⁴ Compliance is

⁸⁷ Laura Hughes, Anna Gross, and Sarah Neville, “NHS England develops new private finance model to fund capital projects,” *Financial Times*, June 12, 2025.

⁸⁸ “What we're going to permanently remove RAAC from schools and colleges,” UK Department for Education, February 8, 2024.

⁸⁹ “Enhancing school infrastructure to support the future of learning,” Singapore Ministry of Education, August 19, 2024.

⁹⁰ “68% of the world population projected to live in urban areas by 2050, says UN,” United Nations, May 16, 2018.

⁹¹ *Statistical handbook of Japan 2024*, Statistics Bureau of Japan, August 2024; Lee Kyung-min and Chunyu Yang, “What ails Korea's housing market?,” *The Korea Times*, October 24, 2021; Chad de Guzman, “Why experts say South Korea shouldn't just throw cash at its low birth rate problem,” *Time*, April 3, 2024.

⁹² “U.S. billion-dollar weather and climate disasters (2025),” National Centers for Environmental Information, January 10, 2025.

⁹³ “Sea level rise and coastal flooding,” C40 Cities, July 4, 2025.

⁹⁴ Florida Building Code, Chapter 16: Structural Design, Florida Building Commission, 2010.

strictly enforced through the building permit process. These regulations underscore a growing recognition that proactive investment in retrofits, resilience, and energy-efficient construction is no longer optional but now necessary to safeguard communities, including their current and future assets.

Financial constraints are spurring the use of public–private partnerships

Public–private partnerships (PPPs) involve private entities partially or completely funding infrastructure investments in exchange for assured long-term government payments. Several developed countries, such as Canada and various European nations, have historically relied on these kinds of partnerships for social infrastructure.⁹⁵

While PPPs have long been used in the United States for transportation and energy projects, their application to social infrastructure is a more recent and growing trend. The University of California campus expansion in the city of Merced exemplifies this model. UC Merced partnered in 2020 with the Plenary Group and other private entities in a 39-year PPP to expand student housing and academic facilities, with Plenary Group contributing \$590 million of the \$1.3 billion project.⁹⁶

PPPs are also becoming prevalent in Africa and the Middle East. Countries including Egypt, Malawi, and Saudi Arabia have adopted them to develop healthcare and educational facilities.⁹⁷

Digital and modular techniques are reducing construction costs

Technological advancements in digital and modular construction present cost-effective solutions for budget-conscious governments. Innovations such as sensor technology, digital twins, and modular building techniques can help reduce operational expenses and project completion timelines. Singapore’s Housing Development Board (HDB) employs modular construction with prefabricated technology, enabling quicker, more economical, and sustainable housing developments to address shortages.⁹⁸ It also pilots advanced technologies such as 3D printing and smart building inspections using drones and AI to enhance construction efficiency.⁹⁹

Nevertheless, construction remains one of the least digitized and automated industries globally, with average IT spending historically nearly 2 percent of revenue, less than a third of the rate for industries like automotive and aerospace.¹⁰⁰ Varied project scopes, tight timelines, limited early-stage budgets, and teams’ reluctance to pilot innovations for the benefit of future undertakings have further hindered the industry’s ability to scale productivity improvements.¹⁰¹ These factors contribute to construction projects frequently taking 20 percent longer than planned and exceeding their budgets by up to 80 percent.¹⁰² Achieving the full potential of digital and modular construction methods will require industry-wide collaboration, increased investment, and sustained attention to workforce training and technological adoption.

⁹⁵ “Transportation and Infrastructure Committee transcript,” Government of Canada, March 2024; “Public–private partnerships financed by the European Investment Bank from 1990 to 2023,” European Investment Bank, April 29, 2024.

⁹⁶ “Project funding,” University of California Merced, July 16, 2020.

⁹⁷ “German–Egyptian healthcare education partnership launched,” German Health Alliance, April 2025; Milward Tobias, *A case study of public private partnerships in the health sector in Malawi*, EQUINET, May 2020; “How Vision 2030 is reshaping healthcare in Saudi Arabia,” Dynamic Health Staff blog post, October 28, 2024.

⁹⁸ “Prefabrication technology,” Singapore Housing & Development Board, accessed August 12, 2025.

⁹⁹ “Building future-ready homes,” Singapore Housing & Development Board, September 2019.

¹⁰⁰ Procore Technologies initial public offering prospectus, registration number 333-236789, Securities and Exchange Commission, May 19, 2021.

¹⁰¹ Jan Mischke, Kevin Stokvis, Koen Vermeltfoort, and Birgit Biemans, “Delivering on construction productivity is no longer optional,” McKinsey, August 9, 2024.

¹⁰² Rajat Agarwal, Shankar Chandrasekaran, and Mukund Sridhar, “Imagining construction’s digital future,” McKinsey, June 24, 2016.

Waste and water



\$6T

estimated investment by 2040

Waste and water infrastructure includes assets and services related to waste management, wastewater systems, drinking-water systems, and stormwater management.

Key takeaways

- Waste volumes are accelerating, with municipal solid waste expected to double by 2050.
- Technology such as AI-powered sorters, route optimization software, and tech-enabled brokers are improving efficiency and creating new value pools in waste collection, recycling, and advisory services.
- Governments are pouring record funding into upgrading aging systems as more than two billion people lack safe drinking water and 3.5 billion go without proper sanitation.
- Industrial water needs are reshaping investment, with industries like semiconductors, pharmaceuticals, and data centers driving demand for ultrapure, uninterrupted supply.

Overview

Waste and water infrastructure spans an array of systems and touches almost every sector of the economy, as well as the other six infrastructure verticals. Waste includes but is not limited to municipal trash collection, commercial waste handling, recycling operations, and waste-to-energy plants. The water vertical comprises three interconnected systems:

1. drinking water infrastructure, which includes raw-water sourcing, desalination plants, traditional filtration processes, and extensive distribution networks that deliver potable water to end users
2. wastewater systems, such as municipal sewer systems, industrial wastewater treatment, sewage plants, and sludge processing and disposal
3. stormwater management, including runoff capture, drainage, and flood prevention

Both waste and water require substantial investment—an estimated \$6 trillion by 2040, according to our estimates. In waste, environmental-sustainability pressures, public-health concerns, and stricter regulations are driving the need. As urbanization and consumption accelerate, global waste volumes are rising rapidly. Municipal solid-waste generation is expected to double from 2.1 billion tons in 2023 to 3.8 billion tons by 2050.¹⁰³

Despite these trends, global recycling and composting rates remain inconsistent. The United States, for example, recycles only about 30 percent of its municipal waste, compared with about 50 percent across Europe.¹⁰⁴

¹⁰³ *Global waste management outlook 2024*, UN environment programme (UNEP), February 28, 2024.

¹⁰⁴ “National overview: Facts and figures on materials, wastes and recycling,” US Environmental Protection Agency, November 8, 2024; “Municipal waste statistics,” Eurostat, January 2025.

A key challenge drawing increased attention is the growing share of organic waste, which accounts for at least of 50 percent of waste globally—exceeding the combined total of plastics, paper, metals, and glass—and requires specialized treatment approaches.¹⁰⁵ More than \$2 billion in US private capital has been invested since 2020 in composting and anaerobic digestion infrastructure. More broadly, capital is flowing into advanced processing facilities, upgraded collection fleets, engineered landfills, and expanded waste-to-energy capacity.

All three water segments face pressing investment needs, especially upgrades to aging pipelines and sewer systems, many of which date back several decades. And, crucially, a large swath of the world's population still lacks access to clean drinking water. Despite worldwide spending on water infrastructure exceeding \$1.3 trillion, more than two billion people lacked access to safe drinking water as of 2022. About 3.5 billion go without proper sanitation services.¹⁰⁶ Even developed economies face substantial challenges. For example, the latest US ASCE Infrastructure Report Card awarded drinking-water systems a C– grade, while wastewater infrastructure scored a D+, underscoring prolonged underinvestment and maintenance delays.¹⁰⁷

Among infrastructure verticals, waste and water—waste in particular—stands out for its distinctly localized nature. In waste, for example, collection rules, recycling targets, tipping fees, and regulatory approvals vary considerably at the municipal level. To be successful, operators and investors must combine global expertise and financial resources with local regulatory insights.

Waste: Trends shaping the vertical

A number of trends have emerged in waste, including a rising number of jurisdictional recycling mandates, increasing challenges associated with solid waste disposal, and emerging technologies that are making operations more efficient.

Mandatory recycling is increasingly the rule in many jurisdictions

Recycling requirements are growing. The EU Waste Framework Directive, for instance, requires the region to reach a 65 percent municipal waste recycling rate by 2035.¹⁰⁸ Other initiatives such as bans on single-use plastics, producer responsibility rules, and higher landfill taxes are also steering capital to innovative recycling and hazardous-waste treatment methods, such as chemical recycling, that could boost recycling rates. The United Kingdom, for example, raised landfill taxes by 21 percent in April 2025.¹⁰⁹

Solid-waste disposal is increasingly challenging

Landfills in some densely populated regions are approaching their permitted limits. For example, a 2023 analysis by the New York State Department of Environmental Conservation found that 25 of its municipal solid-waste landfills had only about 16 to 25 years of remaining capacity.¹¹⁰ Similarly, incineration plants in several regions are nearing full utilization. In 2022, the state of Connecticut had to divert some waste to other states because local incinerators were operating at full capacity.¹¹¹

¹⁰⁵ Kaza et al., *What a waste 2.0: A global snapshot of solid waste management to 2050*, World Bank Group, September 20, 2018; Mark Hillsdon, "The Global South cities getting to grips with methane pollution from organic waste," Reuters, May 29, 2024.

¹⁰⁶ *Global water security and sanitation partnership: Annual report 2023*, World Bank Group, November 16, 2023.

¹⁰⁷ *Drinking water*, 2025 Report Card for America's Infrastructure, June 27, 2025.

¹⁰⁸ "Waste framework directive," European Commission, accessed August 12, 2025.

¹⁰⁹ "Landfill tax increase and its impact on UK residents and businesses," W&S Recycling, April 2, 2025.

¹¹⁰ *New York State solid waste management plan*, New York State Department of Environmental Conservation, February 2023.

¹¹¹ *2022 solid waste disposal and diversion report*, State of Connecticut Department of Energy and Environmental Protection, 2022.

This disposal challenge is far from unique to the United States. Singapore, for example, projects full capacity of its only offshore landfill by 2035.¹¹² Densely populated Japan projected in 2018 that it could run out of landfill space by 2038.¹¹³

Municipalities globally are responding by investing in composting sites, transfer stations, and specialized recycling plants for materials like plastics, organics, and electronic waste.¹¹⁴ New York City, for instance, invested about \$100 million in the Sunset Park Material Recovery Facility in Brooklyn, one of the largest and most advanced recycling centers in the country. This raised the plant's recycling capacity and reduced the city's reliance on landfills.¹¹⁵

New technology is making waste operations more efficient

Waste infrastructure is becoming more intelligent, thanks to a wave of new technologies and expanded services. Technologies like machine-vision-guided optical sorters, route optimization software, and drone-based landfill capacity monitoring are helping operators improve efficiency and reduce costs. For example, Waste Management, a major US-based waste services firm, has implemented advanced logistics software to optimize its national collection fleet, leading to reduced mileage and fuel consumption, higher profit margins, and improved on-time service and driver safety.¹¹⁶

Some companies are using technology that facilitates vertical integration, enabling them to capture more value from waste management and recycling and to reduce landfilling. Republic Services, for example, has adopted sophisticated sorting technology at its Polymer Center in Las Vegas. This 71,000-square-foot facility uses near-infrared optical sorting to separate mixed curbside plastics into high-quality recycled materials.¹¹⁷

Leading waste management companies are also expanding their business models, diversifying not only into adjacent arenas like on-site waste-to-energy solutions but also into related services such as industrial cleaning and waste management advisory roles. Also, a new generation of tech-enabled waste brokers is on the rise. These specialists help waste-generating businesses and municipalities negotiate improved recycling arrangements, identify recyclable materials within waste streams, and connect clients with specialized recycling facilities.

Water: Trends shaping the vertical

The water vertical is seeing impact from a number of trends, including substantial investments in aging water infrastructure, growing industrial demand for reliable water sources, and adoption of advanced water treatments driven by tighter regulation.

Upgrading aging water infrastructure is spurring big investments

Record levels of public funding are flowing into water infrastructure worldwide. The 2021 Bipartisan Infrastructure Law in the United States dedicated more than \$50 billion—the largest federal water allocation in history—to drinking-water, wastewater, and stormwater upgrades.¹¹⁸ Similarly, the European Union's 2021–27 Cohesion Policy programs set aside €16.9 billion to modernize water supply and treatment networks.¹¹⁹

¹¹² "Semakau landfill: 20th anniversary," *Envision Lite* (Singapore National Environment Agency), July 2020.

¹¹³ "Too much waste straining Japan's limited landfill space," *Nippon.com*, October 9, 2018.

¹¹⁴ "Malaysia waste management," International Trade Administration, March, 29, 2024; "Municipal solid waste generation and disposal in FY 2022," Japan Ministry of the Environment, March 28, 2024.

¹¹⁵ *Green Economy Action Plan*, New York City Economic Development Corporation, February 28, 2024.

¹¹⁶ Kristin Broughton, "Waste Management boosts profit margins by rerouting and replacing trash trucks," *The Wall Street Journal*, May 2, 2024.

¹¹⁷ Kate Bertrand Connolly and Rick Lingle, "Polymer center drives bottle-to-bottle circularity," *Plastics Today*, August 5, 2024.

¹¹⁸ "Water infrastructure investments," US Environmental Protection Agency, July 14, 2025.

¹¹⁹ "New data story—water and sustainable water management," European Commission, June 17, 2024.

Emerging economies are following suit. India raised its rural Jal Jeevan Mission budget to 67,000 crore (about \$7.5 billion) in fiscal year 2025–26 and extended the program to 2028 to deliver universal access to tap water.¹²⁰ Singapore's national water agency, PUB, is leading phase two of an ambitious “used-water super-highway,” the Deep Tunnel Sewerage System.¹²¹

Commitments like these show unprecedented investment among both developed and developing economies to replace aging water distribution systems, upgrade wastewater plants, and strengthen storm drainage infrastructure.

Industrial demand for reliable water resources is growing

Even brief operational interruptions can prove costly for industries such as semiconductor manufacturing, pharmaceuticals, and data centers. These industries increasingly depend on reliable water sources through desalination, advanced reuse technologies, and ultrapure water systems.

Semiconductor manufacturing, for example, needs clean water to rinse wafers during the production process. The industry globally already consumes as much water as Hong Kong, a city of 7.5 million people.¹²² With new semiconductor fabrication facilities opening in water-scarce regions like the US state of Arizona, the city of Shanghai, and across Taiwan, the demand for access to ultrapure water will only grow.¹²³

Tighter regulation is driving adoption of advanced treatments

Stricter rules targeting per- and polyfluoroalkyl substances (PFAS), heavy metals, and nutrient pollution are spurring adoption of advanced treatments like ion exchange, reverse osmosis (RO), and thermal sludge drying. For example, the groundwater replenishment system for Orange County, California, uses a multibarrier train of microfiltration, RO, and ultraviolet light with hydrogen peroxide advanced oxidation to satisfy the Environmental Protection Agency's (EPA's) 2024 national PFAS drinking-water rule.¹²⁴

On the wastewater side, EU plants are adding tertiary nutrient-removal stages—including enhanced biological phosphorus removal—to meet the region's tighter 2024 Urban Wastewater Treatment Directive.¹²⁵

Water credit markets are taking shape in parallel. In May 2025, Louisiana certified its first pollutant reduction credit under a statewide water quality trading program.¹²⁶ The February 2025 international Act4Water standard expanded a voluntary market for “Positive Water Credits” that finance projects restoring flow and water quality.¹²⁷

¹²⁰ “Budget outlay for Jal Jeevan Mission enhanced to RS. 67,000 crore,” India Ministry of Finance, February 1, 2025.

¹²¹ “Black & Veatch and AECOM win iconic Singapore water project,” AECOM press release, June 3, 2014.

¹²² Dan Robinson, “Water worries flood in as chip industry and AI models grow thirstier,” *The Register*, February 29, 2024.

¹²³ Kristen James, “The water challenge for semiconductor manufacturing and big tech: What needs to be done,” World Economic Forum, July 19, 2024; Elizabeth Wishnick, “China's thirsty chips,” *CNA*, January 5, 2024.

¹²⁴ Alex Cossin, “Key takeaways from U.S. EPA's potable reuse and PFAS Q&A document,” *WaterWorld*, January 9, 2025; Mallory Moench, “EPA imposes limits on ‘forever chemicals’ in drinking water,” *Time*, April 10, 2024.

¹²⁵ “Urban wastewater: Council adopts new rules for more efficient treatment,” Council of the European Union, November 5, 2024.

¹²⁶ *Between the Lines*, “Water quality trading/Louisiana Department of Environmental Quality: First pollutant reduction credit is certified,” blog entry by Walter G. Wright, Mitchell Williams PLLC, June 15, 2025.

¹²⁷ “Act4water launches global standard for water compensation,” PR Fire, February 27, 2025.

Agriculture



\$5T

estimated investment by 2040

Agricultural infrastructure consists of assets supporting the production and processing of food and food-based products, such as irrigation canals, grain silos, cold storage facilities, and processing plants.

Key takeaways

- Population growth and climate change are driving the need for infrastructure investment across the agricultural value chain.
- Land consolidation and expanded irrigation infrastructure (for example, wells, drip systems) are emerging as key resilience strategies amid climate volatility.
- Adoption of precision agriculture and biologics is accelerating at large US and Latin American farms but remains uneven globally, due to cost and infrastructure gaps.
- Modern supply chain tools such as IoT-equipped silos and digital agronomy platforms are helping to reduce post-harvest losses.
- Incremental demand for crop-based biofuels offers agriculture new opportunities that are particularly important for those affected by geopolitical and trade flow shifts.

Overview

Agricultural infrastructure—including irrigation canals, grain silos, cold storage facilities, and processing plants—remains critical yet underdeveloped globally. With global population projected to grow from eight billion today to about nine billion by 2040,¹²⁸ demand for food will continue to increase. At the same time, rising incomes are shifting dietary preferences toward protein-rich foods, which are much more input-intensive than plants.¹²⁹ This demand is further complicated by competing land uses (for example, biofuels, bioplastics, animal feed) and growing reliance on global trade. For example, the mismatch between food supply and demand is most acute in sub-Saharan Africa, which is projected to account for two-thirds of global population growth by 2040 yet only 13 to 19 percent of global agricultural production growth.¹³⁰

Meanwhile, increasing the food supply is challenging. About 13 percent of all food harvested globally is lost before reaching retail, primarily because of inadequate drying, storage, and transportation systems.¹³¹ By 2050, climate change is expected to double or triple the likelihood of weather events that reduce yields.¹³² Overcoming these and other obstacles will require substantial, sustained infrastructure investment across

¹²⁸ "Current world population: 8,005,176,000," World Population Review, accessed August 12, 2025; "Demographics and human development," US Office of the Director of National Intelligence, March 2021.

¹²⁹ Christopher D. Gardner et al., "Maximizing the intersection of human health and the health of the environment with regard to the amount and type of protein produced and consumed in the United States," *Nutrition Reviews*, February 2019, Volume 77, Number 4.

¹³⁰ "Demographics and human development," US Office of the Director of National Intelligence, March 2021; *OECD-FAO Agricultural Outlook 2025–2034*, Organisation for Economic Co-operation and Development (OECD), July 15, 2025.

¹³¹ "International Day of Awareness of Food Loss and Waste (IDAFWL)," UN Food and Agriculture Organization, September 29, 2025.

¹³² "Will the world's breadbaskets become less reliable?" McKinsey Global Institute, May 18, 2020.

the agricultural value chain, including in advanced field machinery, resilient irrigation systems, and increased storage and processing capabilities to prevent spoilage. Our estimates project that as much as \$5 trillion in investment is required by 2040.

Trends shaping agriculture

Trends shaping the agriculture vertical include transformative smart farming and precision equipment, increased use of sustainable inputs and farming practices driven by climate concerns, supply chain modernization aimed at reducing post-harvest losses, new market opportunities for agricultural products, and shifts in national security and trade policies that are reshaping trade flows.

Smart farming and precision equipment are beginning to transform agricultural practices in some regions

Adoption of agricultural technology (agtech) is accelerating, particularly in the United States: 61 percent of US farmers use digital agronomy tools, 51 percent use precision agriculture hardware, and 38 percent use remote-sensing technologies.¹³³ Such technologies can lower costs, raise crop yields, and reduce diesel fuel consumption. At one global supplier of agricultural inputs, replacing traditional intuition-based forecasting methods with machine-learning models utilizing weather forecasts, satellite imagery, and sales information reduced logistics and return costs by 8 to 10 percent, released \$20 million to \$30 million in working capital, and improved service reliability by 10 to 20 percent.

While digital agronomy and precision hardware are the top two agricultural technologies globally, agtech adoption levels differ among regions.¹³⁴ North America and Latin America are seeing the fastest growth, but uptake in Europe has softened slightly since 2022, and adoption in India remains very low. These differences often reflect local infrastructure readiness, cost barriers, and differing return profiles across farm sizes and crop types. Even in the United States, adoption is highly correlated with scale: US farms of more than 2,500 acres are 45 percent more likely to adopt agtech than farms smaller than 100 acres, reflecting the higher potential for better returns at larger operations.¹³⁵

As a result, scale has become increasingly important, both for improving efficiency and for building climate resilience. In many markets, this has accelerated land consolidation, as larger operations are better positioned to adopt precision tools, which can translate into greater ability to weather climate shocks. Large-scale farms in Australia have leveraged consolidation to invest in drought-resilient strategies—such as climate-hardy crop varieties, precision irrigation systems, and water storage infrastructure—helping them maintain productivity through extreme conditions that smaller farms often struggle to withstand.¹³⁶

Climate concerns and cost-saving innovations are increasing the use of sustainable inputs and farming practices

Sustainable inputs and farming practices are gaining momentum. Innovations such as biologics (natural, biological-based inputs that either complement or substitute for chemical fertilizers), methane-reducing animal feed additives, and solar-powered irrigation pumps can help reduce environmental impact and operational costs.

For example, biological crop protection products (“biocontrols”) are growing incrementally, even in a challenging market environment. Globally, their use among farmers rose from 15 percent in 2022 to 20 percent in 2024, driven by higher efficacy and ROI compared with conventional chemicals and by growing

¹³³ “Global farmer insights 2024,” McKinsey, March 20, 2025.

¹³⁴ “Global farmer insights 2024,” McKinsey, March 20, 2025.

¹³⁵ “Global farmer insights 2024,” McKinsey, March 20, 2025.

¹³⁶ Neal Hughes, David Galeano, and Steve Hatfield-Dodds, “The effects of drought and climate variability on Australian farms,” *Abares Insights*, December 2019, Issue 6.

pressure for more sustainable practices. The momentum will likely continue: About 90 percent of growers say they will maintain or increase their spending on biologicals.¹³⁷

Irrigation infrastructure has also become a top investment priority, as climate change intensifies water scarcity across key growing regions. Resilient farming will require a mix of solutions, including canals, wells, drip systems, and solar-powered pumps. Countries investing in diversified irrigation—such as Israel (drip), Brazil (pivot), and India (solar)¹³⁸—have seen improvements in yields and water-use efficiency. For example, drip irrigation alone can cut water use by 40 to 70 percent compared with traditional methods.¹³⁹ Despite these advances, less than 10 percent of cultivated land in Africa is irrigated, compared with 39 percent in South Asia,¹⁴⁰ highlighting a major infrastructure gap.

Supply chain modernization is underway and helping to reduce post-harvest losses

While post-harvest losses have increased, due to more frequent extreme weather events and global supply chain disruptions, technologies like IoT-enabled grain silos can monitor temperature and humidity to minimize spoilage from poor storage conditions. Meanwhile, AI-driven platforms such as AgriDigital—which originated in Australia—help farmers digitally manage contracts, monitor inventory, and connect with buyers in real time. They use predictive analytics to optimize pricing, match supply with demand, and coordinate logistics.¹⁴¹

Additionally, though their adoption remains nascent, traceability tools and measurement, reporting, and verification (MRV) systems are gaining momentum in agricultural supply chains, especially in areas like organic or regenerative grains. This enables producers to ensure food safety, track product origin, validate sustainability claims, and access premium markets.¹⁴²

New market opportunities for agricultural products are emerging

Traditional commodity-focused operations are evolving as new end use markets emerge. Policy-driven products, such as soy-based sustainable aviation fuel (SAF), are driving the development of new processing capabilities. The European Union agreed in 2024 to subsidize airlines' purchases of 200 million liters of SAF annually, representing about 15 percent of global SAF production, to accelerate the shift from traditional kerosene. Such policies could provide some guaranteed demand, potentially derisking investments into agricultural infrastructure required for SAF production and processing.¹⁴³

The US EPA's draft Set 2 rule for 2026 and 2027 would raise the biomass-based diesel mandate by about 75 percent, from 3.35 billion gallons in 2025 to 5.86 billion gallons in 2027, while cutting by 50 percent the number of renewable identification numbers (RINs) that can be generated per gallon of fuel or feedstock of foreign origin. The rule is meant to curb reliance on imports, which in 2024 supplied roughly 45 percent of total biomass-based diesel feedstocks and finished fuels, thereby redirecting new demand to US-grown soybeans.¹⁴⁴

¹³⁷ "Global farmer insights 2024," McKinsey, March 20, 2025.

¹³⁸ Max Kaplan-Zantopp, "How Israel used innovation to beat its water crisis," *Israel21c*, April 28, 2025; Edson Eyji Sano et al., "Spatio-temporal dynamics of center pivot irrigation systems in the Brazilian tropical savanna (1985–2020)," *Water*, July 2024, Volume 16, Number 13; "140 MW solar power plants set up, 2.73 lakh stand-alone solar pumps installed under PM-KUSUM: Union power and new and renewable energy minister," India Ministry of New and Renewable Energy press release, December 12, 2023.

¹³⁹ Siobhan Fathel, "Drip irrigation can save energy and money," *Farms.com*, October 21, 2020.

¹⁴⁰ *Africa Up Close*, "Investing in irrigation for agriculture productivity in Africa," blog entry by Francis Kobina Appiah Abrebrese, October 4, 2017.

¹⁴¹ Emma Williams, "Leveling the field for grain businesses: Easy-to-use software for competitiveness and community building," *AgriDigital*, April 26, 2023.

¹⁴² Nainsi Gupta et al., "Evaluating traceability technology adoption in food supply chain: A game theoretic approach," *Sustainability*, January 2023, Volume 15, Number 2; "MRV Platform for Agriculture (AgMRV)," CGIAR Research Program on Climate Change, Agriculture and Food Security; "Digitization revolutionizes agriculture: How Farmerline's Mergdata traceability tool saves the environment," *Farmerline*, November 30, 2023.

¹⁴³ Kate Abnett, "EU to subsidise high-volume greener aviation fuel to boost airline demand," *Reuters*, June 12, 2025.

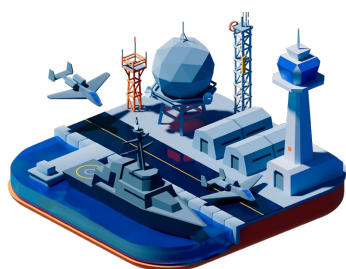
¹⁴⁴ Cole Martin and Matthew Cope, "EPA proposes record US biofuel mandates, foreign limits," *Argus Media*, June 13, 2025; "EPA proposes new renewable fuel standards to strengthen U.S. energy security, support rural America, and expand production of domestic fuels," US Environmental Protection Agency press release, June 13, 2025.

More broadly, policy momentum for ethanol mandates and low-carbon fuels is accelerating. Japan has adopted a nationwide E10 mandate (10 percent ethanol blend),¹⁴⁵ while Brazil continues to expand its domestic ethanol production,¹⁴⁶ supported by a mature sugarcane-processing industry. Proposed increases to Renewable Fuel Standard (RFS) volume requirements in the United States are creating structural tailwinds for soybeans, a key feedstock for biodiesel and renewable diesel.¹⁴⁷ Downstream, agricultural residues such as sugarcane bagasse and animal waste are increasingly being converted into high-value outputs like second-generation ethanol (E2G), biomethane, and biofertilizers—an emerging “bio to x” trend that enhances value capture and supports circular agriculture.¹⁴⁸

Shifts in national security priorities and trade policies are reshaping global agricultural trade flows

Security concerns and various policies are affecting global trade. China has diversified its protein imports since 2016, significantly reducing pork imports from the United States, and increasingly sourcing pork, beef, and poultry from Brazil.¹⁴⁹ Despite such trade fluctuations, the overall reliance on agricultural trade is poised to increase as production becomes increasingly concentrated in a few exporting countries. Just five countries—the United States, Brazil, Argentina, Ukraine, and Russia—account for over 85 percent of global maize exports.¹⁵⁰ Similarly, just five countries—India, China, Bangladesh, Indonesia, and Vietnam—produce 73 percent of the world’s rice. This high concentration increases potential supply risks and underscores the importance of stable international trade flows.

Defense



\$2T

estimated investment by 2040

Defense infrastructure comprises physical assets critical to national security, military operations, and defense logistics.

Key takeaways

- Military assets like airfields, naval bases, radar sites, secure communication hubs, and on-base energy systems are increasingly treated as infrastructure because of their scale, longevity, and strategic value.
- Global defense spending is rising fast: Australia, Japan, and NATO countries, for example, are directing large amounts of capital to defense infrastructure upgrades.
- Governments are designing rail lines, ports, and communication hubs to serve both civilian and military needs.

¹⁴⁵ Yoshihiko Omori, “Towards decarbonization of liquid fuel in Japan,” Sugarcane.org, July 1, 2025.

¹⁴⁶ Joana Colussi, Nick Paulson, Gary Schnitkey, and Jim Baltz, “Brazil emerges as corn-ethanol producer with expansion of second crop corn,” *farmdoc daily* (University of Illinois Department of Agriculture and Consumer Economics), June 30, 2023, Volume 13.

¹⁴⁷ Karl Plume, “Biofuel demand to soak up more than half of US soyoil production next year, USDA says,” Reuters, July 11, 2025.

¹⁴⁸ E. O. Ajala et al., “Sugarcane bagasse: A biomass sufficiently applied for improving global energy, environment and economic sustainability,” *Bioresources and Bioprocessing*, September 2021, Volume 8, Number 27; Patience Afi Seglah et al., “Sustainable biofuel production from animal manure and crop residues in Ghana,” *Energies*, August 2022, Volume 15, Number 16.

¹⁴⁹ Susannah Savage et al., “Donald Trump’s China trade war a ‘boon’ for Brazil but sends US farmers reeling,” *Financial Times*, April 13, 2025.

¹⁵⁰ OECD-FAO *Agricultural Outlook 2023–2032*, Organisation for Economic Co-operation and Development (OECD), July 6, 2023.

- Innovations such as modular construction and 3D printing are speeding up delivery of barracks, field hospitals, and border facilities.
- Private investors are playing a more prominent role in the defense vertical.

Overview

Defense infrastructure comprises physical assets critical to national security, military operations, and defense logistics. Examples include military airfields, naval bases, radar installations, missile defense systems, secure communication facilities, training and simulation systems, cyber infrastructure, space assets directly tied to military functions, and energy resilience solutions such as on-base microgrids.

Recent shifts in defense spending commitments, including NATO's new expenditure targets,¹⁵¹ highlight how investment in defense infrastructure is rapidly emerging as a distinct, expanding category within global infrastructure investment.

This change in the defense's categorization is already evident in investment strategies. For instance, Stonepeak Infrastructure Partners recently acquired Forgital Group, a manufacturer of advanced forged and machine-finished aerospace components used in both military and commercial jet engines.¹⁵² While the forging industry in which Forgital Group operates isn't traditionally characterized as infrastructure, it exhibits key infrastructure-like attributes, including capital-intensive operations, rigorous qualification standards for defense programs, long-term contracts, and an essential role within the defense supply chain.¹⁵³

Another example that underscores the emerging value of logistics infrastructure tied to defense readiness is Stonepeak Infrastructure Partner's acquisition of Air Transport Services Group (ATSG), a leading provider of medium wide-body freighter aircraft leasing and air cargo services. Like Forgital, ATSG operates essential, hard-to-replicate assets that underpin mission-critical logistics. Its long-term contracts, capital-intensive fleet, and integration into defense supply chains give it many of the same durable, cash-yielding characteristics that define infrastructure investments.¹⁵⁴

Many defense assets also exemplify the interconnectedness of infrastructure verticals. For example, military bases rely on dedicated utilities and waste systems, while communication systems rely on secure data networks and resilient satellite systems.

Trends shaping defense

The defense vertical is being shaped by numerous trends, including regional reinvestments in defense, government scale-up of dual-use infrastructure, military adoption of modular construction methods, and the growing role of private capital.

Many regions are reinvesting in defense

European defense spending is sharply increasing. NATO recently set a new benchmark of spending 5 percent of GDP annually on defense by 2035, including substantial investment in infrastructure. Of this total, 3.5 percent of GDP is dedicated to direct military capabilities, while the remaining 1.5 percent focuses on defense-related infrastructure, including logistics facilities, airfields, naval bases, communication networks, cybersecurity centers, and dual-use facilities.¹⁵⁵

¹⁵¹ CFR editors, "NATO agrees new defense spending target," Council on Foreign Relations, June 25, 2025.

¹⁵² "Stonepeak to acquire Forgital Group from Carlyle," Stonepeak press release, December 16, 2024.

¹⁵³ "Defence," Forgital Group, accessed August 12, 2025; "Stonepeak to acquire Forgital Group from Carlyle," Stonepeak press release, December 16, 2024.

¹⁵⁴ "ATSG to be acquired by Stonepeak for \$3.1 billion," Stonepeak press release, November 4, 2024.

¹⁵⁵ Holly Ellyatt, "NATO allies agree to higher 5% defense spending target," CNBC, June 25, 2025.

Outside of Europe, Japan has announced plans to increase defense spending from 1.8 percent to 2 percent of GDP by fiscal year 2027, with the goal of strengthening air bases and missile defense infrastructure.¹⁵⁶ Similarly, Australia's commitments under the AUKUS agreement involve AU \$18 billion in infrastructure upgrades for its navy.¹⁵⁷

Governments are scaling up dual-use infrastructure

Driven by increasing geopolitical uncertainty and governments' desire for flexibility and resilience, nations are increasingly prioritizing dual-use designs. Dual-use infrastructure allows countries to quickly adapt civilian infrastructure assets—such as ports, airports, transportation networks, and communication hubs—for military purposes during times of crisis. The European Investment Bank (EIB), for instance, has agreed to facilitate financing for small and medium-size enterprises (SMEs) in the security and defense industry; additionally, it has expanded financing for dual-use projects such as military mobility, space, critical infrastructure, and border protection.¹⁵⁸ This approach goes beyond enhancing resilience; it also opens up financial incentives for investors, developers, and operators. Under the EU's Connecting Europe Facility (CEF), grants cofinance up to 50 percent of total eligible costs for military—mobility and other dual-use projects, lowering capital risk for investors.¹⁵⁹

The military is using modular construction to save money and speed project completion

Modular construction techniques, using prefabricated components produced off-site, are becoming increasingly important in defense infrastructure, thanks to their ability to decrease project timelines and increase efficiency and adaptability. Modular techniques have become particularly valuable in building barracks and field hospitals. For example, the US Department of Defense and the construction company ICON used 3D printing to build barracks at Fort Bliss in Texas and New Mexico in 2024 that now provide housing for 72 troops.¹⁶⁰ Meanwhile, India's military is employing modular construction to build about 500 border outposts.¹⁶¹

Private capital is playing a growing role in the vertical

Defense infrastructure has traditionally been a governmental responsibility, but private investment is increasingly being used to accelerate delivery, improve efficiency, and foster innovation. Programs in the United States such as the Military Housing Privatization Initiative (MHPI) and utility privatization efforts have opened the door to private capital.¹⁶² Similar models are emerging globally. The United Kingdom's Strategic Sealift PPP provides military transport ships through a private consortium while allowing limited commercial use to offset costs, and France's CEGELOG initiative leverages private investment to deliver thousands of housing units for military personnel under a 35-year concession.¹⁶³

¹⁵⁶ "Japan targets 2% defense spending," *Nippon.com*, June 27, 2025.

¹⁵⁷ "AUKUS trilateral statement," Australia Department of Defence, March 22, 2024.

¹⁵⁸ Richard Willis, "EIB board of directors steps up support for Europe's security and defence industry and approves €4.5 billion in other financing," European Investment Bank press release, May 8, 2024.

¹⁵⁹ "Military mobility: The EU supports strategic investments on dual-use transport infrastructure with €807 million," European Commission, January 24, 2024.

¹⁶⁰ Ada Shaikhmag, "U.S. DOD unveils its new 3D printed barracks at Fort Bliss for troop housing," *3D Printing Industry*, February 28, 2024.

¹⁶¹ ANI, "India to build 509 composite border outposts on frontiers with Pak, B'desh," *Business Standard*, October 10, 2023.

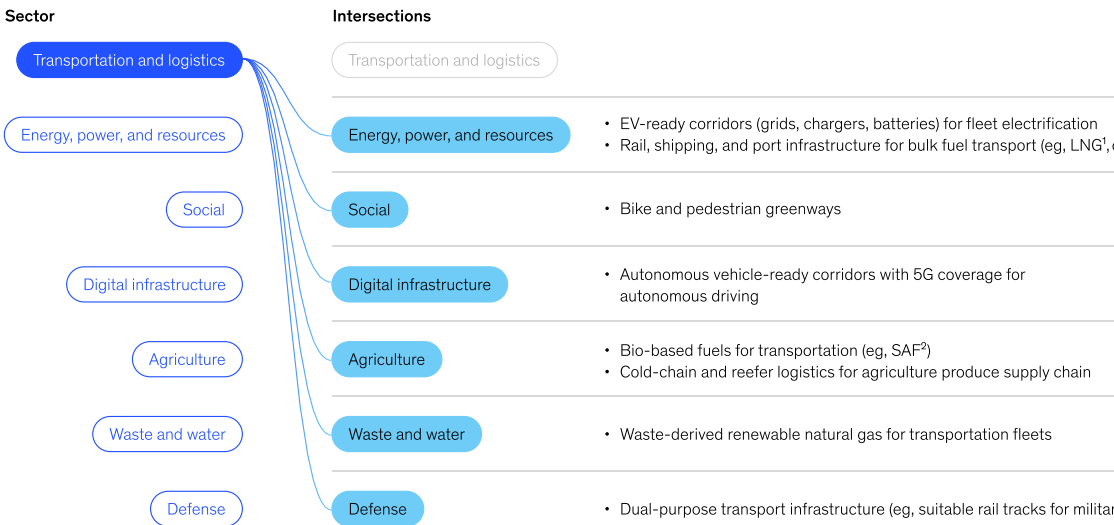
¹⁶² "About MHPI," Military Housing Association, accessed August 13, 2025.

¹⁶³ *Public-private partnerships in security and defense*, European Investment Bank, April 2025.

Opportunities where infrastructure verticals intersect

Infrastructure of the future is being shaped by two forces: the expanding definition of the class and the increasing technical, operational, and financial interdependence of infrastructure systems. As a result, new opportunities are emerging at various intersections of the verticals, primarily enabled by digitalization and other technological advances. This section explores three examples of such cross-vertical opportunities (Exhibit 6).

Exhibit 6
The boundaries between infrastructure sectors are increasingly blurred.



¹Liquefied natural gas.

Example, see Appendix for more

Energy and digital: Power infrastructure for data center expansion

The rise of AI and cloud computing has made data centers among the world's most power-intensive infrastructure. AI, particularly gen AI, requires enormous computing muscle from data centers and, thus, energy. Training gen AI models and inference (a gen AI system's response to a user prompt) each require more energy than traditional computing. For instance, generating a single image using a gen AI model requires about as much energy as charging a smartphone.¹⁶⁴

Consumer and corporate demand for AI is already strong and driving up energy needs. ChatGPT alone is reported to have as many as one billion users.¹⁶⁵ More than three-quarters of organizations across industries

¹⁶⁴ Melissa Heikkilä, "Making an image with generative AI uses as much energy as charging your phone," *MIT Technology Review*, December 1, 2023.

¹⁶⁵ Martine Paris, "ChatGPT hits 1 billion users? 'Doubled in just weeks' says OpenAI CEO," *Forbes*, April 12, 2025.

report adopting gen AI in at least one function.¹⁶⁶ Corporate demand is expected to rise considerably. Gen AI is already demonstrating productivity increases in areas like software coding and marketing, with agents capable of completing even more tasks on the horizon.

As a result, data centers are getting bigger and requiring more power. A decade ago, 30-megawatt facilities were considered large; today, 200-megawatt facilities are increasingly common.¹⁶⁷ In just the next two years, data center power demand globally is expected to increase by 50 percent.¹⁶⁸

Larger and more power-hungry data centers are straining power grids. Data center electricity use in Ireland, for example, rose to 21 percent of total national consumption, prompting a moratorium on new connections of data centers to power until 2028 to mitigate blackout risks.¹⁶⁹

With the relationship between computing centers and energy tightening, investments increasingly target both. BlackRock, Global Infrastructure Partners, MGX, and Microsoft launched the Global AI Infrastructure Investment Partnership to raise up to \$100 billion—starting with \$30 billion in private equity—to build AI data centers alongside renewable energy and storage infrastructure.¹⁷⁰ Abu Dhabi's sovereign wealth fund ADQ partnered with Energy Capital Partners to invest more than \$25 billion in US energy projects that will power data centers. The deal involves developing 25 gigawatts of power generation and infrastructure, with an initial \$5 billion capital infusion.¹⁷¹ These investments reflect an integrated approach in which digital growth is planned hand in hand with energy system expansion and, often, decarbonization.

Investments are targeting new builds based on existing energy sources (natural gas and renewables) and new ones (nuclear and geothermal), augmenting and optimizing existing energy infrastructure, and converting existing assets into those capable of powering data centers (such as converting a coal plant to a gas plant).

Agriculture, energy, waste, and transportation: Sustainable fuel

The drive to decarbonize freight and aviation transport is creating new cross-vertical infrastructure opportunities. McKinsey estimates that sustainable fuels represent one of 12 technologies that, if deployed together at scale, could reduce total human-made greenhouse gas emissions by as much as 90 percent.¹⁷²

A wide range of sustainable fuel technologies developed at the intersection of multiple infrastructure verticals is rapidly emerging and scaling. One example is the use of renewable natural gas (RNG), which is generated through anaerobic digestion of agricultural residues and food waste, for both transportation and power generation.¹⁷³ It marks the intersection of four infrastructure verticals, where agriculture and waste (energy producers) meet transport and energy (end users).

Sustainable aviation fuel is another example. Its development brings together similar industries: SAF production links farm and food waste processing with energy conversion and transport logistics. The SAFs already certified for use in today's jet engines produce about 80 percent less greenhouse gas emissions than traditional jet fuel.¹⁷⁴ By 2030, global demand for global SAF is projected to reach 17 million metric tons per year, accounting for approximately 4 to 5 percent of total jet fuel consumption.¹⁷⁵

Organizations in each participating industry are acting on the SAF opportunity. Pittsburgh International Airport is constructing an on-site SAF plant to produce more than 100 million gallons annually using

¹⁶⁶ "The state of AI: How organizations are rewiring to capture value," McKinsey, March 12, 2025.

¹⁶⁷ "AI power: Expanding data center capacity to meet growing demand," McKinsey, October 29, 2024.

¹⁶⁸ "AI to drive 165% increase in data center power demand by 2030," Goldman Sachs, February 4, 2025.

¹⁶⁹ Matt O'Brian, "Ireland wrestles with AI data center growth and power use," Associated Press, December 19, 2024.

¹⁷⁰ "BlackRock, Global Infrastructure Partners, Microsoft, and MGX launch new AI partnership to invest in data centers and supporting power infrastructure," Microsoft, September 17, 2024.

¹⁷¹ Anthony Di Paola, "Abu Dhabi forms \$25 billion US energy venture to power AI," Bloomberg, March 19, 2025.

¹⁷² "What would it take to scale critical climate technologies?," McKinsey, December 1, 2023.

¹⁷³ "Renewable natural gas: A Swiss Army knife for US decarbonization," McKinsey, November 21, 2023.

¹⁷⁴ "What are sustainable fuels?," McKinsey, October 8, 2024; IATA July 2024.

¹⁷⁵ *Financing sustainable aviation fuels: Case studies and implications for investment*, World Economic Forum, February 26, 2025.

regional feedstocks, integrating biofuel production directly into airport operations.¹⁷⁶ In 2023, the Summit Agricultural Group created Summit Next Gen, an SAF platform that uses Honeywell's ethanol-to-jet processing technology to turn ethanol from corn-producing farms into jet fuel.¹⁷⁷ A partnership between Australia's Ampol (energy), GrainCorp (agriculture), and IFM Investors is exploring SAF production from locally grown canola.¹⁷⁸

Transportation, energy, and digital: Connected and electrified transport

Decarbonizing transport through electrification requires transportation, energy, and digital infrastructure to work in harmony. Electric-vehicle (EV) adoption, for example, often hinges on reliable charging infrastructure. About 40 percent of EV consumers cite charging speed as their most critical consideration for buying an EV, and 35 percent cite charging costs.¹⁷⁹

The transport vertical can also aid in decarbonization by adding energy back to the grid. National efforts in China are advancing vehicle-to-grid (V2G) integration, embedding EVs as energy assets. With more than 760,000 fast-charging stations already deployed nationwide, accounting for roughly 90 percent of global charging growth in 2022, China is piloting V2G systems across nine major cities. These programs allow EVs to draw power when needed and return electricity to the grid during peak demand hours.¹⁸⁰

The convergence of transport, energy, and digital also supports connected vehicle technologies and autonomous driving. A 2022 McKinsey Mobility Consumer Pulse Survey found that 34 percent of respondents are interested in Level 4 (highly autonomous) automation in their next vehicle. This level requires reliable, high-speed digital infrastructure.¹⁸¹

The 5G Autobahn to Autoroute project in Europe illustrates an integrated sector approach to achieving connected mobility. The project—led by Orange, O₂, Saarland University, Telefónica, TOTEM, and Vantage Towers and supported by the Région Grand Est in France and Saarland Ministry of Economic Affairs, Innovation, Digital and Energy in Germany—is deploying continuous 5G connectivity along a 60-kilometer highway corridor between France and Germany. Designed to enable features like cooperative lane changes and real-time collision avoidance, the initiative demonstrates how next-generation roadways depend as much on data infrastructure as on design and construction. The project is scheduled for completion in 2027 and could serve as a model for cross-border connected mobility.¹⁸²

This chapter has explored each of the seven infrastructure verticals in depth, with an eye to the compelling opportunities of each, as well as at their various intersections. Next, we turn to a detailed look at the implications for three core stakeholder groups: governments, investors, and operators/developers.

¹⁷⁶ Aaron Karp, "Pittsburgh airport to build on-site SAF facility," *Aviation Week*, June 18, 2025.

¹⁷⁷ Nicole Frett, "Summit Next Gen to use Honeywell ethanol-to-jet fuel technology for production of sustainable aviation fuel," Honeywell press release, May 15, 2023.

¹⁷⁸ Randhir Patil, "Australian Canola may soon power jets with low-carbon fuel," *Bioenergy Times*, June 16, 2025.

¹⁷⁹ Lauritz Fischer, Felix Rupalla, Shivika Sahdev, and Ali Tanweer, "Exploring consumer sentiment on electric-vehicle charging," McKinsey, January 9, 2024.

¹⁸⁰ Colleen Howe, "China to launch grid-connected car projects to balance power supply," Reuters, April 2, 2025; "Global EV Outlook 2023," International Energy Agency (IEA), April 2023.

¹⁸¹ Kersten Heineke, Philipp Kampshoff, and Timo Möller, "Spotlight on mobility trends," McKinsey, March 12, 2024.

¹⁸² "First cross-border 5G highway corridor between France and Germany to enable innovative driving functions," Telefónica press release, January 15, 2025.

Chapter 4

Implications for stakeholders

A major theme of this report has been how the definition of infrastructure has undergone a fundamental redefinition, broadened to encompass everything from AI-ready power grids to digitally enabled logistics networks. Now the challenge is how to deliver results. As investment ramps up globally, success increasingly hinges on more than how much capital is deployed; it also depends on how effectively governments, investors, and operators coordinate, adapt, and execute. This chapter outlines what infrastructure stakeholders could do to thrive in this evolving environment.

Governments

Despite record-breaking infrastructure budgets, governments face increasingly difficult tradeoffs. To balance fiscal constraints with rising pressure to deliver the infrastructure their populations demand and require, governments should consider strategies such as repurposing assets, streamlining regulatory requirements, and attracting private funding.

Repurpose assets

At times, underused assets offer a starting point for governments to invest in new areas. For example, at Fort Belvoir in the US state of Virginia, the Army's Enhanced Use Lease is transforming surplus land into a renewables-powered data center while redirecting lease payments to base operations.¹⁸³ The Department of Energy is piloting similar land-for-power models for grid-scale storage, as well as repurposing former nuclear sites for solar power.¹⁸⁴ Repurposing can accelerate project completion by avoiding lengthy greenfield permitting processes and attract private capital seeking faster time to revenue generation.

Streamline regulatory processes

One potential blocker to such efforts is permitting processes. Some ways governments can simplify these processes include setting statutory approval deadlines to ensure timely decisions, launching one-stop digital portals to centralize applications and streamline interactions across departments, and adopting risk-based reviews to expedite routine projects. In New South Wales, Australia, a newly established Investment Delivery Authority—backed by an AU \$80 million innovation fund—is set to fast-track major infrastructure projects (including data centers, renewables, and commercial builds), streamline development approvals, and cut red tape across government departments.¹⁸⁵

¹⁸³ *Data storage center phase 3—Sail Fish*, National Capital Planning Commission, December 3, 2020.

¹⁸⁴ Paul Ciampoli, "DOE offers funding to support pilot-scale energy storage demonstration projects," American Public Power Association, September 5, 2024; Neil Ford, "US starts to build solar on ex-nuclear sites across country," Reuters, July 4, 2024.

¹⁸⁵ Sean Mitchell, "NSW sets up authority and funds \$80m innovation drive," *IT Brief Australia*, June 23, 2025.

Create frameworks for attracting private capital

Governments can attract private investors by developing tailored frameworks aligned with their distinct risk/return mandates. These frameworks include clearly structured construction or operational concessions within PPPs. Hong Kong's Mass Transit Railway system used land value appreciation to fund metro expansions.¹⁸⁶ And in 2020, Brazil introduced the New Sanitation Legal Framework to attract \$128 billion in private investments for sanitation and water supply by mandating competitive bidding for service contracts. Previously, contracts were awarded directly to public or semipublic entities without competition, limiting private-sector involvement. The new requirement for open bidding creates transparency, reduces investor uncertainty, and promotes greater private-sector participation.¹⁸⁷ Such approaches help reduce perceived investment risk, making infrastructure projects more attractive, especially in non-OECD countries, where uncertainty can deter investors.

Do more with less

Tight fiscal circumstances mean governments must stretch every infrastructure dollar. One of the most powerful ways to reduce the overall cost of infrastructure is to avoid investing in projects that neither address clearly defined needs nor deliver sufficient benefits. Choosing the right combination of projects and eliminating wasteful ones could save (or redeploy) \$200 billion a year in unnecessary spending globally.¹⁸⁸ For example, the UK's 2017 Transforming Infrastructure Performance program set out to save roughly £15 billion annually through smarter procurement, off-site construction, digital methods, and systemwide coordination.¹⁸⁹ Project owners should use precise selection criteria to ensure that proposed projects meet specific goals, develop sophisticated methods for determining costs and benefits, and evaluate and prioritize projects by their potential effects on the entire network, instead of looking at individual projects in isolation.

Investors

With yields under pressure from rising interest rates and increasing competition, infrastructure investors should consider diversifying into new sectors even as they find synergies across verticals and double down on value creation.

Diversify vertical investments

Limited partners are increasingly interested in infrastructure, given its lower risk profile, stable returns, delivery of essential services, and long-lasting physical assets. But as more money has flowed into traditional infrastructure, competition has driven down profits. For general partners, this means reflecting on infrastructure trends, widening their fund's mandate, and considering traditional infrastructure verticals they may not have typically invested in. One such example is KKR's acquisition of ProTen, an Australian poultry infrastructure operator with contract-backed cash flows. The acquisition reflects the growing push by investors to consider essential service businesses within infrastructure verticals other than the ones they have typically pursued.¹⁹⁰ Similarly, the acquisition of Triton by the Howden Hellas Group underscores growing interest in adjacent segments like marine logistics—assets that fall outside core infrastructure but are becoming more relevant as offshore wind expands.¹⁹¹

¹⁸⁶ Lincoln Leong, "The 'rail plus property' model: Hong Kong's successful self-financing formula," McKinsey, June 2, 2016.

¹⁸⁷ Roberto Vianna do Rego Barros and Jorge Luiz Barbieri Gallo, "Brazil's new basic sanitation legal framework," DLA Piper, November 30, 2020; Cíntia Leal Marinho de Araujo, "The new legal framework for water and sanitation services in Brazil and the standardized guidelines," International Water Association, May 3, 2024.

¹⁸⁸ "Infrastructure productivity: How to save \$1 trillion a year," McKinsey Global Institute, January 1, 2013.

¹⁸⁹ *Transforming infrastructure performance*, Infrastructure and Projects Authority, December 2017.

¹⁹⁰ "KKR acquires ProTen from Aware Super," KKR press release, July 1, 2024.

¹⁹¹ "WFW advises Triton Marine's shareholder on its acquisition by Howden," Watson Farley & Williams, November 6, 2023.

Look for cross-vertical opportunities

Investors with a strategy of exploring cross-vertical opportunities aim for first-mover advantage by identifying such investment opportunities ahead of competitors. Data centers integrate digital connectivity and energy infrastructure through co-located renewable generation, while e-mobility hubs merge transportation networks and grid infrastructure. Shifting from criteria-based models (for example, focusing on a certain asset size or return profile) to a thematic model can help surface these opportunities. Reflecting on the broader themes prevalent today—including climate change, shifting trade flows, and the rise of artificial intelligence—can help investors capitalize directly on the growth driven by overarching macro trends, rather than relying solely on traditional sector-specific performance.

Generate alpha through value creation

Operational improvements have become a primary driver of value creation, rivaling traditional financial engineering approaches. This shift has emerged from higher borrowing costs, less debt available to enhance returns, and diminishing multiples arbitrage. In light of this, investors will increasingly depend on margin cost optimization (strategic sourcing and procurement; rationalization of selling, general, and administrative expenses; and lean operations), revenue acceleration (dynamic pricing, product innovation, and optimized go-to-market strategies), and disciplined capital allocation (portfolio shifts to higher-return opportunities and stringent capital spending management).¹⁹²

Advanced technologies such as AI and gen AI offer investors powerful new tools to improve margins, accelerate revenue growth, and enhance capital productivity. For instance, Brookfield established an AI Value Creation Office to scale AI insights across its portfolio. It installed IoT sensors coupled with AI analytics at the automotive battery manufacturer Clarion to optimize maintenance schedules, prolong machine life, reduce waste, and cut energy consumption.¹⁹³

Operators and developers

At operators and developers, margins are being squeezed by rising costs, labor shortages, aging infrastructure, supply constraints, and performance-based contracts. To stay ahead, firms can pursue strategies that employ technology to gain scale and look for revenue opportunities from areas beyond primary assets, such as services.

Tap new technologies to create value

Technology adoption is accelerating across asset classes to spur efficiency and increase revenue. Infrastructure assets are well positioned to take advantage of AI with applications in pricing, predictive maintenance, real-time scheduling, and project execution.

For example, in transport, a leading global airport deployed a suite of AI-driven tools to optimize performance of its baggage-handling system rather than invest in a costly physical expansion. The airport reduced carousel downtime, which improved passenger experience and system reliability, and reduced peak-period staffing costs through more efficient deployment.

Predictive maintenance has reduced downtime in utilities by up to 75 percent and cut maintenance costs by up to 30 percent.¹⁹⁴ In rail, Siemens' Railigent platform is set to help the Sydney Metro monitor infrastructure health in real time. The platform uses AI to flag anomalies and optimize predictive maintenance, reducing downtime and potentially extending asset life.¹⁹⁵

¹⁹² Alexander Edlich, Christopher Croke, Fredrik Dahlqvist, and Warren Teichner, *Global Private Markets Report 2025: Braced for shifting weather*, McKinsey, May 20, 2025.

¹⁹³ "Game On: Why industrials are in play," Brookfield, 2024.

¹⁹⁴ Nicholas Nhede and Colin Beaney, "Predictive maintenance can unlock lower costs and better performance for African utilities," Smart Energy International, May 15, 2018.

¹⁹⁵ "Siemens deploys MaaS in major Sydney contract," *CDOTrends*, January 17, 2023.

When it comes to energy, several companies are piloting gen AI tools to improve project execution, including applying dynamic, real-time scheduling. AI algorithms continuously reallocate tasks and adjust project timelines based on real-time inputs such as weather changes, workforce availability, equipment status, and supply chain delays.

Expand service offerings across the value chain

Developers are also bundling services to capture more margin. DP World's acquisition of Syncreon shifted it from a port-focused operator to an integrated logistics provider, with warehousing, fulfillment, and transportation under one roof.¹⁹⁶ Similarly, concessionaires like Ferrovial now use their transport assets to offer EV charging and broader energy-as-a-service solutions like second-life batteries, thereby monetizing existing infrastructure in multiple ways beyond traditional fees.¹⁹⁷ Other areas that operators and developers can explore are maintenance, waste recovery, energy optimization, and customer engagement platforms.

Extend asset lifespans

Operators facing aging infrastructure, supply constraints, and tight labor markets are increasingly focused on extracting more value from existing assets to improve performance and delay costly replacements. Instead of investing heavily in new infrastructure, firms are deploying maintenance and predictive optimization approaches to raise asset utilization and profitability. Heathrow Airport partnered with Vanderlande to install sensors enabling predictive maintenance, which is reducing baggage-system downtime by about 25 percent and potentially extending equipment lifespans.¹⁹⁸ Investors are capitalizing on this trend: Macquarie's recent acquisition of the operations and maintenance specialist ZITON underscores a strategic push to extend the service life of offshore wind farms, converting asset life extension into a profitable, recurring revenue stream.¹⁹⁹

An ever more interconnected world demands a shift in mindsets about the infrastructure that enables society to function. With an expanded understanding of what infrastructure comprises, stakeholders including government, investors, and operators can take decisive action to meet the challenges and opportunities emerging from this complex, competitive infrastructure moment.

Governments should reflect on what resources to target and how to remove bottlenecks, then act accordingly. Investors have an opportunity to move beyond buy-and-hold strategies, instead managing assets more actively to unlock new possibilities. Operators and developers can embrace groundbreaking technologies and new areas of service to unlock new sources of value. Those that adapt will shape the next generation of infrastructure—and the economies that depend on it.

¹⁹⁶ "DP World acquires leading US-based supply chain solutions provider," DP World, press release, July 1, 2021.

¹⁹⁷ "Ferrovial installs electric car charging points in Torrejón de Ardoz and advances with its energy solutions," Ferrovial press release, July 25, 2023.

¹⁹⁸ "Introducing predictive maintenance at Heathrow Airport," *EXPO21XX News*, 2023.

¹⁹⁹ "Macquarie Asset Management agrees to acquire ZITON, a specialist in offshore wind O&M services from Permira Credit," Macquarie Group press release, October 1, 2024.

Acknowledgments

Authors

Alastair Green is a senior partner in McKinsey's Washington, DC, office; **Ishaan Nangia** is a senior partner in the Melbourne office; and **Nicola Sandri** is a senior partner in the Milan office.

McKinsey & Company contributors

Adrian Kwok
Alberto Chiulli
Alex Bolano
Andrew Johnson
Anthony Fulham
Connor Mangan
Darren Rivas
Erdem Cebeci
Ginny Hagerty
Jake Kwang
Jared Katseff
Jennie Nevin
Jesse Noffsinger
Justin Rosenthal
Kali Na
Kevin Shi
Killian Murphy
Laura Campbell
Shu Chern Lim
Tobias Otto
Vero Henze
Zach Groffsky

Other contributors

Allan Gold
Chris Grava
David De Lallo
Guillaume Kurkdjian
Hannah McGee
John-Michael Maas
Keith Rondinelli
Kim Simoniello
Paul Cumbo
Susan Moore

Appendix

Table

The definition of infrastructure is expanding to include new physical assets, technologies, and services—and the defense vertical.

XX = Traditional definition

XX = Expanded definition

Transportation and logistics		
Rail and road	Ports and airports	EV and electrification infrastructure
Passenger and freight rail Rail stations Road and highway infrastructure (toll roads, bridges, tunnels) Rail and road maintenance, repair, operations facilities Mass transit systems (urban rail, subways, bus networks) Roadside facilities and parking Vehicle fueling and maintenance facilities for gasoline and diesel vehicles Tolling and traffic management systems	Airports and aviation facilities (passenger terminals, cargo hubs) Seaports and inland waterway hubs (cargo, ferry, multimodal logistics) Fueling and maintenance facilities for aircraft and ships Logistics and warehousing Warehousing and fulfillment centers Distribution centers Intermodal freight terminals Specialized transportation equipment and facilities (eg, hazardous, cold chain) Fleet depot and cargo inspection facilities (depots, terminals, inspection facilities) Supply chain visibility and digitalization	Smart highways Urban mobility charging infrastructure for e-scooters, eVTOLs EV charging, fueling, and energy storage hubs (battery swap stations, hydrogen) Electric and fuel-cell vehicles fleets as-a-service EV maintenance and repair facilities

Table continued

Energy, power, and resources		
Generation	Transmission and distribution	Carbon management
Coal-fired power plants Natural gas and oil-fired power plants Nuclear power generation facilities (eg, large-scale reactors, advanced nuclear solutions such as SMRs) Solar and wind installations (eg, photovoltaic, floating solar arrays, onshore and offshore wind) Hydropower dams and marine energy systems (wave, tidal) Geothermal power plants Alternative fuel production facilities (green hydrogen, biofuels)	Oil and gas pipelines and distribution networks District heating and cooling networks Storage/terminal infrastructures (eg, LNG terminals, crude storage, refueling depots) Power transmission and distribution (high-voltage direct current, AC, substations) Modernized grid and interconnections (smart grids, SCADA, ADMS) Energy storage and grid flexibility Grid-scale electricity storage (eg, batteries, long-duration energy storage) Hydrogen storage and fuel cells Demand-side flexibility and grid-balancing solutions Energy-as-a-service (contracted renewables, microgrids)	Carbon capture, transport, and sequestration networks (CCS, direct air capture, pipeline infra)
Social		
Public infrastructure and civic services	Public facilities and recreations	Healthcare and life sciences
Public-safety and emergency services (eg, fire stations, disaster resilience infrastructure) Education Primary and secondary school campuses Universities and research parks	Civic institutions (government buildings, libraries) Recreational and wellness facilities (theme parks, urban wellness centers) Stadiums, arenas, and public venues Community and cultural centers Residential and storage facilities (eg, student housing, affordable housing)	Hospitals and major medical centers (hospitals, specialty hospitals, academic medical centers) Long-term and senior care facilities (nursing homes, assisted living, rehabilitation centers) Mobile and decentralized healthcare (home care infrastructure, mobile medical units) Medical logistics and waste management (medical equipment rentals, biowaste disposal, sterilization) Medical and biotech infrastructure (labs, biobanks, CDMOs)

Table continued

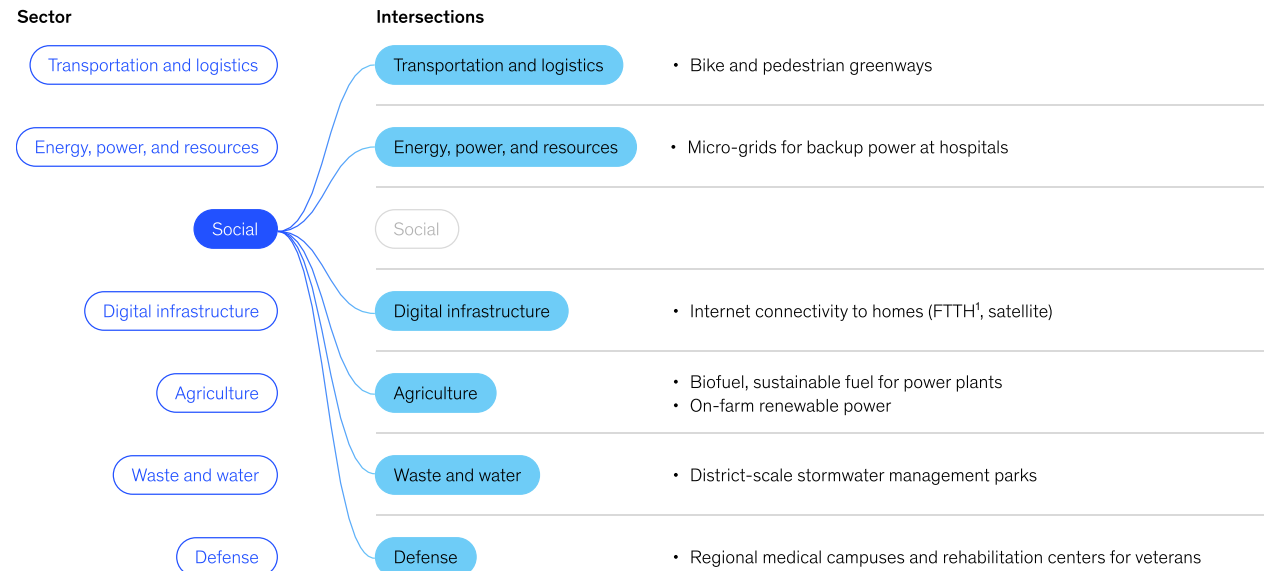
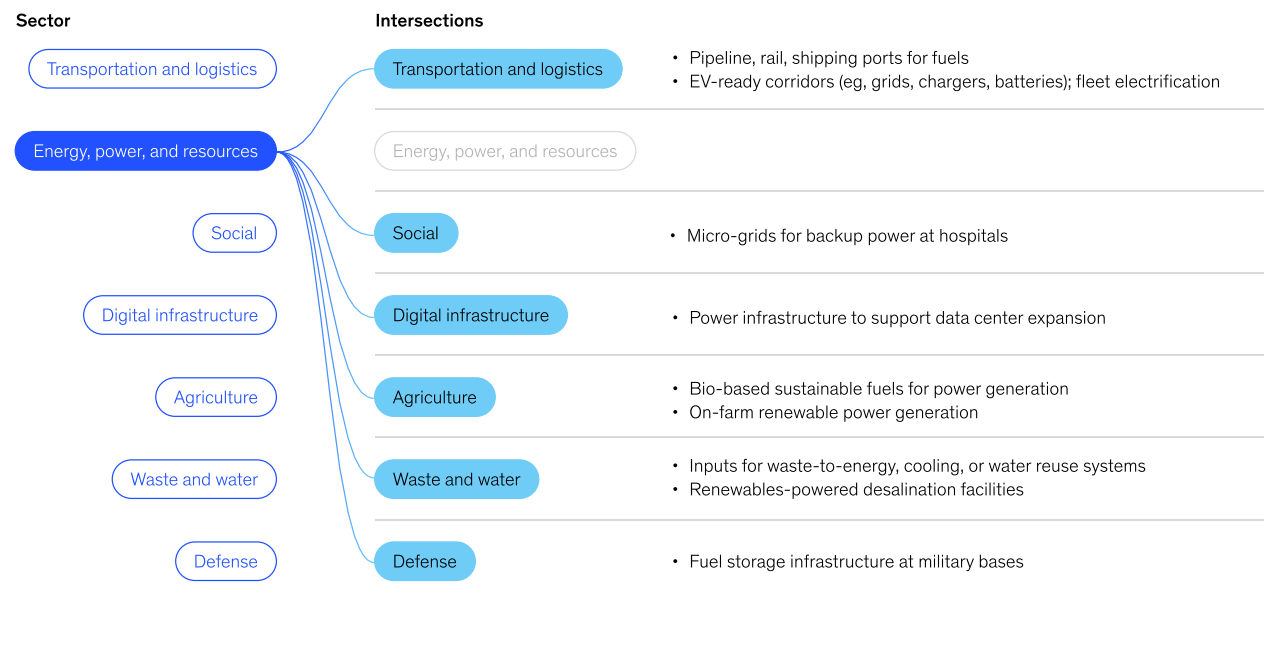
Digital infrastructure		
Data centers	Tower and mobile	Space and satellites
Semiconductors Data centers (hyperscaler, co-location centers) Edge data centers Data center services (eg, third-party maintenance) Fiber and cable Copper cable infrastructure Fiber networks (including niche fiber, eg, submarine) Managed fiber services	Cellular network infrastructure (macro tower, small cells) Indoor 5G and distributed antenna systems Private 5G and connectivity	Low-Earth orbit satellites Air-to-ground communication
Agriculture		
Natural resource and land management	Farming infrastructure	Agricultural supply chain and logistics
Irrigation and water management infrastructure (smart irrigation) Sustainable forestry projects (carbon offsets, reforestation) Soil conservation initiatives and regenerative agriculture practices Aquaculture and marine farming Land-based, offshore, and recirculating aquaculture systems Integrated aquaculture–agriculture systems	Cropland and controlled-environment farming facilities Livestock/dairy farming facilities (including processing plants, waste management systems) Precision agriculture (AI-driven soil and crop monitoring)	Cold storage and refrigerated logistics networks Large-scale food-processing and distribution centers

Table continued

Waste and water		
Waste	Water	
Municipal waste collection (general, food, textile, hazardous)	Drinking-water treatment and distribution systems	
Industrial and commercial waste collection (construction, manufacturing by-products)	Wastewater collection and treatment infrastructure	
E-waste and specialized waste collection (electronics, batteries, medical waste)	Stormwater management systems (urban drainage, runoff control)	
Traditional recycling and material recovery (MRFs, plastics, metals, paper)		
Automated sorting technologies (AI-powered, optical, robotic)		
Hazardous and chemical waste treatment		
Waste-to-x technologies (waste-to-energy, waste-to-fuel, waste-to-chemicals)		
Composting and anaerobic digestion		
Defense		
Defense has not traditionally been viewed as an infrastructure vertical, but the scale, longevity, and strategic value of its assets have prompted its inclusion in the expanding definition of infrastructure.		
Defense		
Military runways	Defense manufacturing plants and assembly lines	
Aircraft hangars and maintenance facilities	Military hospitals	
Naval ports and shipyards	Border security checkpoints and installations	
Space launch facilities	Energy and utilities for military bases	
Military bases (eg, command-and-control centers, training bases and firing ranges, hardened shelters and bunkers)	Maintenance, repair, and overhaul services for bases, vehicles, and equipment	
Military logistics and supply depots (eg, fuel storage and distribution facilities, ammunition storage facilities)		

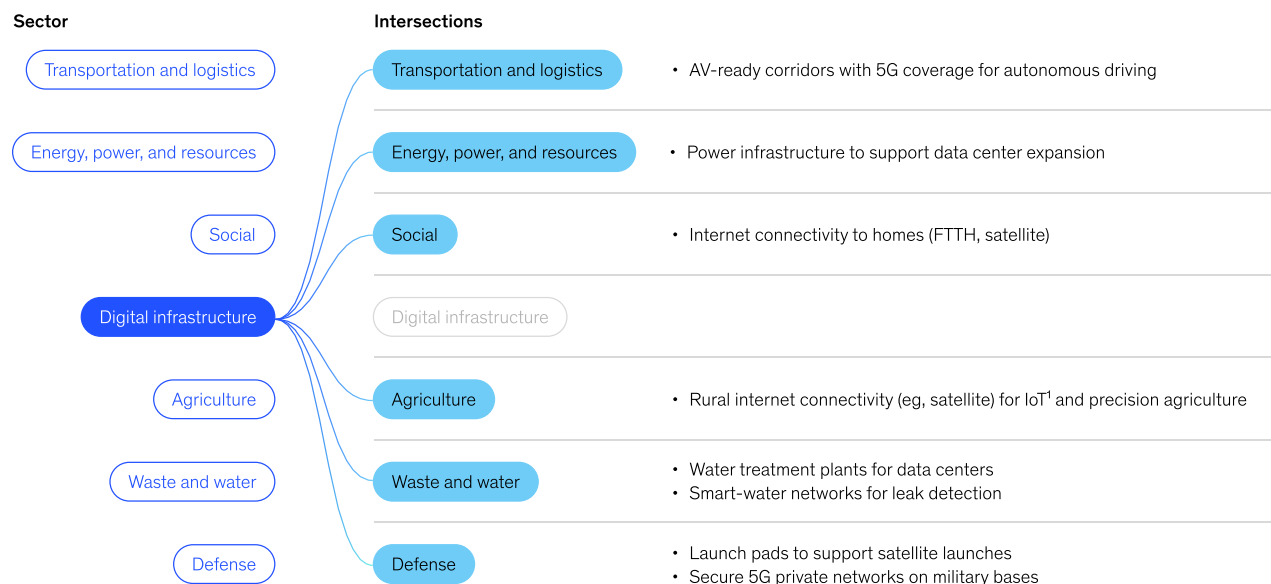
Exhibit 6 continued

The boundaries between infrastructure sectors are increasingly blurred.



¹Fiber to the home.

Exhibit 6 continued



¹Internet of things.

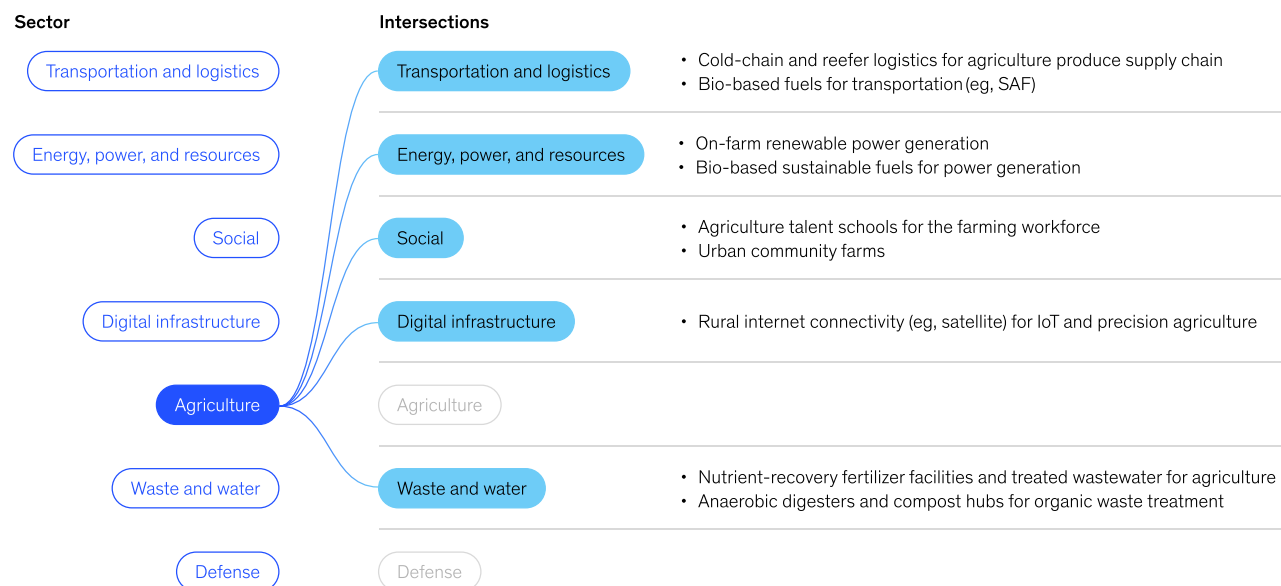
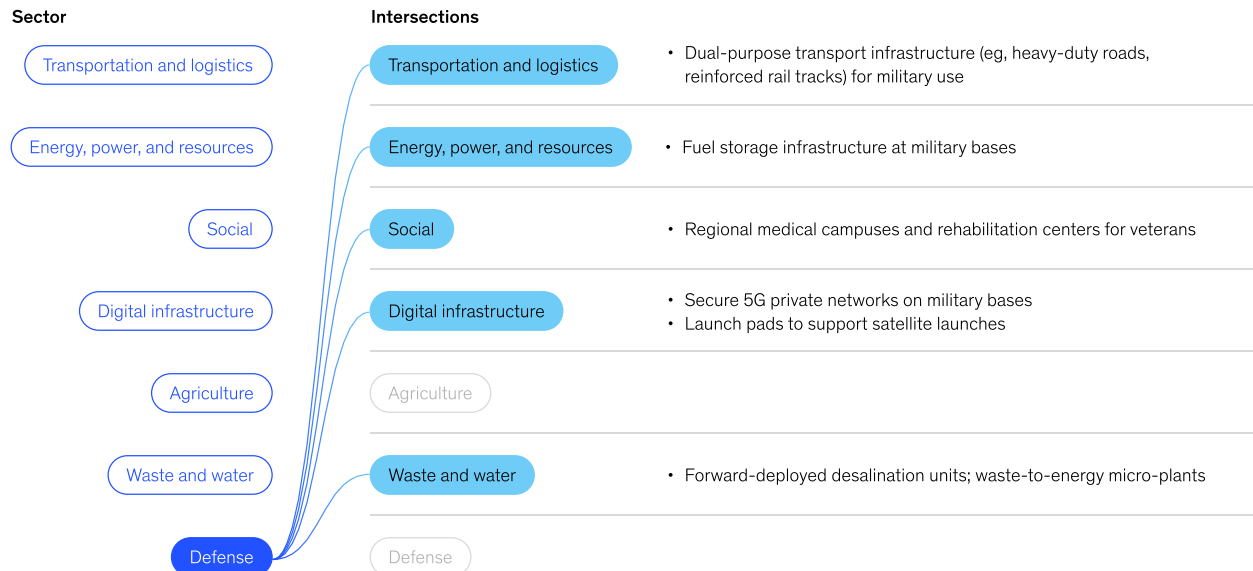
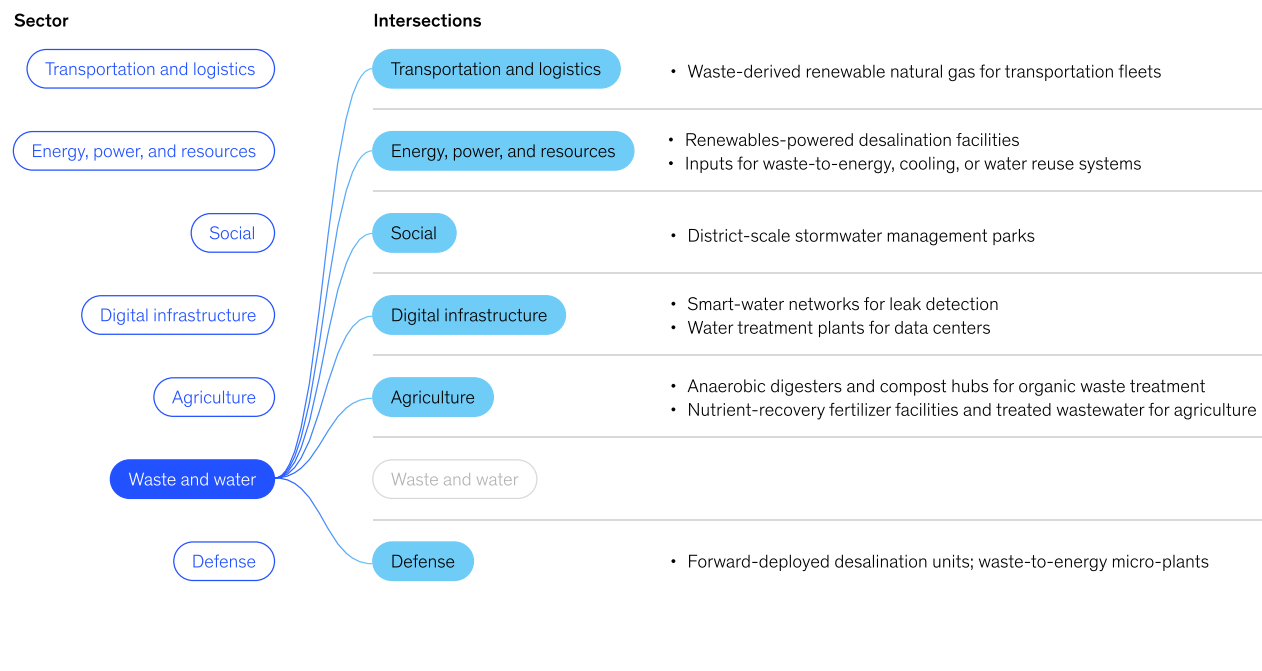


Exhibit 6 continued



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