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GLOBAL INFRASTRUCTURE INITIATIVE

Accelerating progress on future-ready infrastructure

Voices on Infrastructure | February 2024

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As we look ahead to our ninth GII Summit (Dubai, February 2024), this collection of articles highlights the opportunity to capitalize on the energy transition, which entails improving capital productivity, building new clean-energy assets, and hyperscaling the growth potential of key technologies.

— We begin with how *the role of the infrastructure CEO is also changing.* McKinsey spoke to David Cowan, Greg Stanmore, and Hugh Thorneycroft, infrastructure experts at executive search firm Spencer Stuart, to discuss the how the role of the infrastructure CEO is evolving, the challenges those CEOs face, and the range of leadership qualities and capabilities they need in today's environment.

— Improving capital productivity will be critical to making the most of this investment. On this point, *project costs can be fundamentally reconsidered to accelerate development.* However, the industry faces challenges related to adapting to climate technology advancements and shifting stakeholder and societal expectations as well as reducing capital expenditure costs while accelerating project timelines.

— *Effective hyperscaling—or large-scale and repeatable new-asset development—may help increase the growth potential of technologies required by the energy transition, including hydrogen, batteries, and carbon capture.* The "plant as a product" approach, which uses manufacturing methodology to help companies quickly scale green capital expenditures and make construction projects repeatable, may help owners and builders deliver these projects more affordably and efficiently.

— In a preview of the *2024 Global Private Markets Review,* set to be published in March, the outlook for 2024 will depend on players' response to a shift in the decade-long status quo of low and falling interest rates and consistently expanding multiples. A *slower era* for private markets will still be marked by considerable change.

— Delivery of capital investments poses significant challenges. In fact, many projects do not meet their authorized schedules, and cost overruns often exceed initial estimates. *Successfully scaling delivery of green capital expenditures will likely entail controlling cost and time budgets as well as embarking on cost ramp-down curves,* similar to those seen in batteries, solar, and wind.

— Clean-energy assets and their enabling infrastructure play a critical role in meeting climate targets, particularly as they relate to modernizing the electric grid, integrating distributed storage resources, and continuing to build out electric-vehicle charging infrastructure. *Attracting private capital is key, and our research shows that the total annual cost of new physical assets for clean energy and enabling infrastructure could reach $6.5 trillion per year by 2050,* the majority of which will likely be driven by net-zero pledges and sector-specific transitions. In particular, electricity grids are undergoing rapid and profound change to respond to increased climate risks, inspiring grid planners to reimagine their processes and rethink longstanding paradigms for measuring and managing performance.

— We also take a look at how *AI is changing buildings and real estate*—specifically, how a combination of machine learning, AI, and physics-based modeling can help real estate portfolio owners identify building decarbonization opportunities. And a *McKinsey Quarterly* article details how generative AI can help the industry streamline leasing documentation; improve customer engagement; create new revenue streams; and make faster, more precise investment decisions, among other uses.

We hope you find this issue of *Voices* insightful as it relates to your ongoing conversations about capitalizing on the energy transition.

News from the Global Infrastructure Initiative

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Welcome to this edition of *Voices on Infrastructure* by the Global Infrastructure Initiative (GII). The publication of this article collection coincides with our 9th GII Summit, which will take place in Dubai from February 27 to 29, 2024.

This year has been off to a busy start as we prepare for our upcoming summit, which focuses on the theme of accelerating progress on future-ready infrastructure. With increasing consensus that infrastructure needs to digitalize and decarbonize, the question is how the industry can move faster than it has ever had to before. To accelerate the pace, the global infrastructure and projects sector will need to embrace new technologies and ways of working, develop talent and the workforce of the future, and debottleneck financing, materials, and supply chains.

The Dubai Summit—our first ever in the Middle East—tackles these themes with more than 250 C-level executives across the full asset life cycle and all infrastructure sectors. Our program features two and a half days of site visits to innovative infrastructure projects, interactive plenary dialogue, roundtables, and networking. Look for our recap report on the summit's best ideas and takeaways, which will be published in April.

The new year also brings a slate of other GII gatherings. For example, our first roundtable of the year brought together leaders from Europe's roads sector and related value chains for a look at the mobility landscape and a solutions-focused discussion on how road infrastructure is changing and will need to continue changing in years to come. A recap of that roundtable will be available soon on the GII website, and stay tuned for additional events throughout the year.

As ever, we welcome your input on GII's offerings and the topics and themes that are shaping the future of infrastructure and capital projects. If you have an idea for an event or article, please let us know at GII@McKinsey.com.

The changing role of the infrastructure CEO

Infrastructure CEOs can prepare as the industry adapts to changing technology and shifting stakeholder and societal expectations.

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Rapid technology advances, growing stakeholder complexities, and evolving societal and environmental issues are just some of the factors reshaping the infrastructure industry. With traditional approaches now outdated, infrastructure CEOs have to adapt—and fast. What made infrastructure CEOs successful in the past will no longer suffice: communication skills outweigh construction skills, public credibility is more important than ever, and ambition must be balanced with strategy.

To mark the upcoming 2024 Global Infrastructure Initiative Summit in Dubai, McKinsey spoke to David Cowan, Greg Stanmore, and Hugh Thorneycroft, infrastructure experts at executive search firm Spencer Stuart. Together, they discuss the changing role of the infrastructure CEO, the challenges those CEOs face, and the range of leadership qualities and capabilities they can hone to succeed in the future.

McKinsey: How have demands on infrastructure CEOs changed over the past five years?

Hugh Thorneycroft: There is considerably more private equity money in infrastructure than there was five years ago. This has led to more severe financial pressures for CEOs because many funds are now looking for returns over a shorter period of time.

There is also more scrutiny on infrastructure organizations from the public and in the media. For example, in the United Kingdom, water companies are being blamed for not investing enough in assets that prevent sewage from flowing into rivers. With the spotlight intensifying, organizations are more vulnerable than they used to be—and CEOs need to respond mindfully.

Greg Stanmore: An increased flow of private capital has led to bigger projects as well as more joint ventures [JVs] and club deals. This means that infrastructure CEOs must now be familiar with running companies or projects governed by JV arrangements.

Balancing increased governance oversight and regulation with the ambitions of JV partners is challenging, but it's critical for CEOs to master stakeholder management so they can wholly consider the needs of different groups with different agendas.

David Cowan: The fundamental role of the CEO hasn't changed, but the necessary skills and attributes have. Aspiring infrastructure CEOs now have to be more technology savvy and have a deep understanding of the type of collaboration and partnership needed to work with multiple companies at the same time. This knowledge can typically only come from the direct experience gained from working with joint ventures, however, which complicates CEOs' roles and the breadth of experience they need to be successful.

Today, the context in which CEOs are operating is critical to consider. To navigate a changing industry, the infrastructure CEO of today may be the sole person balancing the needs of the investor, the regulator, the public stakeholder, and the employee, often at the same time.

McKinsey: What attributes can help infrastructure CEOs succeed?

David Cowan: CEOs must manage complex ecosystems with many moving parts. A power development CEO, for example, might be under pressure from the local utility to get gigawatts into the ground, but might have a four-year interconnection queue to deal with. This type of issue applies to every element of infrastructure.

In this world of complexity, no one can have all the answers, which means it's increasingly important for CEOs to be like the conductor of an orchestra: they must be able to extract the maximum value from their team in an inclusive way.

Hugh Thorneycroft: The future CEO role will look quite different than it does now and how it looked in the past. There are so many competing demands when it comes to this position, but chief among them is the ability to be a "systems thinker."[1]

Being a systems thinker means strategizing, recognizing overwhelming interconnectivity, and thinking big to develop big ideas. Systems thinkers can strategically move between multiple angles, time horizons, and scenarios, zooming in and out when needed. An infrastructure CEO who is *not* a systems thinker may end up thinking too narrowly and fail to connect the dots when determining what matters most for a project.

Greg Stanmore: Valuing soft skills is also important. The most effective infrastructure CEOs don't need to appear to have all the answers or be the smartest person in the room. Instead, they are all about visibly self-critiquing, seeking feedback, and incorporating others' views, and then adapting their approach, if necessary.

While CEOs hold their organization accountable for results, their approach is also shaped by empathy, inclusivity, and social intelligence. As a result, they are better able to engage and rally people than leaders who lean too heavily on hard skills. Leaders who focus on these technical skills might also achieve results, but their success might become unsustainable if employees feel disempowered or disengaged. CEOs should find a balance between both sets of skills.

McKinsey: What skill set or background does an effective infrastructure CEO need to have?

Greg Stanmore: CEOs now require a different skill set and knowledge than they did 20 years ago, when projects often had less risk and were of a smaller scope.

Back then, CEOs leading companies with exposure to a range of capital projects typically had some construction or project delivery skills, but that is not always the case today. More organizations today have a delivery director, who has the construction knowledge, and a CEO, who presides over everything at the company. Therefore, CEOs no longer need to have a true infrastructure background.

Hugh Thorneycroft: Whether a CEO needs an infrastructure background to be successful also depends on the type of infrastructure in which a company specializes. If an organization's core business is building something, a CEO who doesn't understand program and project management or lacks megaproject experience might struggle to understand effective strategies for execution. At the same time, so much of a CEO's job is now about stakeholder management and partnering, rather than executing projects, so those relationship-building skills are supremely relevant.

McKinsey: What pitfalls should infrastructure CEOs avoid when leading a large project?

Greg Stanmore: CEOs also need to be aware of the money that is made and lost during the tendering and bidding phase, which can be ample, especially for large-scale, high-stakes projects. Once the bids are in place, it's important to craft contractual arrangements that ensure costs will be managed, the right delivery strategy is in place, and the right risk-sharing expectation is set among all the

[1] "Leadership for a complex world: Planning for the CEO of the future," Spencer Stuart, September 2023.

consortium partners. The projects that get the contractual agreements right do the best and make money in the end.

Hugh Thorneycroft: The up-front design, ambition, and tactics can also contribute to a project's undoing. Infrastructure CEOs should be aware of pitfalls and tactics like these early on to complete large projects smoothly.

David Cowan: Many pitfalls can be avoided if the CEO is an effective communicator. CEOs need to be able to motivate people, up close or from afar, and tailor their approach to their audience. Successful CEOs know how to make the vision seem real to win hearts and minds and instill confidence in teams across their organizations.

At the upcoming Global Infrastructure Initiative Summit in Dubai on February 27–29, 2024, McKinsey and Spencer Stuart are leading a panel discussion that will explore the evolving skillsets needed by infrastructure CEOs.

This article is part of Global Infrastructure Initiative's Voices on Infrastructure.

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Comments and opinions expressed by interviewees are their own and do not represent or reflect the opinions, policies, or positions of McKinsey & Company or have its endorsement.

Capital projects are critical for a green future

Constructing new decarbonization assets can help achieve net-zero targets—but doing so requires fundamentally rethinking project costs to accelerate development.

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Capital is critical to tackling climate change. According to McKinsey analysis, meeting net-zero targets will require spending $9.2 trillion a year on physical assets between now and 2050, up from $3.5 trillion today.[1] By then, the energy mix would also include nascent energy technologies such as clean hydrogen; battery storage; and carbon capture, utilization, and storage (CCUS).

Capital projects, including those crucial to the energy transition, typically take many years and many hands to design, build, and launch. The number and scale of projects in the current pipeline will not suffice. Labor costs are increasing as raw materials and components remain in high demand, and the global supply chain has strained to keep pace, making the transition to newer technologies with different cost structures even more challenging. And, by definition, nascent technologies don't have a track record of lessons learned to inform cost productivity improvements to accelerate scaling.

That said, investment in the energy transition is accelerating. As an example, when the Inflation Reduction Act was signed in 2022, the US federal government released $370 billion in funding to provide tax credits for clean-energy projects.[2] With this in mind, the challenge moving forward will be securing the right people, resources, and physical space while overcoming supply chain constraints and financing for nonestablished players.

The time is now for industry players to fundamentally rethink how they approach projects to deliver them faster, cheaper, and more efficiently than ever.

A once-in-a-generation call for capital investment

McKinsey analysis suggests that global annual capacity needs to be drastically increased across four areas—renewables, hydrogen, battery storage, and CO_2 captured—in the next 30 years (Exhibit 1). Each of these decarbonization technologies will be critical to tackling climate change.

In some areas, such as solar and wind, the global industry has already made significant strides in expanding installed renewable capacity. But other areas, such as carbon capture technologies, are still in early stages.[3]

Batteries are projected to see a meteoric rise in demand in the coming decades if the industry can overcome ongoing challenges in securing the raw materials, such as lithium, copper, and nickel, needed to produce at scale. On this point, recent McKinsey estimates show that meeting global demand for copper and nickel alone could require capital expenditures of $250 billion to $350 billion by 2030, both to grow new capacity and to replace depleted existing capacity.[4]

The pathway for hydrogen perhaps best illuminates the challenges of scaling new energy technologies. McKinsey estimates that by 2050, two primary fuels—electricity and hydrogen—will make up an estimated 50 percent of the global energy mix.[5] This growth will be seen across different forms of hydrogen, including renewable "green" hydrogen, which is produced via the electrolysis of water.

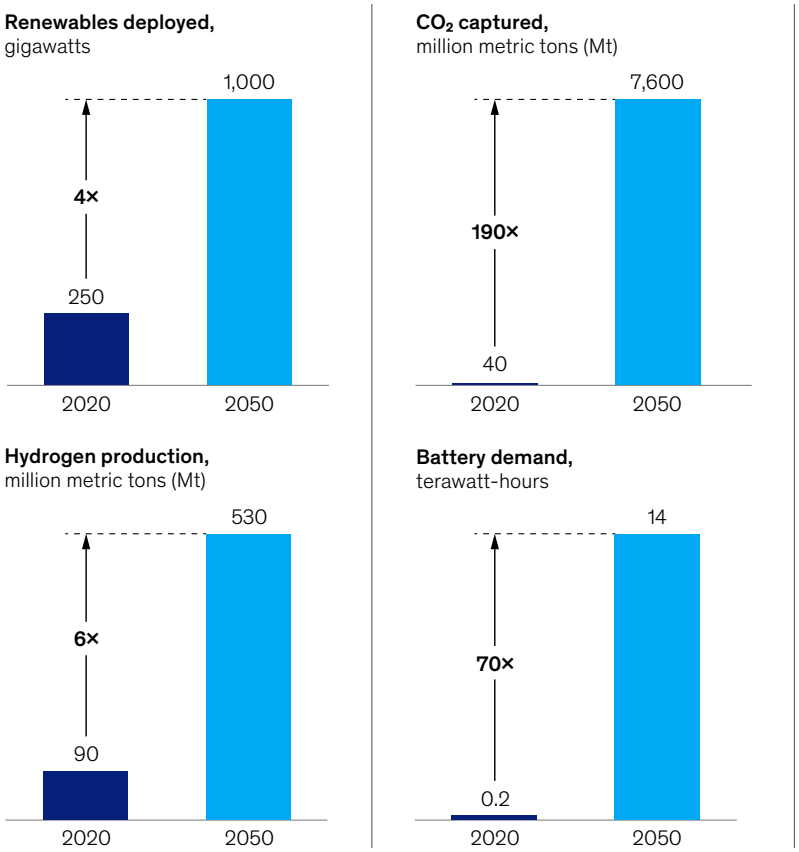
Recently announced projects would add about 22 million metric tons of capacity, but their financing is still unclear—and collectively they would account for only 15 to 20 percent of the estimated 2035 need.[6] Regarding cost parity, improvements are possible in terms of the levelized cost of hydrogen,[7] but this will require the industry to rapidly improve electrolyzer systems, increase hydrogen plant capital expenditures, and lower electricity costs (Exhibit 2).

[1] "The net-zero transition: What it would cost, what it could bring," McKinsey Global Institute, January 2022.
[2] "Here's how the Inflation Reduction Act is impacting green job creation," World Economic Forum, March 14, 2023.
[3] "Scaling the CCUS industry to achieve net-zero emissions," McKinsey, October 28, 2022.
[4] "The raw-materials challenge: How the metals and mining sector will be at the core of enabling the energy transition," McKinsey, January 10, 2022.
[5] *Global Energy Perspective 2022,* McKinsey, April 26, 2022.
[6] Ibid.
[7] The levelized cost of hydrogen refers to the methodology used to calculate the capital and operating costs of producing hydrogen, allowing for the comparison of different production routes.

Exhibit 1

The opportunity in green capital expenditures is massive; investment needs to triple by 2050 to reach decarbonization goals.

Global annual capacity required to decarbonize



$9.2 trillion per year

Global capital investment required to meet decarbonization goals between now and 2050

Source: International Energy Agency; "The net-zero transition: What it would cost, what it could bring," McKinsey Global Institute, January 2022

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In an accelerated scenario, clean hydrogen could account for approximately 95 percent of total supply by 2050, helping to meet the anticipated fivefold increase in demand driven by the road transport, maritime, and aviation industries.[8] Thus, significant scale-up in renewable-energy production, electrolyzers, and CCUS is needed to make hydrogen, renewable fuels, and other clean technologies cost competitive with conventional-energy production, particularly in transport, which is expected to account for more than 50 percent of demand growth by 2050.

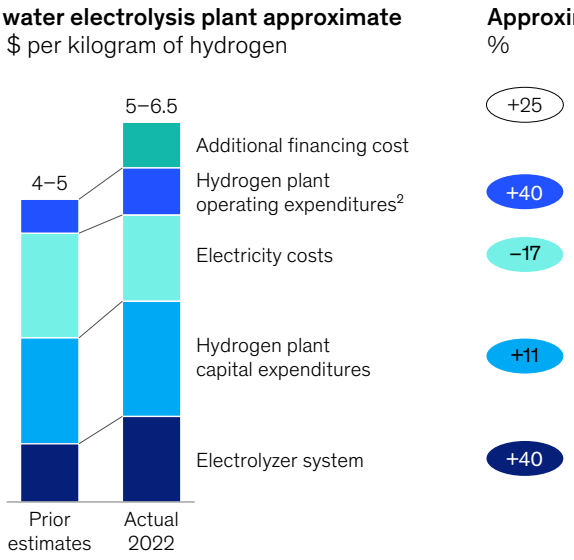
The path forward: Rethinking capital project costs

Considering the starting points of technologies such as hydrogen, batteries, and CCUS, their respective growth potentials are high. Effective hyperscaling—that is, large-scale and repeatable new-asset development—would require project owners to increase their metabolism while rethinking the cost of project delivery. The "plant as a product" approach, which uses manufacturing methodology to

[8] *Global Energy Perspective,* April 26, 2022.

Exhibit 2

In 2022, the levelized cost of green hydrogen increased by approximately 25 percent.



Note: Levelized cost of hydrogen 2022 estimates for a 1 GW alkaline water electrolysis plant in the United States.
[1]Levelized cost of hydrogen.
[2]Includes operations and maintenance, stack refurbishment, and water consumption.
Source: Hydrogen Council; McKinsey analysis

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help companies scale green capital expenditures quickly and make construction projects repeatable, can help owners and builders deliver these projects more efficiently and cheaply.

Several projects currently underway could produce hydrogen at a cost of $6 to $8 per kilogram. For hydrogen to be economical, however, it will need to be produced at roughly $3 per kilogram for most applications.[9] This means industry leaders need to fundamentally rethink capital costs for future projects. Some of the necessary efficiency will come from experience, reducing costs—particularly for electrolyzer system improvements for power density and efficiency—and some will come as more projects are built and others are scaled. However, cost competitiveness won't happen within the necessary time frame if industry players don't approach things differently.

With this in mind, the following decisions throughout the project life cycle can help facilitate the required timelines, costs, and levels of efficiency of green projects.

Rethink the approach to project design

Moving forward, players—particularly incumbents accustomed to large-scale capital projects with massive specifications and scale—can help make these projects economical by rethinking how they are designed for the minimum technical solution. This can be done in part by taking a radical approach to design and standardization. For example, Tesla claims that it has been able to reduce the capital expenditures per gigawatt-hour of its gigafactories by 70 percent, which has led to knock-on benefits of standardized materials and supplies.[10] In addition, this approach has been facilitated by the creation of an ecosystem

[9] Depending on the price of natural gas. For more, see Yuanrong Zhou, "Can the Inflation Reduction Act unlock a green hydrogen economy?," International Council on Clean Transportation, January 3, 2023.
[10] Eva Fox, "Tesla Giga Texas battery factory will enable 70% lower capex per GWh than industry norm," Tesmanian, April 21, 2023.

of partners and suppliers that are aligned on aspirations related to speed, massive scale, and low costs.

Engage in collaborative contracting

Players can pursue strategic partnering models across the value chain with suppliers that are new to the industry. Companies can also consider investing time and energy into building more collaborative partnerships with contractors rather than relying on transactional bid–buy relationships. One option is developing an ecosystem of contractors, for which shared incentives and partnerships can be improved with each subsequent build, as opposed to changing up contracts each round. Our analysis shows that undertaking multiple projects in parallel and using the same contractors can improve performance by an additional 15 to 20 percent beyond the average.

Build next-generation capabilities

Simply put, the industry needs more people with clean-energy expertise. Although training can help upskill current employees and ensure they're ready to tackle climate change on the ground, more skilled workers will be needed. On this point, players can partner with unions, trade schools, and vocational schools to build their talent pools. For instance, in 2018 Quanta Services acquired Northwest Linemen College, which focuses on the electric power industry. This allowed Quanta to create a pipeline for certified line technicians, who are in high demand. As another example, Ontario's Express Entry Skilled Trades Stream has removed requirements for domestic experience for foreign nationals with experience in skilled trades. Now, those with the right work experience can transfer their accreditations by passing an exam.

Apply digital tools

Project owners can build smart, data-driven setups across the value chain and life cycle. Advanced analytics and digital twins are now table stakes; including them from the outset will help optimize the system as a whole. Digital twins in particular are needed not only for operations but also for optimizing or right-sizing project designs and delivering the lowest life cycle costs needed to make projects economical. Advanced analytics or an AI-enabled digital twin can add 5 to 15 percent savings over so-called basic techno-economic models. This is achieved by subcomponent granularity, a look "inside" the chemical or physical properties, and increasingly accurate dynamic optimization. In addition, if the digital twin is set up correctly during the design phase, it can serve as the basis for a variety of use cases throughout the plant life cycle, ranging from operations and maintenance to strategic investment.

Without a large pool of project examples to learn from, many project owners may feel that they're starting from scratch, and they may be tempted to take it slow and steady. But at the current pace, the world will never hit its 2050 goals. Capital project leaders have a range of options to reconsider how they approach project costs, from project design to future-proofing the partnerships and capabilities that will provide the foundation for hyperscaling.

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The plant as a product: Hyperscaling green capex

Most capital projects overrun schedules and exceed budgets. A new delivery system for capital expenditures can help reduce costs and increase efficiency for green tech projects.

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As industry players race to meet increasingly ambitious net-zero emissions targets, it's clear that capital expenditure costs need to be reduced while project timelines are accelerated. This is particularly true for the construction of gigafactories, which are critical to hyperscale the green technologies needed to meet climate targets by 2050, including renewable energy sources, hydrogen, batteries, and carbon capture, utilization, and storage (CCUS).

Our estimates show that achieving carbon reduction targets will require the equivalent of 7.5 percent of global GDP in green capital expenditures by 2030. In turn, this capital expenditure will play a critical role in setting future costs of products, ultimately determining 10 to 15 percent of the cost of batteries and an even higher percentage of the cost of green hydrogen and ammonia.

Given that players in new green tech sectors typically have no blueprint for factory and production process design, industry leaders can borrow recent insights from battery manufacturing to drive down costs. On this point, a fundamentally new delivery system for capital expenditures, known as the plant-as-a-product approach, can help players industrialize the end-to-end process of designing and delivering gigafactory projects.

By reducing both costs at the plant level and lead times for green capital expenditures, the plant-as-a-product approach can lower capital expenditure costs by 10 to 20 percent for the first plant, with ultimate capital expenditure reductions reaching as much as 75 percent.

Global investment in green technologies: An overview

Meeting the world's decarbonization goals is a significant challenge in terms of both increasing capital expenditures and overcoming technological limitations. That said, the main types of investments being made today are related to hydrogen (green steel, hydrogen plants, and green ammonia), battery gigafactories, renewables, and carbon capture technologies, all of which are necessary to help reach decarbonization goals by 2050. In Europe alone, 30 battery gigafactories will be built over the next seven years to help meet rapidly increasing demand for electric-vehicle batteries.

In addition, companies around the world are planning to build hundreds of installations for hydrogen, many of which will be highly accelerated because of recent stimulus programs, such as the Infrastructure Investment and Jobs Act and the Inflation Reduction Act in the United States.[1] As part of the former, the US Department of Energy has allocated $9.5 billion to fund clean-hydrogen hubs, electrolysis programs, and manufacturing and recycling programs.[2] The latter offers a production tax credit of up to $3 per kilogram of hydrogen produced.[3]

Hyperscaling green capital expenditures: Reducing costs while increasing efficiency

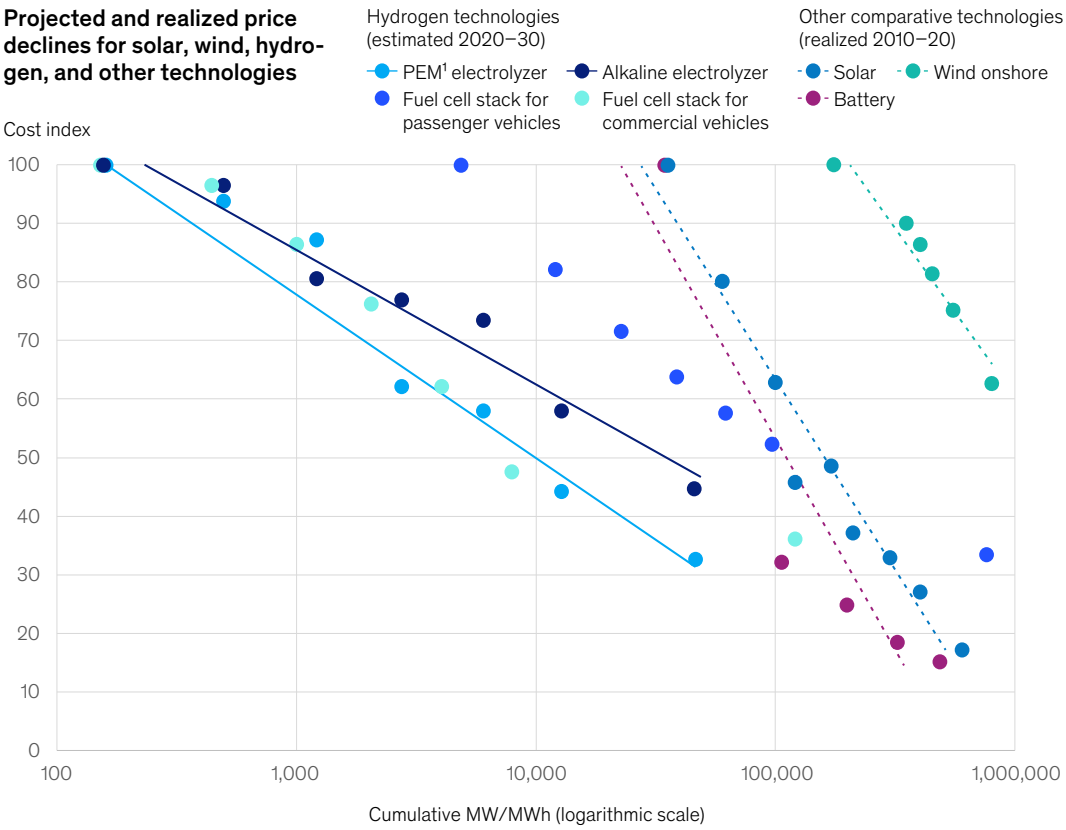
Delivering capital investments has always been difficult. The vast majority of projects do not meet their authorized schedules, and cost overruns can drastically exceed initial estimates. To successfully scale delivery of green capital expenditures, construction players need first to fully control cost and time budgets and then to embark on cost ramp-down curves, similar to those seen in batteries, solar, and wind (exhibit).

Most companies will need to embark on aggressive expansions that involve building multiple plants in parallel. As an example, battery producers will likely need to build four plants in parallel, all in different stages of construction, to keep pace with the required scale-up. By contrast, scaling hydrogen plants could

[1] For more, see Infrastructure Investment and Jobs Act of 2022, Pub. L. No. 117-58; and Inflation Reduction Act of 2022, Pub. L. No. 117-169.
[2] "Infrastructure and Jobs Act: Clean hydrogen initiatives," International Energy Agency, May 16, 2023.
[3] Yuanrong Zhou, "Can the Inflation Reduction Act unlock a green hydrogen economy?," International Council on Clean Transportation, January 3, 2023.

Exhibit

A significant reduction in capital expenditures has been seen in batteries, solar, and wind power and is expected in hydrogen.



[1]Proton exchange membrane.
Source: BloombergNEF (BNEF); Eleonora Ruffini and Max Wei, "Future costs of fuel cell electric vehicles in California using a learning rate approach," *Energy*, May 2018, Volume 150; International Renewable Energy Agency (IRENA)

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theoretically require building as many as eight to ten in parallel, considering the ambitious plans of most hydrogen players.

That's a very tall order. But it may be possible if companies deploy a plant-as-a-product capital expenditure delivery system, which would let them design and implement future ways of working across all capital expenditure projects globally—potentially yielding both short-term productivity gains and continuous improvement in the midterm. This system is built around three complementary building blocks: technical, management, and people systems.

Technical system

The first building block refers to fit-for-purpose technical tools and systems to help optimize fact-based decision making. Such systems can help owners optimize plant design by simulating the construction phase, as well as ramp-up and operations, through digital twins.[4] For example, various scenarios and design

[4] For more on digital twins, see "What is digital-twin technology?," McKinsey, July 12, 2023.

choices that influence building and equipment capital expenditures can be simulated, such as the required capacity of individual pieces of equipment, layout of production lines, and infrastructure. To reach optimal cost levels quickly during the design stage, owners can test maintenance costs and other operating expenditures—including any impact on final cost, yield, and returns on investment—before construction begins. Furthermore, tool kits can be expanded with updated market pricing and resource availability to help owners make informed trade-offs in their design up to the point of start of construction.

Another example includes integrating the design, procurement, and planning processes via digital platforms. This can help ensure seamless operations among the relevant parties by preventing the procurement of materials based on outdated designs and the arrival of subcontractors at sites based on older work schedules.

With such tools in place, one Europe-based battery producer was able to reduce expected capital expenditure costs significantly by implementing an aggressive minimum-technical-solution approach during concept design, which challenged the required scope and technical requirements. For example, equipment footprint was reduced by eliminating nonfunctional spaces, compressing open spaces, and optimizing equipment paths. Overall, capital expenditure cost estimates were lowered by 50 percent by reducing unnecessary space in production areas, optimizing storage areas, and combining heating, ventilation, and air conditioning (HVAC) equipment, among many other initiatives.

Management system

Having the right setup and performance management is the second building block. A critical component of this is a performance management office at both internal (the owner organization) and external (suppliers and engineering, procurement, and construction [EPC] companies) levels. Here, steering meetings can be supported by live performance-management dashboards with KPIs across all stages of the project life cycle, allowing owners to rapidly identify obstacles—such as low construction productivity; slow delivery, checking, and updating of design deliverables; interface clashes between contractors; and a lack of available materials on-site—and intervene for course correction or decision making.

"SWAT" teams can also help debottleneck and drive performance.[5] For example, a solar player implemented SWAT teams and lean performance management and also parallelized labor onboarding and ramp-up, which accelerated the schedule by 30 percent and improved productivity by 40 percent. In this case, crew-level task assignments, performance targets, and daily performance dialogues helped to rapidly improve issue escalation and resolution, and to accelerate issue-resolution cycles.

People system

The final building block refers to the required capacities and capabilities. Often, implementing a successful people system entails a culture shift: companies will need to embrace innovative change and break down silos to help create the mindset for implementing minimum technical solutions. This will likely require creating innovative roles at the central and project levels (such as a blueprinting team) and building internal EPC capabilities (such as capital expenditure controllers).

With these points in mind, a global battery cell manufacturer mobilized its best organizational capabilities by installing full-time project teams and, in turn, identified improvement potential of more than 70 percent for the business case for a pilot gigafactory. In response, core team roles were identified and defined across sites, and

[5] For more on digital SWAT teams, see "Clearing data-quality roadblocks: Unlocking AI in manufacturing," McKinsey, January 20, 2023.

daily communication was implemented globally to increase the speed of decision making across capabilities and organizational functions. As a result, a team blueprint was formed to roll out the pilot approach across sites.

The challenges for green tech projects in the years to come are formidable. In addition, owners and operators must contend with various external pressures related to changing regulations and increasingly stringent climate targets. One thing that's certain, however, is that industry players need to make bold decisions today to approach things differently. Taking its cues from cost reductions in batteries, solar, and wind, the plant as a project is a promising solution.

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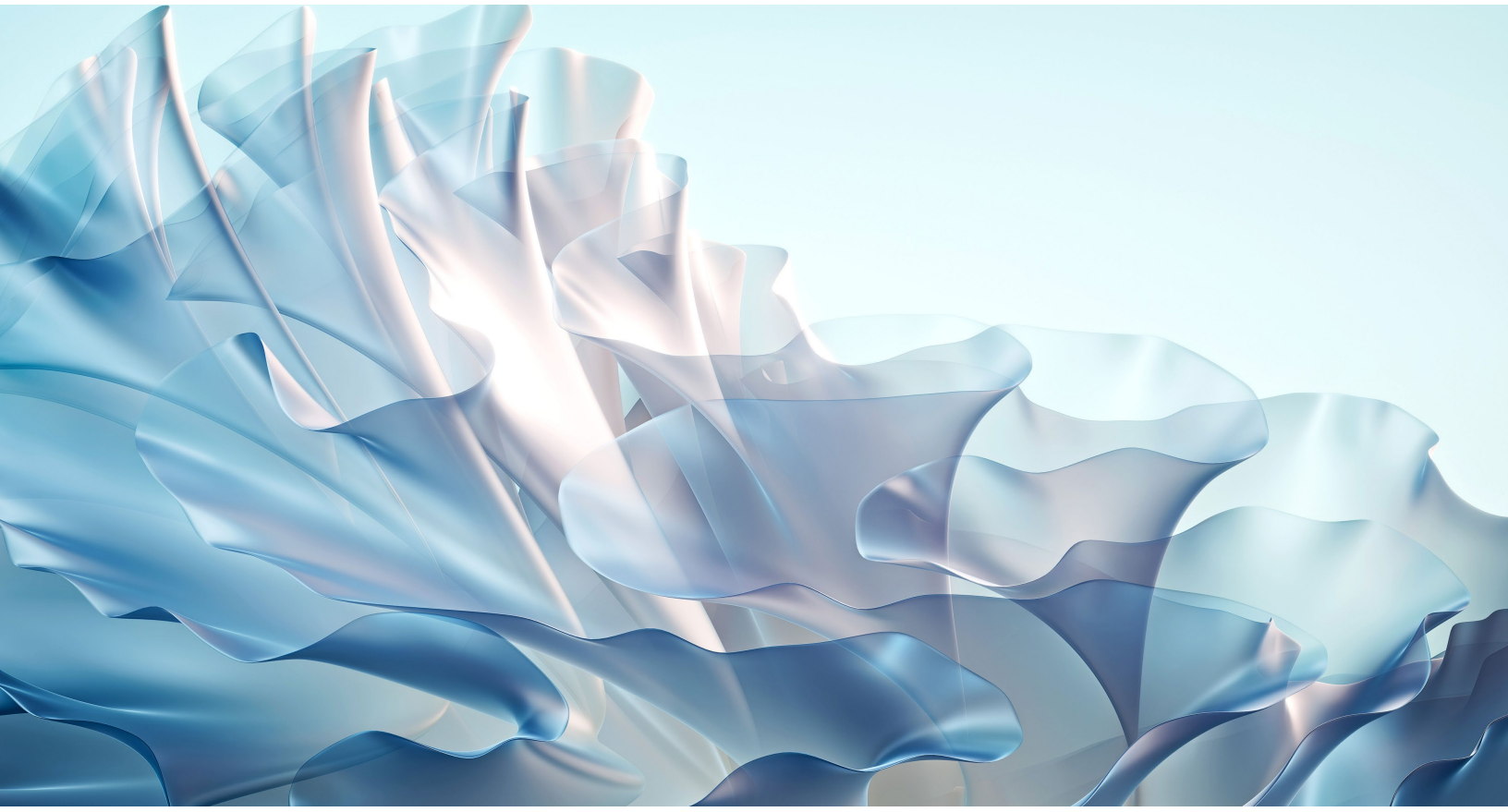
Private Equity & Principal Investors

Private markets: A slower era

In 2023, private markets fundraising, deal activity, and performance remained under pressure, although there were some notable exceptions across strategies and regions.

This article, and the underlying report on which it is based, is a collaborative effort by Fredrik Dahlqvist, Alastair Green, Paul Maia, Connor Mangan, Alexandra Nee, David Quigley, Aditya Sanghvi, Rahel Schneider, John Spivey,



February 2024

If 2022 was a tale of two halves, with robust fundraising and deal activity in the first six months followed by a slowdown in the second half, then 2023 might be considered a tale of one whole.

Macroeconomic headwinds persisted throughout the year, with rising financing costs and an uncertain growth outlook taking a toll on private markets. Full-year fundraising continued to decline from 2021's lofty peak, weighed down by the "denominator effect" that persisted in part due to a less active deal market. Managers largely held onto assets to avoid selling in a lower-multiple environment, fueling an activity-dampening cycle in which distribution-starved limited partners (LPs) reined in new commitments.

Performance in most private asset classes remained below historical averages for a second consecutive year. Decade-long tailwinds from low and falling interest rates and consistently expanding multiples seem to be things of the past. As private market managers look to boost performance in this new era of investing, a deeper focus on revenue growth and margin expansion will be needed now more than ever.

This preview article of our full *2024 Global Private Markets Review* summarizes the highlights from our latest research. The report, which will be published in March, covers the 2023 journey of each private market asset class in detail.

Global fundraising contracted

Fundraising fell 22 percent across private market asset classes globally to just over $1 trillion, as of year-end reported data—the lowest total since 2017. Fundraising in North America, a rare bright spot in 2022, declined in line with global totals, while in Europe, fundraising proved most resilient, falling just 3 percent. In Asia, fundraising fell precipitously and now sits 72 percent below the region's 2018 peak.

Despite difficult fundraising conditions, headwinds did not affect all strategies or managers equally. Private equity (PE) buyout strategies posted their best fundraising year ever, and larger managers and vehicles also fared well, continuing the prior year's trend toward greater fundraising concentration.

The numerator effect persisted

Despite a marked recovery in the denominator—the 1,000 largest US retirement funds grew 7 percent in the year ending September 2023, after falling 14 percent the prior year, for example—many LPs remain overexposed to private markets relative to their target allocations. LPs started 2023 overweight: according to analysis from CEM Benchmarking, average allocations across PE, infrastructure, and real estate were at or above target allocations as of the beginning of the year. And the numerator grew throughout the year, as a lack of exits and rebounding valuations drove net asset values (NAVs) higher. While not all LPs strictly follow asset allocation targets, our analysis in partnership with StepStone Group suggests that an overallocation of just one percentage point can reduce planned commitments by as much as 10 to 12 percent per year for five years or more. (See sidebar, "Sources," for more information on the data and analysis on which this article is based.)

Despite these headwinds, recent surveys indicate that LPs remain broadly committed to private markets. In fact, the majority plan to maintain or increase allocations over the medium to long term.

Investors fled to known names and larger funds

Fundraising concentration reached its highest level in more than a decade, as investors continued to shift new commitments in favor of the largest fund managers. The 25 most successful fundraisers collected 41 percent of aggregate commitments to closed-end funds (with the top five managers accounting for nearly half that total). It bears noting that closed-end fundraising totals may understate the extent of concentration in the industry overall,

Sources

This article is based on analysis created in collaboration with CEM Benchmarking and the StepStone Group and data drawn from the following sources: Bloomberg, CoStar, Green Street, LSEG LPC, MSCI Private Capital Solutions, National Council of Real Estate Investment Fiduciaries (NCREIF), *Pensions & Investments*, PitchBook, Preqin, and Real Capital Analytics. Please refer to the upcoming full report for complete citations.

as the largest managers also tend to be more successful in raising noninstitutional capital.

While the largest funds grew even larger—the largest vehicles on record were raised in buyout, real estate, infrastructure, and private debt in 2023—smaller and newer funds struggled. Fewer than 1,700 funds of less than $1 billion were closed during the year, half as many as closed in 2022 and the fewest of any year since 2012. New manager formation also fell to the lowest level since 2012, with just 651 new firms launched in 2023.

Whether recent fundraising concentration and a spate of M&A activity signals the beginning of oft-rumored consolidation in the private markets remains uncertain, as a similar pattern developed in each of the last two fundraising downturns before giving way to renewed entrepreneurialism among general partners (GPs) and commitment diversification among LPs. Compared with how things played out in the last two downturns, perhaps this movie really is different, or perhaps we're watching a trilogy reusing a familiar plotline.

Dry powder inventory spiked (again)

Private markets assets under management totaled $13.1 trillion as of June 30, 2023, and have grown nearly 20 percent per annum since 2018. Dry powder reserves—the amount of capital committed but not yet deployed—increased to $3.7 trillion, marking the ninth consecutive year of growth.

Dry powder inventory—the amount of capital available to GPs expressed as a multiple of annual deployment—increased for the second consecutive year in PE, as new commitments continued to outpace deal activity. Inventory sat at 1.6 years in 2023, up markedly from the 0.9 years recorded at the end of 2021 but still within the historical range. NAV grew as well, largely driven by the reluctance of managers to exit positions and crystallize returns in a depressed multiple environment.

Private equity strategies diverged

Buyout and venture capital, the two largest PE sub-asset classes, charted wildly different courses over the past 18 months. Buyout notched its highest fundraising year ever in 2023, and its performance improved, with funds posting a (still paltry) 5 percent net internal rate of return through September 30. And although buyout deal volumes declined by 19 percent, 2023 was still the third-most-active year on record. On the other hand, venture capital (VC) fundraising declined by nearly 60 percent, equaling its lowest total since 2015, and deal volume fell by 36 percent to the lowest level since 2019. VC funds returned –3 percent through September and have now posted negative returns for seven consecutive quarters. VC was the fastest-growing—as well as the highest-performing—PE strategy by a significant margin from 2010 to 2022, but investors appear to be reevaluating their approach in the current environment.

Private equity entry multiples contracted

PE buyout entry multiples declined by roughly one turn from 11.9 to 11.0 times EBITDA, slightly outpacing the decline in public market multiples (down from 12.1 to 11.3 times EBITDA), through the first nine months of 2023. For nearly a decade leading up to 2022, managers consistently sold assets into a higher multiple environment than that in which they had bought those assets, providing a substantial performance tailwind for the industry. Nowhere has this been more true than in technology. After experiencing more than eight turns of multiple expansion from 2009 to 2021 (the most of any sector), technology multiples have declined by nearly three turns in the past two years, 50 percent more than in any other sector. Overall, roughly two-thirds of the total return for buyout deals that were entered in 2010 or later, and exited 2021 or before, can be attributed to market multiple expansion and leverage. Now, with falling multiples and higher financing costs, revenue growth and margin expansion are taking center stage for GPs.

Real estate receded

Demand uncertainty, slowing rent growth, and elevated financing costs drove cap rates higher and made price discovery challenging, all of which weighed on deal volume, fundraising, and investment performance. Global closed-end fundraising declined 34 percent year over year, and funds returned –4 percent in the first nine months of the year, losing money for the first time since the 2007–08 global financial crisis. Capital shifted away from core and core-plus strategies as investors sought liquidity via redemptions in open-ended vehicles, from which net outflows reached their highest level in at least two decades. Opportunistic strategies benefited from this shift, with investors focusing on capital appreciation over income generation in a market where alternative sources of yield have grown more attractive. Rising interest rates widened bid–ask spreads and impaired deal volume across food groups, including in what were formerly hot sectors: multifamily and industrial.

Private debt pays dividends

Debt again proved to be the most resilient private asset class against a turbulent market backdrop. Fundraising declined just 13 percent, largely driven by lower commitments to direct lending strategies for which a slower PE deal environment has made capital deployment challenging. The asset class also posted the highest returns among all private asset classes through September 30. Many private debt securities are tied to floating rates, which enhance returns in a rising rate environment. Thus far, managers appear to have successfully navigated the rising incidence of default and distress exhibited across the broader leveraged lending market. Although direct lending deal volume declined from 2022, private lenders financed an all-time high 59 percent of leveraged buyout transactions last year and are now expanding into additional strategies to drive the next era of growth.

Infrastructure took a detour

After several years of robust growth and strong performance, infrastructure and natural-resources fundraising declined by 53 percent, equaling the lowest total since 2013. Supply-side timing is partially to blame: five of the seven largest infrastructure managers closed a flagship vehicle in 2021 or 2022, and none of those five held a final close last year. As in real estate, investors shied away from core and core-plus investments in a higher yield environment. Yet there are reasons to believe infrastructure's growth will bounce back. LPs surveyed by McKinsey remain bullish on their deployment to the asset class, and at least a dozen vehicles targeting more than $10 billion were actively fundraising as of the end of 2023. Multiple recent acquisitions of large infrastructure GPs by global multiasset-class managers also indicate marketwide conviction in the asset class' potential.

Private markets still have work to do on diversity

Private markets firms are slowly improving their representation of females (up two percentage points

over the prior year) and ethnic and racial minorities (up one percentage point). On some diversity metrics, including entry-level representation of women, private markets now compare favorably with corporate America. Yet broad-based parity remains elusive and too slow in the making. Ethnic, racial, and gender imbalances are particularly stark across more influential investing roles and senior positions. In fact, McKinsey's research reveals that at the current pace, it would take several decades for private markets firms to reach gender parity at senior levels. Increasing representation across all levels will require managers to take fresh approaches to hiring, retention, and promotion.

Artificial intelligence generating excitement

The transformative potential of generative AI was perhaps 2023's hottest topic (beyond Taylor Swift). Private markets players are excited about the potential for the technology to optimize their approach to thesis generation, deal sourcing, investment due diligence, and portfolio performance, among other areas. While the technology is still nascent, and few GPs can boast scaled implementations, pilot programs are already in flight across the industry, particularly within portfolio companies. Adoption seems nearly certain to accelerate throughout 2024.

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Grid planning under uncertainty: Investing for the energy transition

In the face of climate and transition risks, an updated planning paradigm can help grid operators mitigate evolving challenges and ensure grid resilience and affordability.

by Alfonso Encinas Fernandez, Blake Houghton, Adam Rubin, and Aaron Schifrin

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Globally, the electricity grids that power the economy are undergoing rapid and profound change. In the United States, policies supporting decarbonization and increasingly cost-competitive renewable resources are transforming the generation stack, with nearly 100 gigawatts (GW) of wind and solar added between 2017 and 2022, a record 32 GW of solar likely to be added in 2023 alone, and nearly 2 terawatts (TW) of capacity in the interconnection queue.[1] At the same time, building and transport electrification are adding to demand pressure on these grid networks.

Climate risks, including wildfires and severe storms, are on the rise in many geographies, placing additional stress on communities and the power infrastructure that serves them.[2] Extreme heat is increasing cooling demand while reducing the efficiency of grid infrastructure. Minnesota, for example, could see a 75 percent increase in extreme heat days over the next decade, equivalent to current levels in Ohio.[3]

Thunderstorms also pose a challenge for grid operators. In New Jersey, for example, where such storms already cause around 80 percent of major outages, the number of thunderstorm-risk days per year is expected to rise by more than two-thirds by 2050.[4]

Such risks come amid heightened concern around affordability, aging infrastructure, and surging inflation, all which have elevated the cost of core essentials by a fifth since 2021.[5]

Altogether, the challenge of providing safe, reliable, resilient, and affordable power—all while enabling the energy transition—is forcing grid planners to reimagine their processes and rethink longstanding paradigms for measuring and managing performance.

It will be incredibly inefficient and difficult to meet these needs independently. By adopting an integrated system planning approach, utilities can deliver all these outcomes supported by probabilistic analytical models and a granular, segment-specific view of future grid needs. The rewards of this shift could be significant: up to 20 percent capital efficiency, 15–30 percent reduction in major event outages, and a clearer pathway to achieving decarbonization milestones and goals.[6] This article explores approaches for securing these gains.

Emerging challenges in distribution grids

Grid planning is becoming a critical strategic capability, requiring a combination of technology, expertise, and understanding of market trends. Future grid needs can only be met cost-effectively if utilities are able to model and assess key drivers including climate risks, asset health, and customer adoption of distributed-energy resources (DERs) (such as heat pumps and rooftop solar) collectively.

By building tech-enabled, integrated system planning capabilities, utilities can understand and quantify these challenges. Defining the full scope of grid needs is a necessary precursor to identifying cost-effective investment solutions, making it imperative to start building these capabilities now.

A suite of interconnected analytical models with circuit- or asset-level granularity can help grid planners manage growth, reliability, affordability, resilience, and flexibility (Exhibit 1). By providing

[1] Short-term energy outlook data browser, U.S. Energy Information Administration, November 15, 2023; "US solar power capacity to expand by record 32 gigawatts in 2023, report says," Reuters, September 7, 2023; Tony Lenoir, "US Interconnection Queues Analysis 2023," S&P Global, August 28, 2023.
[2] "Climate risk and response: Physical hazards and socioeconomic impacts," McKinsey, January 16, 2020.
[3] "NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6), ensemble of 10 climate models," NASA center for climate simulation, published and accessed in 2022; McKinsey analysis.
[4] Electric Disturbance Events (OE-417) Annual Summaries, U.S. Department of Energy; date range of consideration is from 2002–2022 and defined by events with greater than 50,000 customers impacted; "MACA CMIP5 statistically downscaled climate projections," U.S. Climate Resilience Toolkit, accessed in May 2023; McKinsey analysis.
[5] In its last review, the Department of Energy found that 70 percent of transformers and transmission lines are 25 years or older and 60 percent of circuit breakers are 30 years or older; *Quadrennial Technology Review 2015,* U.S. Department of Energy, September 2015; Gabriel Cortes and Mike Winters, "These 5 charts show how much 2 years of inflation have really cost you," CNBC Make it, April 14, 2023.
[6] McKinsey analysis.

Exhibit 1

Utilities should leverage a 'model of models' architecture to enable integrated grid planning.

Illustrative architecture

Expected grid performance	Growth	Reliability	Resiliency	Affordability	Flexibility
Optimized investment portfolio	Integrated, optimized capital and O&M portfolio Prioritization of investments to enable growth (eg, generation capacity, grid capacity, monitoring, and control)		Prioritization of investments to enable reliability (eg, vegetation management, asset maintenance, engineering solutions)		
Localized understanding of grid needs	Capacity shortfalls, grid congestion, and grid instability risk		Risk return on investment (RROI): cost-effectiveness of reliability and resiliency investments		
Model grid inputs, components, and solutions	Hourly available supply by generation asset	Hourly demand by circuit, including impacts from customer DER[1]	Impact of climate and weather on demand, asset health, and performance	Failure risk by asset (probability and consequence of failure)	Vegetation risk (probability and consequence of failure)
Integrated asset data model ("Digital Twin")	Enterprise data model (ie, single source of truth)				

[1]Distributed energy resources.

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practical insights into key planning questions, these models can be a critical tool for navigating uncertainty—for example, by identifying the optimal mix of vegetation management and undergrounding to hit resilience targets, or revealing where capacity expansion and undergrounding can be combined to drive costs down.

Climate risks and resilience

Climate-related hazards, which pose a growing threat to grid resilience, will evolve differently across geographies. For example, over the next decade, Kansas expects to see a 25 percent increase in extreme heat days, while a 29 percent increase in severe thunderstorm frequency is predicted for Colorado. Approximately 88 percent of the western part of the United States could be subject to at least 30 high Fire Weather Index days per year.[7] Similarly, the likelihood of extreme precipitation and amplified urban growth are elevating flood risks and changing flood plains in some areas.

Broadly speaking, warming is increasing the frequency and intensity of extreme weather events in many areas, putting grid resources at heightened risk.[8] In the United States, for example, "major events"—often involving extreme weather coupled with aging grid infrastructure—have caused annual power interruptions to rise in average duration from less than four hours in 2015 to more than seven hours in 2021.[9]

[7]"NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6), ensemble of 10 climate models," NASA center for climate simulation, published and accessed in 2022; Chiara Lepore, Ryan Abernathey, Naomi Henderson, John T. Allen, and Michael K. Tippett, "Future global convective environments in CMIP6 models," *Advancing Earth and Space Sciences*, 2021, Volume 9, Issue 12; The Fire Weather Index (FWI) is a meteorologically based index used to estimate fire danger. A high FWI is defined as a day with FWI > 38; McKinsey analysis

[8]*Climate risk and response: Physical hazards and socioeconomic impacts*, McKinsey, January 16, 2020.

[9]Extreme weather events could be headline-grabbing hurricanes and wildfire, or the less extraordinary thunderstorms with high winds that most frequently impact local grids. "Today in energy: U.S. electricity customers averaged seven hours of power interruptions in 2021," U.S. Energy Information Administration, November 14, 2022.

Higher peak temperatures pose substantial challenges for grid operators, impacting both peak loads and grid performance. Dallas, Texas, for example, could see the annual number of heatwave days almost triple, from an average of 25 days per year between 1975 and 2022 to 67 by 2050.[10]

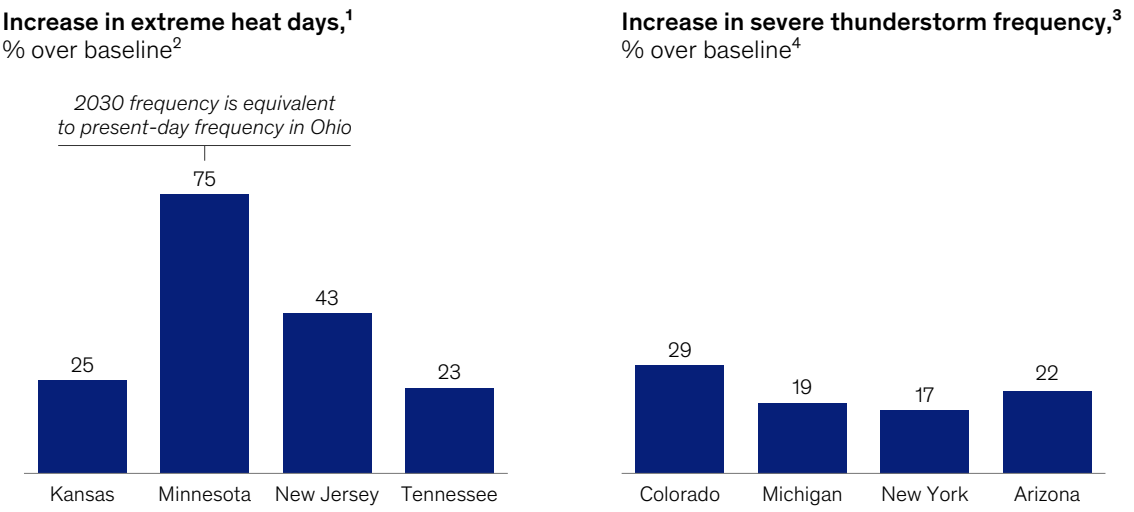
Recognizing these shifts, McKinsey has established an in-house Climate Analytics capability to translate the latest climate science into granular, investment-relevant insights (see sidebar "McKinsey's Climate Analytics in the utility industry").

Historically moderate climates could be affected, too. In an analysis for a Midwestern utility, cooling degree days were predicted to rise by 30 percent over that same period.[11] Grids will need to be prepared to meet demand increases from higher cooling loads, while also managing less efficient performance of essential equipment under extreme heat. Power line losses increase at higher temperatures, with capacity dropping as much as 7 percent below normal design ratings when temperatures exceed 100° F—undermining grid performance precisely when customers need it most.[12]

[10] Heatwave days are defined as having maximum temperatures above 95° F and minimum temperatures above 77° F for at least four consecutive days. ECMWF "ERA5-Land," European Centre for Medium-Range Weather Forecasts, accessed October 2022; Historical assessment was from 1975–2022; "WCRP coupled model intercomparison project (CMIP)," World Climate Research Programme, October 2022, where data from both Phases 5 and 6 were utilized.
[11] McKinsey analysis based on industry experience.
[12] Melissa R Allen-Dumas, Binita KC, and Colin I Cunliff, *Extreme weather and climate vulnerabilities of the electric grid: A summary of environmental sensitivity quantification methods*, Oak Ridge National Laboratory, August 2019.

Exhibit 2

Extreme weather events impacting utilities will increase by 2030, due to climate change.



[1] Extreme heat days are those where the maximum temperature exceeds 95°F.
[2] The baseline distribution is today's (1.1°C) distribution across 10 climate models. Metrics are calculated for each year and model, then averaged to show climate and ensemble mean projections. 1.1°C reflects today's global mean surface temperatures above pre-industrial (1850–1900). By 2030, that warming level is expected to reach 1.5°C.
[3] Severe thunderstorms are those that produce tornadoes, have hail with a diameter of at least 1", and/or winds greater than 58 mph.
[4] Compared to baseline period, which represents conditions from 1980–2014.
Source: CMIP6, Lepore et al. 2021; NASA NEX GDDP CMIP6 ensemble of 10 climate models; McKinsey Climate Analytics

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McKinsey's Climate Analytics in the utility industry

McKinsey's Climate Analytics leverages data from an ensemble of global climate models from the Coupled Model Intercomparison Project, which are bias-corrected and downscaled to provide additional special granularity.[1] Our global team of climate scientists processes the data in-house to model client-specific hazards, producing investment-relevant insights.

We have honed the use of these models in over 55 client engagements across a range of industries, including financial institutions, corporates, and the public sector. For utilities, we have assessed the rate of change of climate trends with pronounced effects on utility assets, including catastrophic events (such as tropical cyclones) as well as more common climate challenges like convective storms with high winds, freezing rain, and heat waves).

[1] "WCRP coupled model intercomparison project (CMIP)," World Climate Research Programme, October 2022, where data from both Phases 5 and 6 were utilized.

There can be significant disparities in these hazards at a circuit level, even within small geographic areas (Exhibit 3). For example, when one Midwest utility examined the expected increase in severe convective storms over time, some circuits saw increases at quadruple the rate of others.[13] Understanding the evolution of hazards circuit by circuit (as opposed to by state or region) will be critical for steering capital toward critical network segments.

Transition risks and grid constraints

There are multiple new, complex transition risks and constraints that grid planners must also take into account. These include electric vehicle (EV) adoption and usage; electrification of space heating and buildings; distributed-energy resource adoption and usage (for example, solar that is attached to storage versus unattached); and fundamental changes in demand due to economic shifts and new sources of demand (for example, data centers and AI).

While this article is focused on the distribution grid, there are multiple additional transition risks across the electric system—for example, generation assets can have significantly impaired performance under extreme temperature, which can create stress on the grid.

Many energy-transition scenarios project a significant increase in electrification and adoption of related technologies as countries reduce their reliance on fossil fuels. The rapid electrification of road mobility and varied deployment of distributed energy resources (such as at-home, at-work, managed, and unmanaged EV charging) create uncertainty around future load profiles. Recent research in California, for example, found that EVs can increase overall household load from 4.8 up to 14.0 kWh per charging event, depending on the type of vehicle. The impacts on distribution feeders varies materially, with feeders exceeding capacity thresholds by up to 300 percent and for as long as 22 hours.[14]

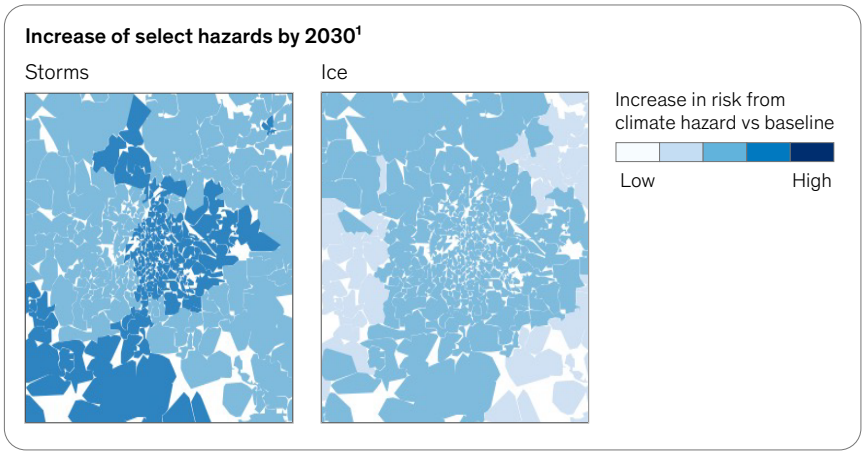
The adoption of distributed solar and batteries compounds this uncertainty. The United States has accumulated more than 32 GW of installed residential solar capacity and 17 GW of commercial capacity, and this is only expected to grow.[15] These resources have the potential to help offset investments in

[13] McKinsey analysis based on industry experience.
[14] Alan Jenn and Jake Highleyman, "Distribution grid impacts of electric vehicles: A California case study," *iScience,* 2022, Volume 25, issue 1.
[15] "Solar industry research data," Solar Energy Industries Association, September 27, 2023.

Exhibit 3

Circuit-level view of climate risks can help provide the fact base for identifying investments with the highest risk return on investment.

Illustrative climate analytics dashboard



[1]Relies on 4km x 4km resolution climate, weather, and hazard data built from a 5-model ensemble. CanESM2, CCSM4, GFDL-ESM2M, HadGEM2-365, MIROC5, which accounts for a range of warming sensitivity from the latest CMIP6 data.
Source: McKinsey Climate Analytics

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grid capacity and management, but may also challenge grid stability and flexibility.

The electrification of heat is also noteworthy as it creates concentrated demand that frequently coincides with periods of low renewable generation (such as winter mornings). For the first time, annual heat pump sales in the United States rose above four million units in 2022, exceeding gas-powered furnaces—a trend likely to be accelerated by the Inflation Reduction Act's support for home electrification.[16] The United States is not alone in this trend: around the world, the energy crisis has driven heat pump sales to record levels, with sales in Europe climbing by nearly 40 percent from 2021 to 2022.[17]

The trend towards electrified heat could fundamentally transform seasonal load profiles. In select geographies, rapid heat-pump adoption could increase residential heating loads and shift traditionally summer peaking systems to winter peaking. In one utility's territory, the share of winter peaking circuits could grow from less than 10 percent of total circuits to nearly 40 percent, with some circuits increasing peak hour winter load by as much as 80 percent (Exhibit 4).[18] As more consumers rely on the electric grid to meet critical heating needs, grid operators will need to ensure the system is prepared to supply winter peak periods reliably.

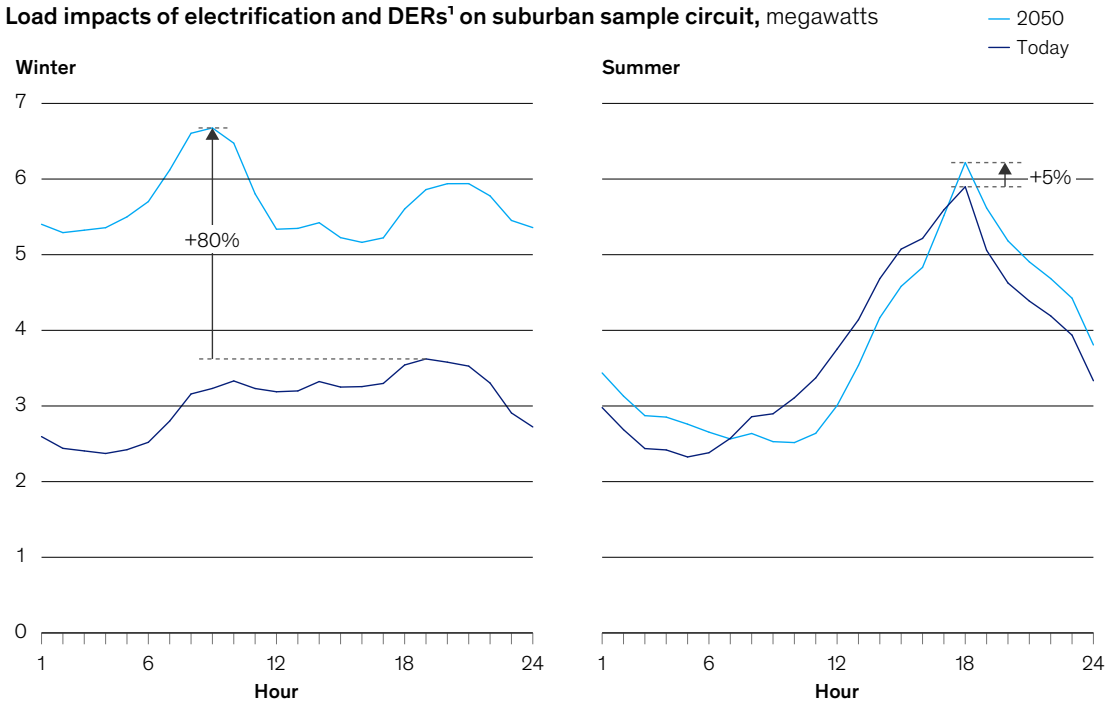
An updated approach for an uncertain future

Longstanding tools and processes for managing grid performance are no longer up to the task. How grid operators move to address these

[16]Raphael Breit, "The IRA includes a big push for heat pumps, but states can do even more," Regulatory Assistance Project, August 16, 2023; "U.S. heat pump sales surpass gas furnaces," New York State, 2023.
[17]"Heat pumps," International Energy Agency, November 6, 2023.
[18]McKinsey analysis.

Exhibit 4

Some circuits increase peak-hour winter loads by as much as 80 percent.



[1]Distributed energy resources.

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challenges will attract public and regulatory scrutiny and have profound business implications, impacting operational performance directly.

To get out in front of the problem, utilities may need to move further and faster than ever before, updating planning paradigms and making strategic investments in AI to support their processes. This can be achieved with four key shifts.

From siloed to integrated system planning. Historically, capital planning has been siloed—both across the value chain (for example, generation planning managed independently of distribution planning) and within specific programs (for example, vegetation management, undergrounding, and smart grids budgeted and planned separately).

Only by addressing grid issues holistically can utilities fully understand challenges and trade-offs across investments. When making planning decisions, they should simultaneously consider evolving climate risks, heightened electrification load, strategic constraints (such as budget and workforce capacity), and performance targets (including fleet electrification, reliability, performance, and resilience).

This will require a real shift in how planning happens, not only across generation, transmission, and distribution, but also across alternative energy systems (such as gas

distribution infrastructure and transportation fuels). The grid needs of an electric system that powers dual-fuel air source heat pumps, for example, will be considerably different to one reliant on electric-only pumps.

From limited outcome quantification to clear performance outcomes tied to investment. Grid operators may need to look beyond traditional, blue-sky reliability and affordability measures and benchmarks to assess performance. The standard "non-MED" average outage duration for each customer served (SAIDI) and average interruptions per customer (SAIFI) metrics used today exclude major events—creating a disconnect between what grid planners are incentivized to solve and what matters most to customers. With impacts of major event days frequently treated as uncontrollable, utilities are typically only pushed to invest in resilience following major disasters (for example, hardening after Superstorm Sandy and hurricane hardening in Florida).[19] This has largely remained the case even though the likelihood of these events is increasing.

Customers tend to be more heavily impacted by grey-sky outages due to longer average outage duration and the higher cost of restoring power. Their patience, however, is wearing thin, with leaders pushing for greater accountability. In Michigan, for example, extended outages driven by summer storms in 2021 led Governor Gretchen Whitmer to call for immediate action to harden the grid.[20] Legislatures are also making moves. In Texas, for example, Act HB 2555 aims to streamline approval and cost recovery for transmission and distribution investments.[21]

Utilities may need to consider performance metrics that reflect the impact of heightened physical climate-change risks (for example, customers experiencing long interruptions or the percentage of customers offline), while planning for load shifts, like heat-pump adoption, stemming from decarbonization.

From a top-down, historical view of grid needs to a circuit- and segment-specific view of future needs. Traditionally, grid operators have relied on historical trends when planning for resilience challenges and load growth. With accelerating electrification and mounting climate hazards, grid operators can no longer rely on past trends. Instead, they need dynamic plans that account for emerging risks and rapid load shifts. This will require new, predictive modeling capabilities that inform planning horizons with granular insights. Service-territory-wide forecasts won't identify the specific areas of the electric value chain that require the greatest investment.

From tiered risk models to granular "risk return on investment" modeling that drives integrated decision making. Utilities are moving away from more subjective, tiered risk ratings (for example, assigning assets a simple risk score) toward probabilistic risk assessments (for example, 20 percent likelihood of 100 customers experiencing an outage versus 30 percent likelihood of 50 customers experiencing an outage). The former can be useful for prioritizing capital within a budget, but doesn't help decision makers determine whether an incremental dollar is better spent in one program or another.

Planners could seek to understand the expected benefits from each dollar of capital and operating expenditure invested based on a circuit or asset-level view of potential risk. They can leverage predictive models and AI to identify the highest-impact interventions (such as vegetation management or microgrid development) and prioritize capital allocation while managing affordability.

[19] Katherine Blunt, "Florida's strengthened electric grid mostly withstood Hurricane Ian," *The Wall Street Journal,* October 3, 2022.
[20] "Governor Whitmer calls on Michigan utilities to put families first," Government of Michigan press release, August 20, 2021.
[21] "An act relating to transmission and distribution system resiliency planning by and cost recovery for electric utilities," Texas Legislature Online.

Calculating the risk return on investment

Prioritizing potential investments and communicating value to regulators and the public will require careful consideration of the risk return on investment. Grid planners have a range of tools at their disposal to tackle physical risk and transition-driven load growth challenges (see sidebar "Critical investment programs"). Understanding the cost-effectiveness of these programs can help with capital allocation decisions and ensure utilities are getting the most value for every dollar invested (Exhibit 5).

As grid planners prioritize these investments, a granular, circuit-specific view of system needs over time can provide insight into when and where intervention is required and help to determine the risk return on investment of each measure. Such geo-specific views are necessary for prioritizing capital within programs, too (Exhibit 6).

Critical investment programs

When grid planners are considering investments and improvements to grid resilience, there are several notable programs that have the highest risk return on investment, particularly in preventing outages during major events:

— *AI-enabled vegetation management.* Tree obstructions are one of the largest sources of outages for utilities, and vegetation management is often one of the costliest programs. With aerial and satellite imagery, light detection and ranging (LIDAR), and other imaging techniques, utilities now have the rich data needed to train highly sophisticated machine learning models that identify the highest-risk scenarios and what treatments (such as trimming or removal) are most effective—ensuring every dollar spent maximizes risk reduction.

— *AI-enabled asset analytics.* Utilities manage millions of assets. Modern cloud computing and software platforms enable them to capture higher-quality data about these assets than ever before, and build probabilistic, predictive risk models that help them anticipate asset failures. Unlike tiered risk models, these newer models can help utilities compare the cost-effectiveness of a dollar spent across different programs.

— *Feeder hardening and design standards.* Hardening programs are a critical tool in ensuring grids can withstand severe weather and high wind speeds. Stronger poles, installation of guy wires, and new design standards (such as reducing span lengths) are all tools to help safeguard critical grid infrastructure.

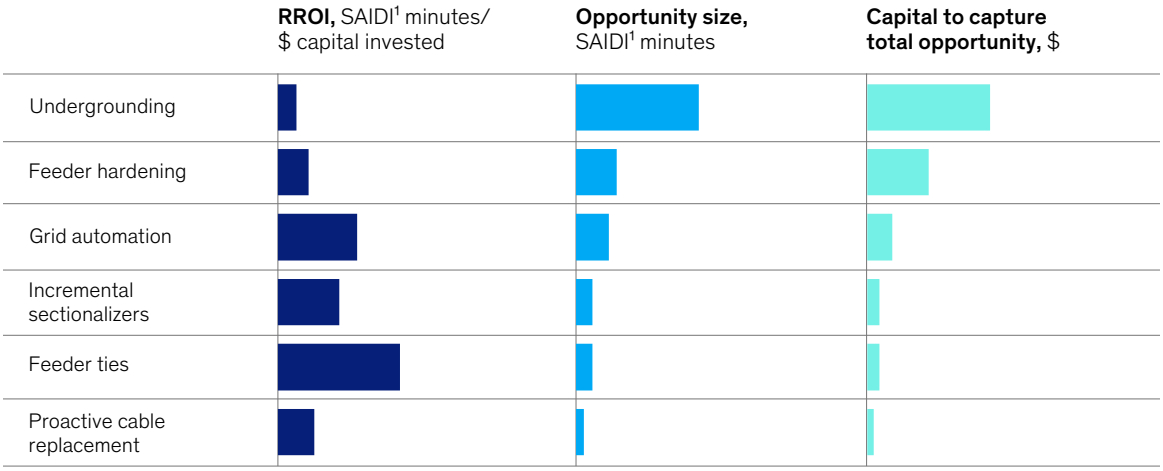
— *Targeted undergrounding.* Undergrounding high-risk segments of the grid is one of the most effective ways of preventing outages. Undergrounding has historically been much more expensive than overhead systems. However, new technologies and a focus on at-scale programs are making this a more cost-effective tool for improving resilience for many utilities.

— *Grid automation and control devices.* Digitally enabled reclosers and switches are effective tools for minimizing customer outages. Their value and effectiveness will increase as distributed generation sources (like community solar) continue to grow on the grid.

Exhibit 5

Risk return on investment can be used to compare programs and determine reliability and resiliency spend priorities.

Illustrative risk return on investment (RROI) example



[1]The System Average Interruption Duration Index.

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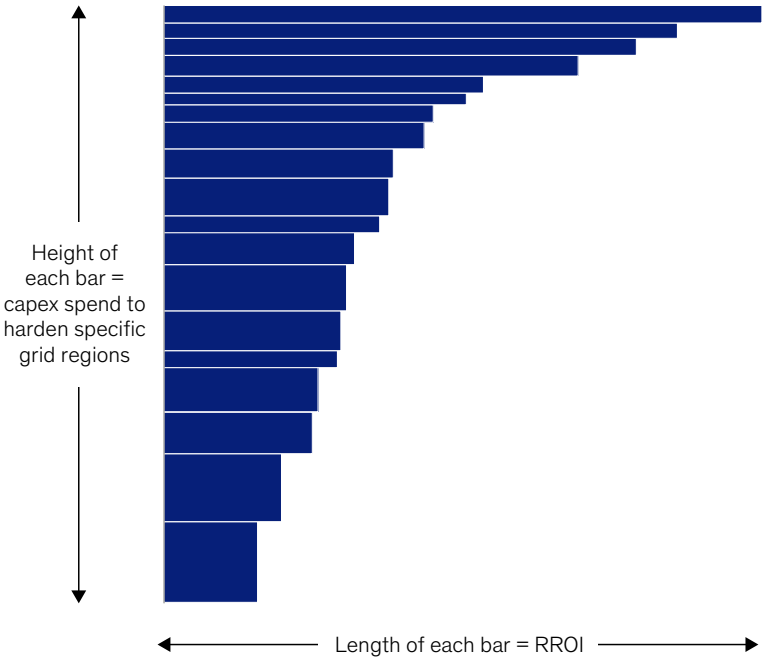
Exhibit 6

Within capital programs, risk return on investment analysis can identify opportunities to strategically reprioritize spend.

Illustrative risk return on investment (RROI) of grid hardening by region, indexed



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Climate risks and increasing decarbonization are driving both demand and uncertainty, creating unprecedented challenges for planners juggling resilience, reliability, flexibility, and affordability. Grid planning processes that worked in the past are becoming less effective, increasing risks and resulting in higher costs for customers. By managing and planning for these challenges, grid planners could catalyze the energy transition and deliver increased value to communities and customers.

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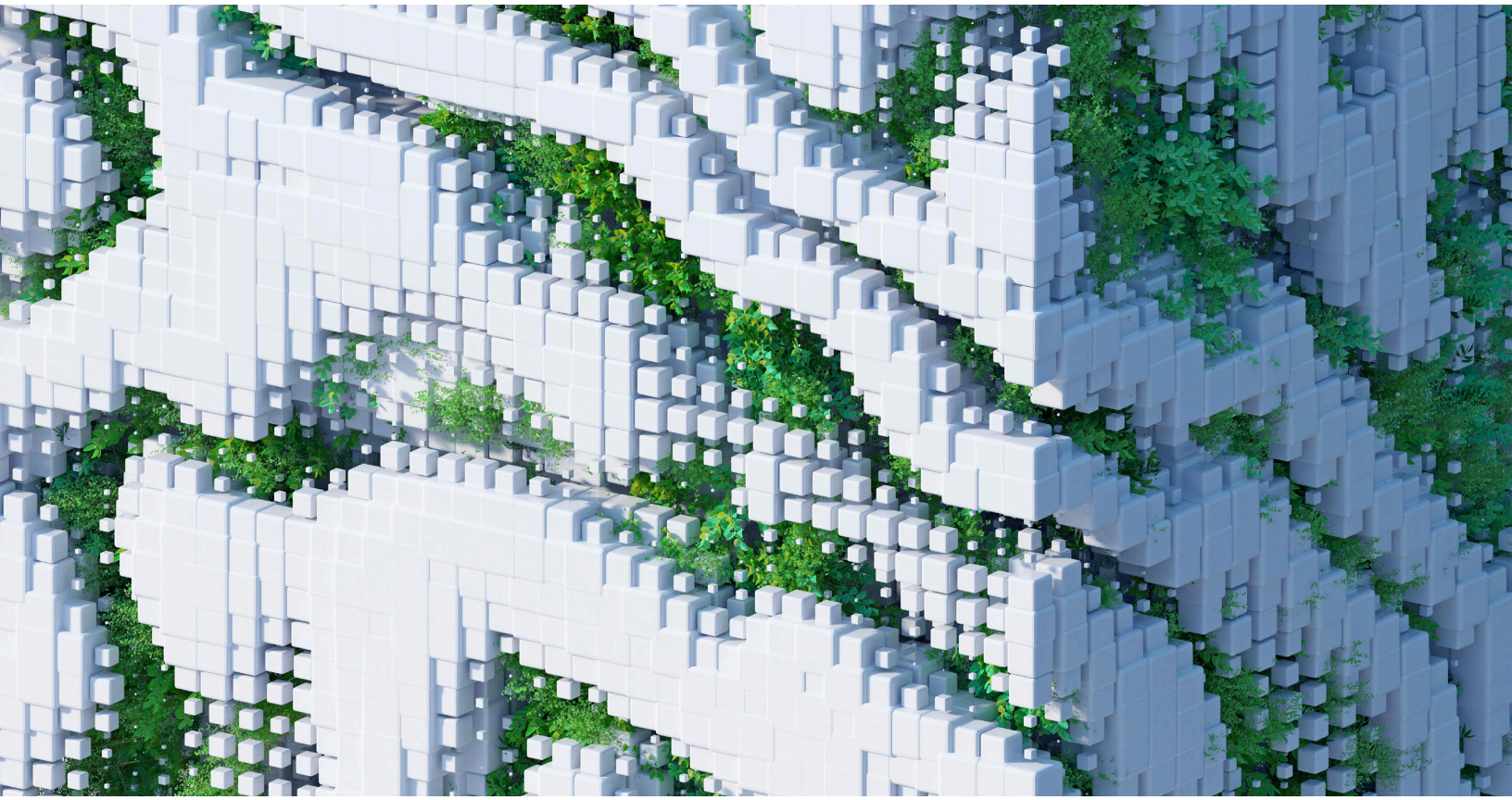
McKinsey Quarterly

A new way to decarbonize buildings can lower emissions—profitably

Real estate can use generative AI to turn the industry's data into treasure in seven steps.

This article is a collaborative effort by Brodie Boland, Daniel Cramer, Alastair Green, Darya Guettler, Focko Imhorst, and Marita Winslade, representing views from McKinsey' Real Estate Practice.



November 2023

Real estate companies are increasingly accepting the imperative to decarbonize buildings, but they frequently find the task difficult, laborious, and expensive.

Owners with portfolios of many unique buildings often have no centralized inventory that indicates the conditions inside or the types of equipment they contain. What's more, physical energy audits and building-by-building net-zero plans are lengthy, costly, and enjoy no benefits of scale. Due to these limitations, the traditional approach to decarbonization has created a widespread impression that decarbonizing buildings is significantly unprofitable.

But thanks to improvements in the quantity and quality of data and analytic methods, there is a better approach. It is now possible to use a combination of data from satellites, geospatial analytics, regulations, labor and equipment costs, building characteristics, energy, and other sources to rapidly create a high-fidelity picture of the current state of an individual building without ever stepping foot inside.

By applying machine learning, AI, and physics-based modeling, portfolio owners can quickly identify building decarbonization opportunities. This includes the current type and estimated capacity of heating and cooling systems, the site-specific potential for solar or geothermal power, and where insulation and efficiency levels are substandard. Advanced evolutionary optimization algorithms can then determine the optimal set of solutions and sequence of actions for each building—and the portfolio as a whole—to reach net zero on a given timeline.

These capabilities can quickly generate a set of financially optimized plans for each building in a portfolio based on the building's unique starting point, regulatory environment, lease structure, and many other factors. These plans—which can be generated for a full portfolio in a matter of weeks—can include a set of time-bound actions, associated capital costs, and documentation of the effect on emissions and operating costs. For large portfolios, this novel approach to reaching net zero represents a more than 100-fold increase in the pace and scale of decarbonization planning compared with the traditional approach of conducting energy audits and net-zero studies. It also eliminates the need to rely on vague building archetypes or general marginal abatement cost curves, which often lead to poorer plans and higher costs. This system yields specific, detailed, actionable plans with faster abatement and better economics.

By developing the full path to net zero, real estate organizations can plan ahead instead of reacting. They can integrate decarbonization cost insights when deciding which buildings to move into or acquire. Because this new approach can rapidly generate a plan for every building, owners and occupiers can decide where to invest limited capital and coordinate equipment procurement, design, and project management to minimize costs.

Additionally, owners can aggregate building-level plans across the portfolio to develop capital plans and reporting. Building-level plans for energy efficiency and electrification allow owners and occupiers to estimate and procure required volumes of renewable power, increase the potential to take advantage of government incentives, and make building managers' jobs easier.

This article begins by exploring the importance of adopting a more efficient way to decarbonize buildings. Next, we describe how this new approach often makes it possible for real estate portfolios to achieve net zero at a net present value (NPV) that is neutral to positive. For example, we highlight a company that recently developed a net-zero pathway plan that's projected to cost roughly $85 million less than a traditional-approach plan would have cost. Finally, we describe the seven features of a credible building decarbonization plan.

Decarbonization efforts are challenging, but a faster, more economical way of accomplishing the real estate industry's decarbonization goals provides an opportunity to meaningfully accelerate actions required to limit global warming.

Building owners, operators, and occupiers have obligations to decarbonize

The real estate industry accounts for approximately 40 percent of global combustion-related emissions, of which 28 percentage points come from building operations and 12 from embodied carbon—that is, emissions from building materials and construction (Exhibit 1).[1] To keep global warming within approximately 1.5°C and to reach a net-zero-carbon building stock by 2050, the IEA estimates direct building emissions (such as from onsite gas or oil boilers) will need to be reduced by 50 percent and indirect emissions by 60 percent (for example, through energy efficiency measures and grid decarbonization) by 2030.[2]

However, the world's buildings are not currently on track to achieve these goals.

Some progress has been made and more is within reach

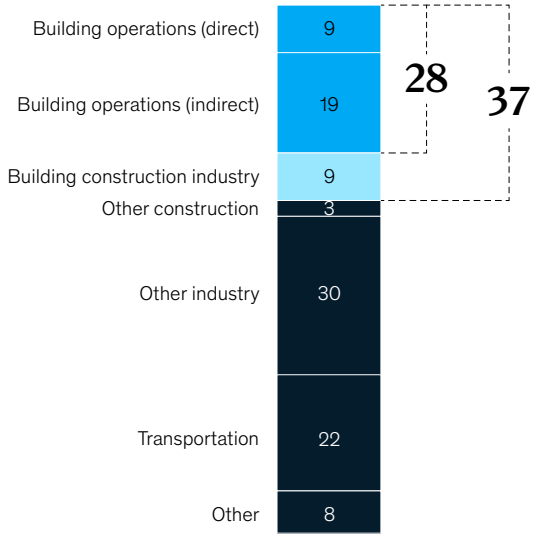
Real estate companies across the ecosystem are increasingly making net-zero commitments.[3] Meanwhile, regulators and governing bodies are working to implement a mix of incentives and regulations, including the European Commission's Energy Performance of Buildings Directive, the United Kingdom's Minimum Energy Efficiency Standards, and the US Securities and Exchange Commission's proposed climate disclosure. Adding to momentum are investors who are increasingly allocating capital to support the transition.

[1] *2022 Global status report for buildings and construction*, United Nations Environment Programme, November 9, 2022.
[2] "Building sector emissions hit record high, but low-carbon pandemic recovery can help transform sector – UN report," United Nations Environment Programme, December 16, 2020.
[3] "Companies taking action," Science Based Targets initiative dashboard, August 2023.

Exhibit 1

Thirty-seven percent of global energy emissions are related to buildings, with 28 percentage points of that due to building operations.

Global energy and process emissions by source, 2021, %



Source: UNEP 2022 Global Status Report for Buildings and Construction

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Progress is within reach. Unlike in some areas that are addressing decarbonization (such as heavy industry and shipping), our work in real estate has shown us that the technology already exists to replace the use of fossil fuels and dramatically improve energy efficiency in most buildings around the globe. If companies deploy the most efficient approaches, a large share of buildings (and an even larger share of building portfolios) can be decarbonized with neutral or positive financials[4] within the existing technology, policy, supply chain, and energy market environment.

Fulfilling the industry's obligations for the climate transition while creating value is possible. However, it requires that building owners do things differently.

Building decarbonization can be economical today

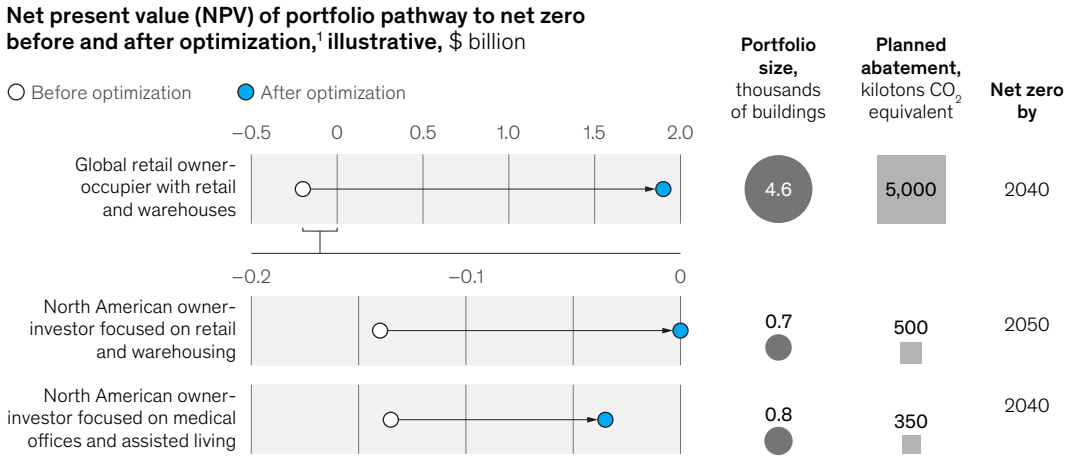
In detailed decarbonization work covering approximately 20,000 buildings, more than 15 megatons of CO_2 equivalent annual emissions, and various property types and geographies, we have come to a notable conclusion: using the new approach, it is often possible for real estate portfolios to achieve net zero with neutral to positive returns on investment as savings meet or exceed costs over time. This conclusion is valid with conservative assumptions, including no green premiums on rent or property valuation, no incremental future regulations or carbon pricing, and no new or significantly improved technology. By executing energy efficiency and electrification measures for each building's full path to net zero and optimizing renewable-power procurement at the portfolio level, building owners and occupants typically can recoup their investments through energy savings, capital cost optimization, and avoidance of existing regulatory penalties.

A diverse cohort of real estate portfolios used the new approach to dramatically improve the NPV of reducing their operational emissions to net zero (Exhibit 2). These plans were verified through

[4] "Sustainability upgrades are driving a vacancy gap in offices," JLL, January 16, 2023.

Exhibit 2

Building decarbonization can be economical today.



[1]The NPV values given are calculated without considering green premiums, future regulations, or step change improvements in technology performance or costs; were they included, NPV would likely increase.

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testing and refinement with engineers and facility managers and from the approval of business cases and capital plans by finance departments, executives, and boards.

A real estate investor improved the NPV of its net-zero pathway by roughly $85 million

A US real estate investor with roughly $20 billion in assets under management across multiple property types recently used the modern approach to develop asset-level decarbonization plans for more than 750 buildings. Developing the initial plans took less than eight weeks and improved the NPV of the real estate investment trust's net-zero pathway by about $85 million, to a near-neutral NPV (see sidebar, "A company's optimized approach"). This investor's net-zero journey could pay for itself due to lower utility bills, avoided existing regulatory penalties, and reduced capital costs (by coordinating projects and negotiating bulk procurement pricing, for example). Changes in these factors, such as a new price on carbon in a certain jurisdiction or green premiums, are likely to result in positive economics over the long run.

Traditional approaches are typically slower and more costly

Traditionally, owners have taken a project-by-project approach across their portfolios, focusing on discrete actions with clear stand-alone payback periods, such as installing high-efficiency equipment, lighting, and automated building controls.

Marginal abatement cost curves, or MACC curves, have historically been used to identify and prioritize stand-alone payback period projects by calculating the average industry costs, or savings, per ton of carbon abated for that type of project. MACCs have been a useful prioritization tool in the past and remain so for highly standardized industries where site-specific optimization is not yet available. However, for real estate portfolios, an optimized approach that uses data and analytics can yield significantly improved results.

To illustrate the relative benefit of the optimized approach, take, for example, a building following an average commercial building MACC curve that would yield an NPV of negative $1.1 million to reach net zero. The same building, by optimizing the pathway for the specific building conditions via the new approach, could yield an NPV of positive $100,000 to reach net zero, representing a $1.2 million NPV improvement compared with the alternative method.

Why is this the case? For companies with a net-zero commitment, the MACC approach does not consider site specifics (such as if the building envelope is leaky) or interdependencies and coordination opportunities between decarbonization levers. Accordingly, it often pushes costly actions into the future. Real estate owners could then be forced to implement more expensive initiatives at later, nonoptimal times, leading to wasted capital (due to issues such as oversize systems or equipment that has to be retired before end of life) and lost energy savings.

Other owners have traditionally worked from the bottom-up, conducting building-by-building energy audits and engineering studies to examine issues including insulation, current heating, ventilation, and air-conditioning (HVAC) systems, and onsite solar potential, and then developing bespoke decarbonization plans. This approach often takes months per building and can result in a series of individual reports, making it difficult to aggregate plans, understand portfolio-wide costs, avoid wasted capital such as by having to strip out equipment before end of life, comply with regulations or targets, or find portfolio-level efficiencies (such as through bulk procurement).

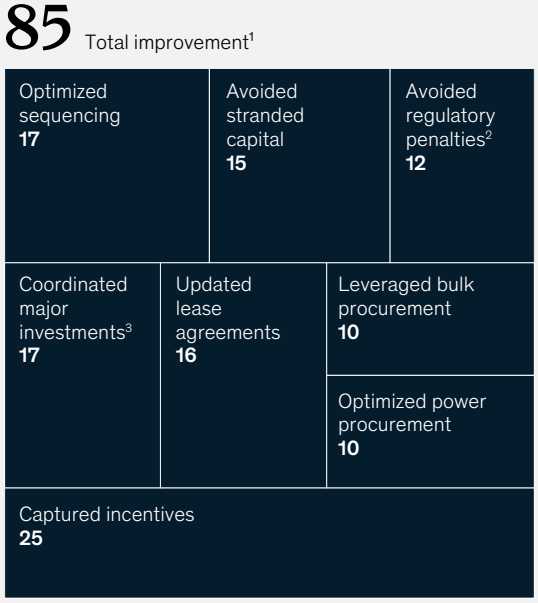
How to get started: The seven features of a credible building decarbonization plan

While a range of building owners and occupants are making commitments to achieve net zero, many lack comprehensive plans. Given what is

A company's optimized approach

Eight ways a large real estate owner-investor improved the net present value of its path to net zero.

Net present value improvement, real estate investor,
$ million



[1]An additional $35 million could be achieved through incentives and lease structure changes.
[2]Also reduces the risk of last-minute, more expensive actions required to react to future regulations. Only existing regulations were considered for the purposes of calculating net present value (NPV) optimization potential. Avoided penalties from last-minute action/fines from future regulations are considered further upside.
[3]Only applied where roof and rooftop HVAC systems have similar expected end-of-life dates.

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Total NPV improvement. To produce a conservative estimate, the NPV improvement figure does not include additional upside potential from rental or cap rate premia, increases in occupancy, the ability to capture local incentives, and/or the avoidance of future regulations.

Optimized sequencing. Used evolutionary optimization to determine the highest value set of actions to reach net zero; eg, the company installed efficiency measures early to maximize operating-expense savings and reduce capital expenditures required to electrify later.

Avoided stranded capital. Acted immediately to ensure that near-term capital investments across the portfolio were aligned with long-term decarbonization plans. (Because roofs and major equipment often have useful lives of 10 to >25 years, missed opportunities to electrify at end-of-life is likely to result in stranded capital or the need to retire equipment before the end of its useful life.)

Avoided regulatory penalties. Developed plans to help ensure that fossil-fuel-powered assets are replaced before the required dates in applicable regions.

Coordinated major investments. Coordinated major renovations and equipment upgrades (eg, roof replacements, insulation upgrades, and electrification of rooftop heating, ventilation, and air-conditioning [HVAC] systems) to reduce installation costs by sharing labor, project management, design, crane, and other costs.

Updated lease agreements. Reviewed leases to ensure current templates allow for capital recoveries for investments that yield energy savings for tenants. This allows landlords to align costs and benefits across parties and avoid the "split-incentive

problem." (For nonserviced leases, landlords may wish to consider metered-efficiency structures that can allow owners to receive a share of energy savings.)

Leveraged bulk procurement. Developed plans that provide long-term visibility into all major HVAC and building envelope needs to negotiate bulk discounts and secure delivery timelines for major equipment and materials.

Optimized power procurement. Developed an optimized power procurement strategy tied to an electrification timeline. The goal was to reduce the risk of signing large contracts at higher costs right before net-zero target dates.

Captured incentives. Created a plan to apply for incentives available for net-zero-related electrification and energy efficiency measures. (These incentives were treated as an upside and were not factored into the NPV improvement estimate.)

now possible with evolving data and AI and the significant effects they could have on the pace of building decarbonization and profitability, major building owners and occupiers have a new set of options for developing credible plans. Optimal plans will require the following seven components:

- *Portfolio lens to net zero.* Many building owners or occupants have hundreds or thousands of buildings in their portfolios. Plans for decarbonizing these buildings are often patchwork, starting with a subset of buildings based on emissions (for example, some take the "worst first" approach), regulations (some only create plans where regulations already exist), or other factors (some assets fall within certain divisions where there is an enthusiastic sustain-ability leader). Under the new approach, owners can capture value by making building plans across the portfolio work together, such as through joint procurement, coordination, and smart sequencing. Until there is a plan for every building, the plan is not complete.

- *Asset-specific plans.* For optimized financials, general lists of levers (such as LED lights, heat pumps, and on-site solar), archetypes, and MACC curves fall short. To maximize decarbonization impact per dollar spent, each building needs its own plan that considers its specific starting point (such as type of insulation, current equipment and systems, and building layout), conditions (including local climate, geological conditions, and local solar radiation), and asset strategies, including lease types, tenant composition, and operating objectives.

- *A full pathway to net zero.* Companies are wise to avoid plans that only get part of the way to net zero, such as plans to reach 30 percent energy-efficiency improvements in the next two years without visibility past that point. This kind of short-term view can significantly compromise long-term decarbonization outcomes and costs. For instance, some insulation measures that don't meet the short-term hurdle rate could reduce future HVAC sizing requirements and expenses. Companies that make only short-term decisions—or wait until regulations require them—may end up spending more in the long run.

- *Linked Scope 1 and 2 plans.* Plans for Scope 1, such as electrification measures, and for Scope 2, such as renewable-power purchasing, often are created separately. For example, facilities managers might handle retrofits, while procurement departments might take on renewable-energy purchasing. This approach doesn't take advantage of interdependencies between Scopes 1 and 2, such as demand estimates that consider the sometimes-opposing effects of energy efficiency and electrification actions. The result can be slower and more expensive renewable-energy procurement.

- *Actionable steps.* Plans for each building should include specific steps that a building's facility manager can implement. (For example: "Replace gas-fired system with air source heat pump and auxiliary electric resistance backup as needed. Additional natural gas backup with condensing boiler can be implemented to mitigate temperatures below –10°F.") Building personnel should be able to quickly send these instructions to vendors or facilities management teams for execution.

- *Quantified plans.* Plans should be specific enough to inform financial planning at a building and portfolio level. Leaders need to understand the exact financials of achieving net zero, including the required changes in capital investment and operating costs, the potential costs of additional debt or the implications of front-loading capital expenditures, and how both costs and benefits will accrue to either building owners or tenants.

- *Net-zero-oriented decision making.* Owners and operators can embed decarbonization plans into operations across the entire organization, including processes, incentives, and governance structures. Fortunately, decarbonizing buildings' operational emissions can often be accomplished with small tweaks to existing processes rather than an entirely new campaign. "Business as usual" should come to include updating capital-planning processes to consider the decarbonization plans for each building, creating funds and allocating capital (which often can have a positive return) for low-emissions systems, and incorporating decarbonization analyses into the process of acquiring new assets.

The real estate industry faces daunting challenges as it works to decarbonize: it needs to scale supply chains to meet new demand, train millions of skilled workers to deploy retrofits, and upgrade grid generation and storage capacity to accommodate electrification. The good news is that developing decarbonization plans has recently become much simpler, faster, and cheaper, making it easier for the industry to get moving.

Most important, real estate companies that make use of the AI-backed, full-life-cycle approach to decarbonization can make a genuine dent in building-related emissions. Given the profound decarbonization challenges across sectors, this new approach could be an important part of global efforts to minimize climate change. It is possible and necessary. The time to start is now. Q

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McKinsey Quarterly

Generative AI can change real estate, but the industry must change to reap the benefits

An AI-informed approach makes it faster, easier, and cheaper to decarbonize real estate. Here's how.

by Matt Fitzpatrick, Vaibhav Gujral, Ankit Kapoor, and Alex Wolkomir

December 2023

Generative AI (gen AI) is maturing at an auspicious moment for the real estate industry. Investors have mountains of both proprietary and third-party data about properties, communities, tenants, and the market itself. This information can be used to customize existing gen AI tools so that they can perform real estate–specific tasks, such as identifying opportunities for investors at lightning speed, revolutionizing building and interior design, creating marketing materials, and facilitating customer journeys while opening up new revenue streams.

Although gen AI has only recently captured the public's imagination, AI has been fundamentally changing the way the world does business for decades. This more familiar version of AI—also known as analytical AI—is goal oriented and focused on activities such as predicting values for a future forecast or assigning categories to segment customers. It is already embedded in parts of the business world: AI-assisted forecasts, for example, have altered how investment professionals think about the future, and dynamic pricing models have changed how several industries charge for goods and services. One industry in which AI's transformative power has been missing, however, is real estate, a historically slow adopter of new technologies.[1]

Gen AI represents a fresh chance for the real estate industry to learn from its past and transform itself into an industry at technology's cutting edge. Gen AI has not replaced analytical AI; instead, its open-ended and creative nature introduces a new frontier of use cases that analytical AI does not address. Based on work by the McKinsey Global Institute (MGI), we believe that gen AI could generate $110 billion to $180 billion or more in value for the real estate industry.[2]

For all the hype that gen AI has received to date, many real estate organizations are finding it difficult to implement and scale use cases, and thus have not yet seen the promised value creation. This is not surprising: deriving competitive advantage from gen AI is not as simple as just deploying one of the major foundational models, and many things have to go right in an organization to make the most of the opportunity. To help companies get started, this article will explore the technology's potential and provide examples of use cases, each of which real estate actors we work with are in some phase of exploring or implementing. The article will then describe seven pivotal, interconnected actions that real estate companies can take to realize the full value of this gen AI–fueled vision and create strategic distance from their peers.

Real estate can benefit from gen AI in a multitude of use cases

Gen AI's strengths generally fall within one of four categories, which we dub "the four Cs." The first is customer engagement, which can be supported by tools such as conversational chatbots that answer questions and remove doubt from customer decisions. The second is creation, in the form of tools that generate new creative content, including text and images. The third is concision: gen AI excels at synthesizing insights from unstructured data, interpreting conversations, and querying large data sources. The fourth is coding solutions, of which gen AI offers many, including interpreting, translating, and generating code.

In our own work with AI, we have seen real estate companies gain over 10 percent or more in net operating income through more efficient operating models, stronger customer experience, tenant retention, new revenue streams, and smarter asset selection. Here are five examples of how businesses can apply gen AI's four Cs to specific real estate issues.

Sifting through mountains of leasing documentation (concision)

Gen AI can be applied to a repository of lease documents, which can be dense and filled with bespoke terminology, making it difficult for

[1] "Construction in the cloud: An interview with Thomas Wolf, CEO of RIB Software," McKinsey, April 30, 2018.
[2] *The economic potential of generative AI: The next productivity frontier*, McKinsey, June 14, 2023.

owners of many properties to sift through and find information at scale. A gen AI–powered tool can summarize key themes across the leases, such as how much rent is expected monthly or what market forces (such as local environmental, social, and governance compliance laws) could affect leases. Additionally, the tool can scan across leases for a particular parameter (for example, all leases with a rent price per square foot below a certain level) and generate tables of information. At that point, professionals can examine the information the AI tool has compiled.

Copiloting real estate interactions (concision and customer engagement)

Gen AI can be used to create a powerful copilot (a gen AI–powered bot) for a variety of real estate interactions, including managing tenant requests and lease negotiation. Simple requests from tenants, such as for routine maintenance, can prompt the copilot to directly contact a building's maintenance staff. The copilot can identify a more complex question and flag it for a specialist at a property management company. As the specialist interacts with tenants, gen AI can observe conversations and written responses and suggest ways to improve communication. For high-stakes moments—such as a commercial lease negotiation with an office, warehouse, or retail tenant—a gen AI tool can take in all the information about a tenant, the property, and the market and craft a negotiation transcript. If communications and calls are recorded or turned to text, the copilot can monitor these interactions at scale, providing coaching while reminding specialists to refrain from using certain terms that could incite moments of risk.[3]

Enabling visualization and creating new revenue streams (creation and customer engagement)

Today, when a prospective office tenant looks at raw space on a tour or a potential resident views pictures of an apartment on a listing site, they see an empty unit or photos filled with someone else's finishes and furniture. Virtual reality tours have helped, but these static, noncustomizable simulations usually only go part of the way toward showing the end user what the result could be.

Gen AI tools can help a potential tenant visualize exactly what an apartment would look like in, say, their preferred midcentury modern style or in cherrywood versus walnut finishes. This data can then be fed back into a model to predict which types of furnishings and finishes work best for different customer segments, improving prospect-to-lease conversion and shaping future capital expenditure decisions.

There can also be e-commerce tie-ins: as a prospective tenant tours a unit, an app can virtually impose a variety of couches, window trims, or kitchen appliances that match a desired design style. If the prospective resident decides to buy or lease, these choices can be ordered and set up to coincide with the move-in. The resident benefits by moving into a home that already expresses their signature style, and the brokerage or apartment company benefits by reaping revenue from cross-selling.

One large furniture retailer has launched a gen AI–powered product visualization tool that enables users to upload a photo of a room and populate it with furniture from its catalog. A variety of businesses throughout the value chain can use this capability to create new revenue streams while deepening customer loyalty.

Making faster, more precise investment decisions (concision)

Today, investment decisions are often informed through individual analysis of bespoke data pulls across sources. An investor interested in warehouses, for example, typically starts by performing a macroanalysis of markets that have attractive factors such as ports, airport locations, and high e-commerce volume. Then, they perform more granular analysis to locate areas of interest, pulling building information from local brokers or digital tools. As part of the decision-making

[3] Nico Grant and Karen Weise, "Microsoft and Google unveil AI tools for businesses," *New York Times*, March 16, 2023.

process, the investor conducts discrete analyses to figure out how their investment hypotheses have panned out in the past.

With a gen AI tool that's fine-tuned using internal and third-party data, an investor can simply ask, "What are the top 25 warehouse properties up for sale that I should invest in?" or, "Which malls are most likely to thrive in the future?" The tool can sort through the unstructured data—both internal (such as the performance of a company's existing properties and the lease terms related to this performance) and third party (such as the US Census and publicly recorded, comparable sales). This multifaceted analysis can be overlaid on a list of properties for sale to identify and prioritize specific assets that are worth manual investigation.

Drawing architectural plans known to create desired outcomes (creation)

In website design, there are specific patterns and design choices known to generate e-commerce sales or higher click-through. Similarly, there are underlying design principles in the physical world that gen AI can unlock and use to draw architectural plans.

A gen AI–assisted process can introduce Internet of Things sensors and computer vision[4] algorithms that collect data points on space use, such as how customers move through a store before purchase or when conference rooms are used in an office. This insight—along with outcome data about sales, customer loyalty, productivity, employee retention, or other areas—can then be fed to a gen AI tool. This information can be overlaid with spatial data about square footage, location, walls, furniture, and other architectural elements. The gen AI tool can then develop architectural plans that are optimized to create desired outcomes in a space. Human architects and designers can work from these plans to ensure art and emotion in the design, but with less guesswork over whether a space is purpose driven (illustration).

Seven pivotal actions real estate players can take to realize the full value of gen AI

Gen AI holds the promise of transformation, but real estate companies will have to do more than just learn how to use off-the-shelf products. Although foundational models are essential, they are just a small component of a real estate firm's ability to realize value from gen AI.

To seize the opportunity, businesses in the real estate value chain can strive to outcompete by rewiring the way they work in the following ways.

Align the C-suite around a business-led road map tied to a specific part of the real estate value chain

CEOs who want to lead in gen AI can prioritize technology, onboard new internal capabilities, and organize for agile delivery just as top start-ups and tech-native companies do. New ways of delivering technology are essential not just to gen AI delivery but also to ensuring modernity and staying ahead of the strategic curve. Winners are willing to experiment, iterate, and self-disrupt.

That starts with having capabilities that go beyond the traditional real estate IT organization. This does not mean leaders have to welcome scores of new tech hires into their companies. Rather, it requires investing in a nimble squad of engineers and designers who are familiar with gen AI and can be directed to focus exclusively on value-adding use cases.

C-suites can start by assessing which part of the real estate value chain they occupy—such as development, operations, or investment—and considering how the journeys of tenants, employees, and other stakeholders can be reinvented. Then, they can begin redesigning roles and structures to make the alignment happen. Getting value from gen AI requires that executives be willing to question the industry's traditional hierarchies and operating models

[4] A subfield of machine learning that uses visual data, such as images, videos, and 3-D signals, extracting complex information and gaining rich interpretations.

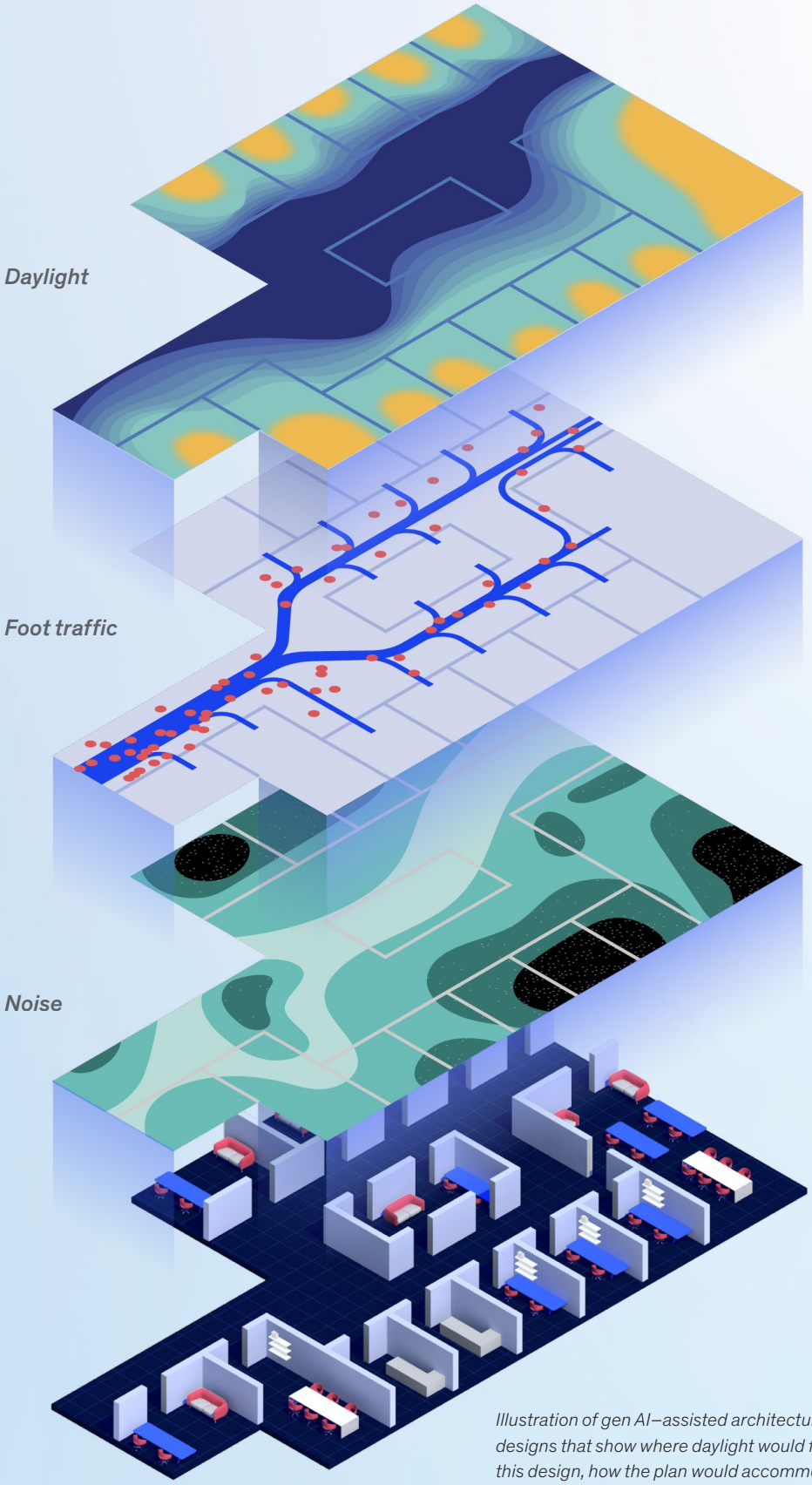

Illustration of gen AI–assisted architectural designs that show where daylight would fall on this design, how the plan would accommodate typical foot traffic patterns, and whether noise levels would distract people in the space.

Source: McKinsey research and experience with sensor and computer vision data

and, most important, to accept a new technology layer throughout the organization. Gen AI requires executive-led adoption of new ways of working that will elevate the power of professionals across functions and levels.

Adopt a laser focus on data—especially new proprietary data

In the gen AI future, those with access to and control over unique, informative data will be able to generate insights that others cannot. Companies can start by thinking about what data they need—as well as what proprietary data about tenants and properties is available but not currently being collected.

It is essential not only to have the best data set but also to have it engineered the right way with the right data governance. A conversational AI tool that has been trained on a building's past maintenance requests can efficiently respond to resident complaints. A tool trained on a real estate portfolio's net-operating-income data can provide answers about performance that could be useful for investment decisions and for reporting to investors and internal company divisions. Internet of Things sensors and computer vision applications in office buildings, for example, can provide anonymized insights into how tenants use spaces, creating nuanced views of the built environment.[5] Tenant apps and dashboards are not merely interaction channels; they themselves can become data sources. What kind of amenity space a residential tenant books, what stores a shopper in a mall browses, or what services an office tenant needs to produce an event are all valuable pieces of data that can be harnessed and structured.

It is important that this harnessing and structuring occurs in a data lakehouse controlled by the real estate firm (as opposed to by a third-party system). A variety of vendors should be able to interact with this single source of truth. This will allow real estate firms to cut data by building, tenant, or type of unit or space for their own internal uses and to be flexible enough to switch systems and applications easily. Companies should be conscious of data ownership and should make the ability to easily access and work with data a key part of vendor decision making as they design their future tech stacks.

Engineer a prompt library that gets results from foundational models in a real estate context

Foundational gen AI models are only as good as the questions (known as "prompts") asked of them. As models are fine-tuned with data specific to real estate, it's important to engineer a prompt library.

A prompt could say, for example, "Use the following resident history and property data to craft an initial outreach email to a resident looking to renew their lease," followed by, "Generate a follow-up email based on their response and consider offering one of the following more-personalized concessions based on what you know about the resident: waived pet fee for two months, complimentary deep carpet cleaning, or membership to the building's gym for six months."

Slight edits in syntax, detail, or framing can yield meaningfully different outputs with an impact that can only be discovered in action. There is no precedent for knowing what works until it is tried. To create a playbook, a rigorous process of testing and refining to ensure questions return expected answers is essential.

Create digital tools that promote action—not just insight

Newly popular large language models fascinate the public because of how easy it can be to write prompts and receive a comprehensible response. But real estate firms should not be lulled into thinking that all gen AI outputs are intuitive or that plug-and-play point solutions deliver the full promise of gen AI. Instead, outputs often need another layer of digital tooling to be useful to an organization.

A foundational model, for example, may generate marketing copy, but it may require additional tooling to check it for grammar and brand

[5] Craig Smith, "Can sensor technology help keep office workers healthy," *New York Times*, November 23, 2022.

compliance and ensure the language abides by regulations. A gen AI model may come up with insights on how customer service should be delivered by a real estate agent, but agents may need to receive prompts in a specific cadence during client interactions or explanations that clarify why a particular recommendation is important.

Design is another crucial component. Color, style, and physical-design patterns for how a user clicks are paramount in traditional apps. With a gen AI interface, it could be more important to fine-tune a conversational system's writing style or to make sure the customer-facing avatar and its spoken tone and pitch are agreeable to the audience and encourage desired behaviors. In short, the definition of design will have to expand as a new playing field of psychology tied to interactions with algorithms and machines emerges.

A self-service portal that makes it easy for employees to access company-approved tools and learn how to use them can enable organization-wide innovation.

Invest in a modern technology stack to enable data use

A vital leg of the gen AI stool is the tech stack: the right infrastructure, feedback loops, safeguards, and integration should be built in a secure, scalable, and user-friendly way.

Gen AI requires new capabilities relative to traditional AI and machine learning, including toxicity checks (ensuring gen AI is not creating problematic content, such as words or statements that would violate relevant fair-housing or antidiscrimination laws) and guardrails against hallucination (preventing gen AI from providing false answers without sharing that the tool is uncertain). Compared with traditional data science and analytics, gen AI relies more on engineering unique tech stack elements to make it effectively operational—capabilities that real estate businesses may lack in their current IT organizations.

Real estate companies across the value chain that embrace early proofs of concept and start orienting their tech stacks in the right direction to enable use cases in the future will be in the best position to benefit. Fruitful actions include taking the time to thoughtfully link vendor systems and connect the dots on data across property management systems, customer relation management, and maintenance portals.

Adopt a new operating model that can scale as a real estate portfolio grows and diversifies

To enable a gen AI upgrade to processes for investing, leasing, and more, operating models and jobs may need to be redrawn to match the new focus points of work.

New roles and capabilities, such as prompt and data engineers who can implement foundational models, may be needed. People in existing roles, such as agents or on-site staff, may be able to hand off time-consuming tasks to gen AI tools, allowing them to focus on specialized tasks. In other cases, such as on marketing and investing teams, gen AI may evolve the discipline and create demand for new roles and skill sets. Companies need to be open to change, because the face of the IT or marketing organization will not look the same with AI tooling, even if the objectives of the business unit remain the same.

Recognize and mitigate risks unique to real estate created by gen AI

Gen AI is new, maturing, and facing open questions. There may be biases in training data that are unintentional but create outputs with real consequences. There may also be questions about the intellectual properties feeding foundational models as the legal precedent around the space evolves.[6] Marketing content, for example, may emerge from an algorithm trained on unlicensed images, catching the real estate business anawares. Provider tweaks to the foundational model that underpins a real estate–specific tool could create unforeseen consequences for output quality and content, making it important to reengineer prompts.

[6]Christopher Mims, "AI tech enables industrial-scale intellectual-property theft, say critics," *Wall Street Journal*, February 4, 2023.

Additionally, some use cases may not be right for gen AI in its current stage. These might include emergency response, where the stakes are too high, or leasing decisions, where it could be difficult to comply with regulations that require explanation.

Deploying gen AI in situations where investment professionals, operating teams, and tenants meet introduces new risks to working, living, and shopping environments that have to be weighed. Companies that identify risks early on and iterate to find improvements will be positioned to react effectively.

We believe that the time is right for real estate to make the leap to gen AI for two primary reasons: first, the technology has now caught up to the problems that real estate companies face and, when properly designed and executed, can provide game-changing solutions. And second, commercial real estate today faces headwinds, and these new challenges demand innovative approaches. Gen AI will not replace analytical AI—there are use cases (such as producing a rent forecast or a retention prediction) for which more traditional machine learning excels. Rather, gen AI is opening up use cases that were never before possible and are relevant to dimensions of the real estate value chain that technology did not previously touch.

But can an industry that is a reputed tech laggard overcome structural challenges, invest in underlying technology, restructure operating models, and emerge as a gen AI leader? The fact that real estate has been a laggard may actually be an advantage, because the industry did not overinvest in previously available but now-outdated technology as some other industries did.[7] The learning curve may be steeper for those who have not yet invested in technology and data strategies, but we believe gen AI's insights, speed, and transformational power for the real estate industry are worth the climb. Data—and use of that data to create strategic distance—are the new terrain on which businesses will compete for investor dollars, tenants, buyers, and longevity.

The idea of getting started can be daunting, but we urge executives to start simply. Our technology professionals advocate for a "2x2" approach: identify two use cases that can launch a company into taking ownership of data, deliver measurable impact quickly, and build excitement; and identify two use cases that are more aspirational, will fundamentally change the business, and take more time to deliver. This approach encourages companies to push the technology toward its full potential.

There is no question that the real estate industry is changing. The question is which companies will answer that call of change, adapt, and embrace a new, digitally powered future. Q

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[7] "Should US banks be moving to next-generation core banking platforms?," McKinsey, July 26, 2022.

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