



The future of infrastructure: Building a **better tomorrow.**

2022 SEI Survey of Infrastructure
Managers and Investors

SEI Investment Manager Services

Contents.

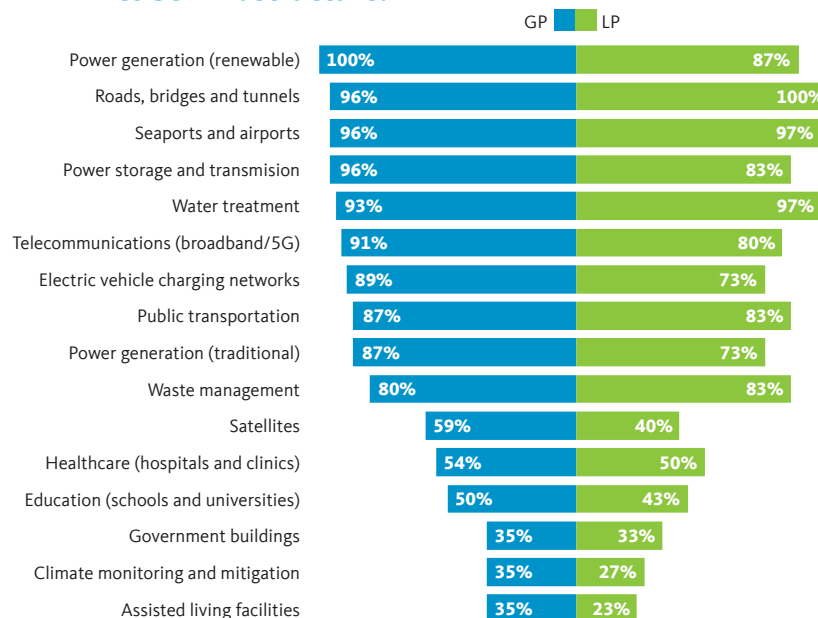
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The times they are a-changin’

Infrastructure is the stuff civilization is made of. If culture is the software, infrastructure is the hardware, consisting of things like roads, bridges, and sewers. This did not change much between the Roman Empire and the industrial revolution. Rail, automobiles, mass production, power grids, telecommunications, global shipping, and aviation dramatically expanded the definition of infrastructure as governments and corporations raced to service the needs of an increasingly productive, complex, and interconnected world.

We are now in the middle of another transformational moment, with formidable challenges and innovative technologies converging to create an unprecedented opportunity to build the infrastructure of tomorrow. The current infrastructure boom is characterized by unprecedented scope. According to fund managers and institutional investors who actively invest in infrastructure, the asset class arguably includes everything from satellites and electric vehicle charging networks to schools and senior living facilities (**Figure 1**). There is no universal agreement, but it is hard to deny that modern civilizations have more complex needs, and the interconnectedness of modern life means investments in the systems that support it are better considered holistically.

Figure 1. When it comes to investing, what do you consider to be infrastructure?



Source: 2022 SEI Survey of Infrastructure Managers and Investors.

To discern what's behind the newfound enthusiasm for this often-overlooked asset class—and why it is viewed differently than the past—we collaborated with ANZU Research and Global Fund Media to survey 84 managers (general partners, or GPs) and institutional investors (limited partners, or LPs). Through the results of that survey and additional accompanying interviews of participants, we identified five factors driving today's conversations around infrastructure investing:

1. Climate change
2. Demographic shifts
3. Deferred maintenance
4. Technological innovation
5. Geopolitics

Climate change

The issue of climate change is a key driver of this more expansive approach. Forward-thinking investors are focusing squarely on the opportunities revealing themselves from this crisis. Succinctly summarizing the investment thesis for any number of infrastructure projects, Vincent Gerritsen, Head of UK and Europe for Morrison & Co, says, “Climate change is an established threat to humanity.”

Infrastructure, in other words, can no longer be considered as something built exclusively for its own benefit, running roughshod over ecosystems that happen to be in the way. Environmentalists and conservationists were fringe figures not long ago, but with sustainability having entered mainstream conversations over the past decade, infrastructure investments are increasingly being evaluated for their potential impact on the surrounding environment.

This is no abstract concept. According to Hamish Mackenzie, Head of Infrastructure at DWS, “Decarbonization policies and technological change are reshaping the global economy, and the infrastructure investment gap has increased substantially as a result, with multi-trillion-dollar infrastructure policy measures across the U.S. and Europe focusing on achieving net zero and aimed at supporting the post-pandemic recovery.”

Demographic shifts

We will have to adapt our infrastructure in other ways as well. Low birth rates and aging populations pose a relatively new challenge in many developed countries as the ratio of dependents to productive society members rises.

Elder care will move from residential communities to permeate every facet of life in many richer nations.

Many poorer countries continue to see booming growth, resulting in unprecedented population density in megalopolises. Remote work has fundamentally altered concepts of home and work, changing how people move about. Transportation and energy use are closely tied to all these trends, meaning global infrastructure must be adapted if we are to avoid the trap of building for yesterday rather than tomorrow

Deferred maintenance

Another simmering problem galvanizing the current infrastructure boom is deferred maintenance. Many countries on the leading edge of the industrial and communications revolutions saw early infrastructure investments pay off in spectacular ways. But those same assets were often neglected in the years that followed, as budget resources flowed elsewhere. The United States is a vivid example of this phenomenon. According to the American Society of Civil Engineers (ASCE), almost two out of three types of infrastructure deserve a grade of D+ or lower (**Figure 2**).

Even this dire appraisal may understate the problem. The country’s rail system, which merited the highest grade, falls far short of standards found in many other countries. Awarded a middling grade of B-, ports were clearly overwhelmed as trade resumed in the wake of the pandemic. U.S. ports handled almost 25 million inbound 20-foot units in 2021. This represents four times the volume of 1995, despite reliance on the same infrastructure. The system is reaching its limits, and further growth cannot be accommodated by incremental improvements.¹

Figure 2. ASCE infrastructure categories & grades



Source: ASCE

Innovation

Faced with such formidable challenges, infrastructure investors can take heart from the fact that we have never been better equipped to tackle them from a technological standpoint. With venture capital funding a constant stream of innovative ideas in technology centers around the world, computing power growing apace, and the flow of data prompting further discoveries and ideas, infrastructure innovation is at an all-time high.

Data is a key focal area for infrastructure investors who recognize its critical role. We are used to thinking about telecommunications infrastructure facilitating the transmission of knowledge, but we are entering a profoundly different age where everyone, from farmers in Rwanda to bus drivers in Malaysia, will interact with and learn from data on the job. Furthermore, autonomous monitoring systems will not only gather data on infrastructure projects but will optimize systems in real time. Justin De Angelis, Partner at Denham Sustainable Infrastructure, notes that “If COVID taught us anything, it’s that digitization and data are king. Data centers are a significant infrastructure investment, and energy efficiency and sustainability around them should be a significant focal area.”

Applying new technology to infrastructure is not easy. Given the cost and longevity of these projects, it is naturally tempting to stay with proven technologies. Conservative approaches are adopted to minimize risk, but they face the risk of irrelevance in times of rapid change. Selecting the best new technology may be even more fraught, especially when track records of success are short. Partnering with seemingly clear frontrunners is no guarantee of success, as anyone who remembers the Betamax videotape format can attest.

Geopolitics

War has driven technological advancements through the ages, but usually in the pursuit of military advantage. Occasionally, other vulnerabilities are laid bare, spurring action. The Russian invasion of Ukraine precipitated a humanitarian crisis and countless stories of heartbreak. As it drags on, it also threatens to cast a shadow over the lives of millions more as energy supplies to Europe are imperiled. Yet there may be a silver lining. As tragic

as it is, Justin De Angelis, Partner at Denham Sustainable Infrastructure says, “The Ukraine situation is – in an odd kind of way – good for the energy transition overall.” Reto Schwager of Patrimonium agrees, stating that “The Ukraine and Russia conflict will certainly have a tremendous positive effect on the alternatives to the conventional energy businesses.”

Where next?

Change, uncertainty, and existential threats make compelling arguments for infrastructure investment, but opportunities for growth may be even more persuasive. According to the World Bank, infrastructure quality is highly correlated to GDP growth per capita. The U.S. Congressional Budget Office estimates that “every dollar spent on infrastructure brought an economic benefit of up to \$2.20.” The U.S. Council of Economic Advisers has calculated that \$1 billion of transportation-infrastructure investment supports 13,000 jobs for a year.”² Additionally, the World Economic Forum (WEF) listed infrastructure as one of its twelve pillars of global competitiveness, where it is grouped with institutions, the macroeconomic environment, and health and primary education as necessities.

The World Economic Forum listed infrastructure as one of its twelve pillars of global competitiveness.

Furthermore, infrastructure’s role as an economic accelerator is buffered by its ability to hedge against inflation. Despite vulnerability to labor shortages and rising materials costs, inflation-linked cash flows make infrastructure assets an attractive proposition. Preqin points to investor worries over inflation as a key motivator, noting that “the inflation protection afforded by many infrastructure assets is often cited among the top reasons investors allocate to the asset class.”³

Infrastructure, it seems, has something for everyone. As Vincent Gerritsen of Morrison & Co says, “Infrastructure is an essential component of nation-building and inclusion, delivering long-term value for investors, the environment and society.”

Meanwhile...

The United States and other countries that industrialized early are faced with the task of maintaining, improving, or mothballing obsolete infrastructure. Developing nations, on the other hand, can find themselves in a position to play leapfrog. Lacking the ability to finance large infrastructure projects internally, many are signing up to play a role in China's Belt and Road Initiative (BRI), widely viewed as the world's most ambitious infrastructure endeavor currently underway. Setting aside any debate over human rights, environmental degradation, or ulterior geopolitical motives, there is no doubt that BRI is having a transformative effect on areas that were previously neglected. A centerpiece of Xi Jinping's foreign policy, this massive undertaking was launched by the Chinese government in 2013 as a modern echo of the ancient Silk Road trade routes, investing in nearly 150 countries and international organizations across the Eastern Hemisphere.

Debt traps have long been a problem for low- and middle-income nations short on financing for critical infrastructure. Depending on one's perspective, China's role as a willing lender can be characterized as anything from benevolent to predatory.

What does this look like on the ground? Ethiopia provides a striking example. With 110 million people, it is the largest country in East Africa, next door to Djibouti. Yet it traditionally took seven days overland from Addis Ababa to reach Djibouti's port at the mouth of the Red Sea on one of the world's busiest shipping routes. With Chinese funding, expertise, and labor, Africa's first electrified railway opened in 2018 and shrank travel time to ten hours, opening the African interior as a market and source of raw materials.⁴

As impressive as BRI is, it may ultimately demonstrate the pitfalls as well as the benefits of central planning. China is lauded for its ability to deliver large-scale projects such as the Three Gorges Dam and the world's largest high-speed rail (HSR) network, but without the checks and balances found in freer markets, financial viability sometimes seems to be an afterthought. With over 40,000 kilometers of track, for example, the scale of China's HSR network is matched only by the size of its debt financing: \$900 billion and counting.⁵ Conceived as a cohesive vision, BRI is nevertheless subject to countless risks across multiple jurisdictions and markets.

Partner nations are also at risk. Debt traps have long been a problem for low- and middle-income nations short on financing for critical infrastructure and economists have speculated that China's lending practices have contributed to their debt crises. Depending on one's perspective, China's role as a willing lender can be characterized as anything from benevolent to predatory.⁶ Some nations are likely to thrive, thanks to closer integration in the global economy. Others such as Sri Lanka, already teetering on an economic precipice, risk financial ruin and the potential loss of control over strategic assets.

China is hardly the only nation forging ahead with groundbreaking infrastructure projects. Flush with oil money, Saudi Arabia is proposing to reinvent life for millions of people expected to live and work in The Line (aka Neom), a radically reimagining of city life which forms a cornerstone of the country's broader Vision 2030 plan to diversify and transform itself. A technologically advanced 200-meter-wide project extending 170 kilometers to the country's Red Sea coast and rising 500 meters above sea level, The Line is being built for nine million inhabitants.⁷ Despite the undeniable appeal of a clean and efficient metropolis relying only on renewable energy, it remains to be seen if a population density 30 times greater than Singapore's in an area of 13 square miles (34 sq. km) is attractive to enough people, particularly when a main selling point is pervasive data harvesting from its inhabitants. Transformative projects like this may prove to be the ultimate manifestation of the risks inherent in a "build it and they will come" approach.

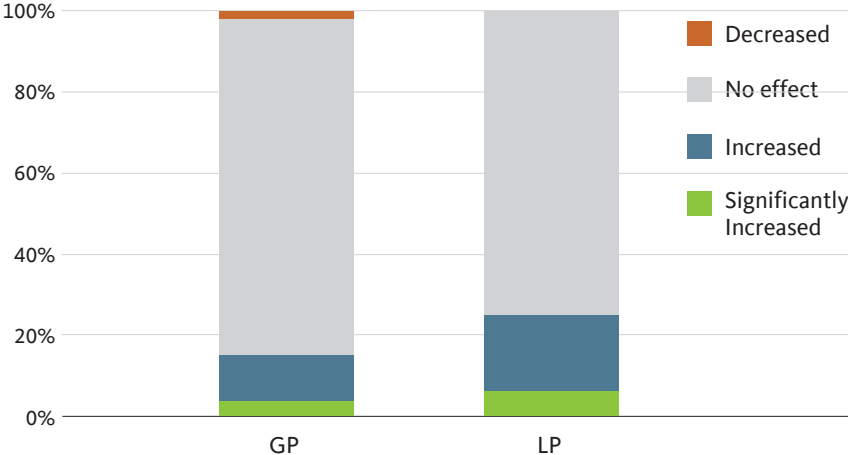
Politics as usual.

How will the public and private sectors work together?

Infrastructure usually hums along in the background as it powers modern life. Despite representing the largest physical objects ever produced by humans, infrastructure is not often discussed in any detail, except to complain about potholes or failing bridges. This changed in 2021, when U.S. politicians, pundits, and the public loudly argued over what is (and is not) infrastructure. In the U.S., this debate produced the Infrastructure Investment and Jobs Act which, despite its hefty size, was widely met with shrugs from institutional investors. .

The new law had less impact on fundraising and asset allocation than might be imagined. Only one out of four LPs in the SEI Infrastructure survey said they increased allocations when it passed, with only a small minority saying allocations rose significantly. GPs were largely unmoved, proceeding with fundraising as planned. Only 16% said fundraising plans had accelerated to any degree (**Figure 3**).

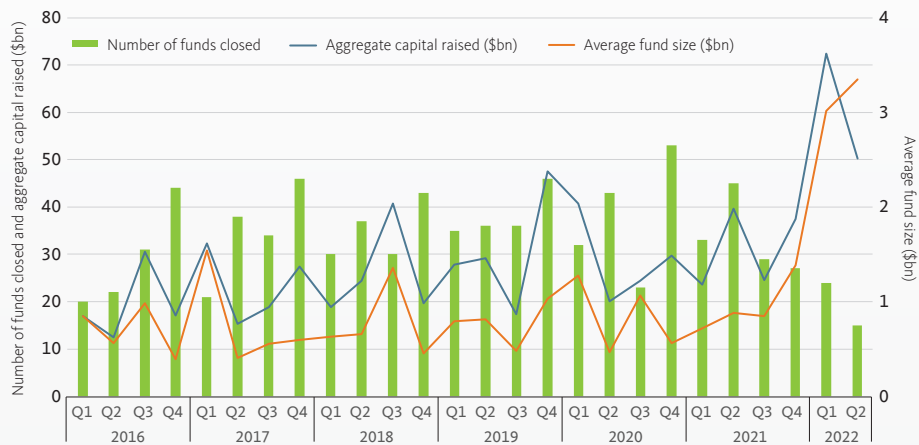
Figure 3. How did the recent passage of the trillion-dollar infrastructure law by the U.S. Congress affect your fundraising [allocations for LPs] plans for infrastructure investments?



Source: 2022 SEI Survey of Infrastructure Managers and Investors

Their indifference toward public spending should not be misinterpreted. A new cadre of super-sized infrastructure funds underscore an unprecedented appetite for infrastructure as an asset class (**Figure 4**). Private markets are now standing by with more than \$360 billion of dry powder at their disposal.⁸ Some investors may be wary of putting those funds to work alongside the public sector, but there is extensive evidence that this model is likely to flourish in various forms over the coming years. With unprecedented levels of spending forecast for maintenance, improvements, and innovation, a certain level of collaboration is unavoidable.

Figure 4. Global quarterly unlisted infrastructure fundraising



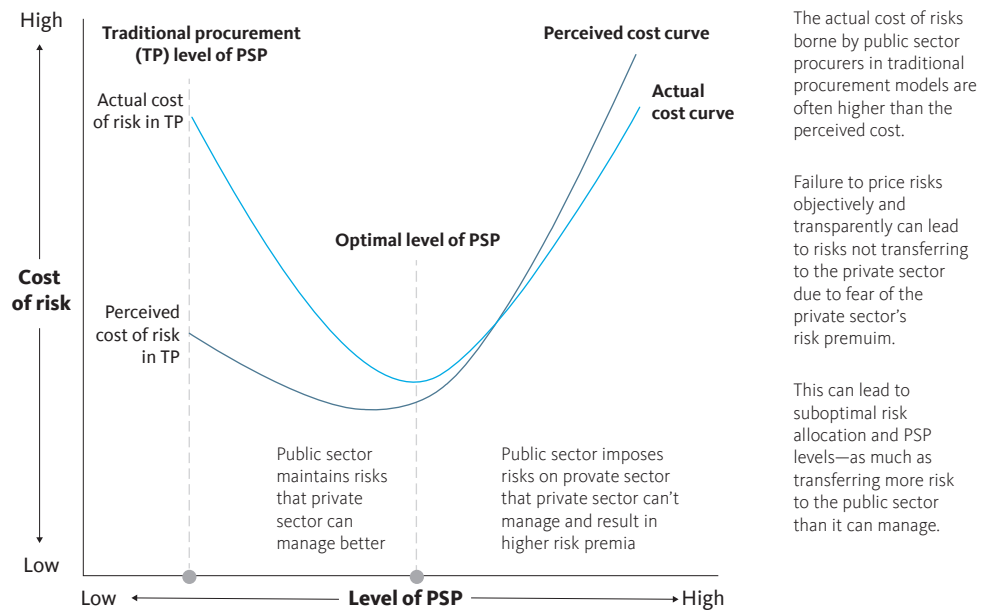
Source: Preqin Pro

Some investors embrace such cooperation, stressing the private sector’s role in pushing projects forward. Andrea Cornetti of Azimut states, “I think it’s important to mix the...private and public worlds.... We need to be aligned completely...with the public sector, because we are the ones able to somehow accelerate the goals of the public sector.” Others point out that high levels of public debt make such cooperation almost inevitable. Infrastructure can be an important fiscal tool, but public coffers cannot generally support the level of needed investment. Reto Schwager of Patrimonium puts it plainly: “Almost every single country is over indebted, and I would therefore expect government funding to decrease. Private markets will certainly step into a growing hole on the government side.”

According to the U.S. Congressional Budget Office, state and local governments traditionally contracted a private firm to handle a single phase of a project, such as construction or maintenance. In the context of public-private partnerships (PPPs), private partners are responsible for multiple stages of a project, including “designing, building, financing, operating, and maintaining the infrastructure.” By transferring risks to the private partner, this arrangement creates incentives for that partner to be efficient.⁹

In addition to enhancing efficiency and effectiveness throughout a project’s life cycle, PPPs can spread a project’s cost over a longer period, freeing up public funds for other uses where private sector participation might not be an option (**Figure 5**). McKinsey, however, points out that these outcomes are not guaranteed, with PPP initiatives often failing to “find the optimum level of private-sector participation and, as a result, face the same challenges of traditionally procured public projects—cost overruns, delays, and increased complexity.” The impulse to retain control can be self-defeating, leaving governments unable to “capitalize on the true advantage of involving private-sector stakeholders: their ability to assess, price, and manage certain types of risk.”¹⁰

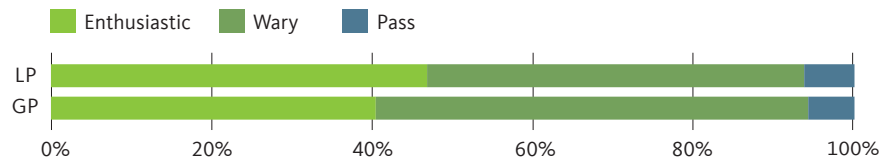
Figure 5. Optimal level of private sector participation (PSP)



Source: Symbolos Management Consultancy

Attitudes toward PPPs are mixed. Almost half of all LPs and GPs surveyed are enthusiastic, but they are matched by a similar number who are wary of the myriad pitfalls that can accompany such partnerships. Additional complexity and risk mean these deals are often scrutinized with extra diligence. Some GPs and LPs surveyed (6% of each) choose to avoid PPPs altogether (**Figure 6**).

Figure 6. Which of the following best describes your perspective on public-private partnerships (PPP)?



Source: 2022 SEI Survey of Infrastructure Managers and Investors

Wariness stems in part from infrastructure’s notoriously close relationship to pork barrel spending, where investments are directed at projects benefiting certain districts or companies rather than investors or society at large. Even if they are comfortable with the contractual and regulatory frameworks, investors may be leery of joining large projects justified by questionable reasoning.

Still, PPP models, dominated by large, complex projects in the past, are evolving. Some investors now see PPPs as a type of concession financing for smaller projects in sectors such as healthcare with a high level of demand for capital but constraints on public investment. Policy frameworks are also developing more quickly in some markets to facilitate broader adoption of PPPs. The decarbonization drive in Europe, for example, provides investors with long-term visibility of the regulatory environment. Investors in other markets face considerably more opacity and uncertainty.

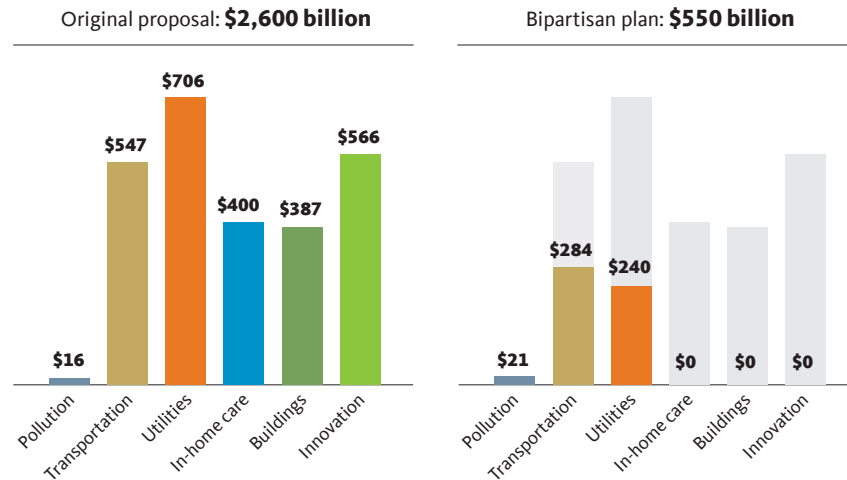
There has traditionally been more resistance to PPPs in the U.S. market, but the flow of federal budget dollars appears to be changing this, causing planners and managers at the city and county level to show they might use federal money to catalyze projects. According to Jed Freedlander, Head of Business Development & Managing Partner at Phoenix Infrastructure, “There was a lot of resistance to PPPs in the U.S. And that’s disappearing.”

Regardless of the precise mix of public and private investment, it is instructive to examine budget priorities laid out in the recently passed laws. Many are shaped by historical investments. The extent to which highway spending dominates spending in the U.S. might be surprising except for the fact that the original system, begun in the mid-20th century during the Eisenhower administration, became the single most expensive infrastructure project in world history, costing over \$500 billion in 2020 dollars.¹¹ Simply maintaining an investment of this magnitude is an expensive proposition, which explains why surface transportation accounts for such a large share of the recently passed law, whose \$1.2 trillion price tag includes \$550 billion of new spending. After things such as schools, elder care facilities,

and industrial R&D were stripped from the bill, the U.S. Department of Transportation was left directing more than half of all new funding under the law (**Figure 7**). The more recently passed \$369 billion Inflation Reduction Act, on the other hand, is more forward-looking, with substantial tax credits (left out of the original bill) expected to spur further investments in renewable energy.¹²

Figure 7. Where is the infrastructure law money going?

(Billions of U.S. Dollars)



Source: *The New York Times*

Given the scale (and/or urgency) of many projects, there is growing emphasis on transparency and coordination among not only governments and investors, but other interested parties as well. According to the World Economic Forum, “The policy and regulatory environment must be modernized to create a flourishing ecosystem of infrastructure innovations. Regulatory goals that balance various societal needs and create a consensus appropriate for citizens, private companies and government entities must be better understood. Additionally, creating the right partnerships between the public and private sectors can produce effective policies and fully informed strategies. Only by taking an open, multistakeholder approach can new commercial models thrive while the public is protected.”¹³

What do successful PPPs look like to institutional investors? According to Vincent Gerritsen, Head of UK and Europe for Morrison & Co, “We see investment in essential services that support local communities and drive national building as hugely important. We have found PPP investments to offer good collaborative engagement between public and private sectors, generating stable and predictable cashflows for investors, and efficient value for money services for taxpayers.”

Rise of city states.

Competing visions of urbanization

The COVID-19 pandemic upended the age-old notion of “going to work” and proved that working from home was possible for a significant portion of the populace with access to the requisite technology. Despite the potential for a significant reshuffling of populations, it is increasingly apparent that many are content to stay where they are. Commuting emerged as the true villain, dreaded by most and pinpointed by employers as a drag on productivity.

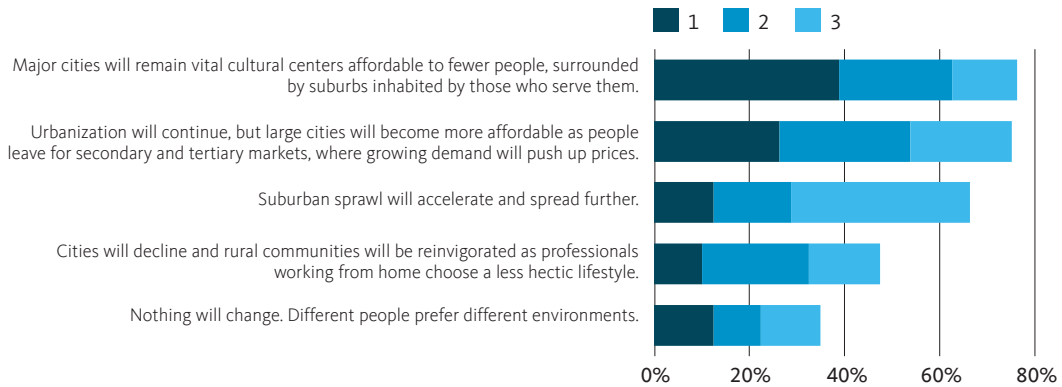
Disagreement over the desirability of remote work persists, with employers and employees coming down on both sides of the issue. As a result, we find ourselves at a crossroads, facing the potential remaking of established patterns and habits. Where will people choose to live? How will they shop and entertain themselves? Will the tolerance for commuting decrease?

Assuming widespread investments in transportation and communications infrastructure, we asked survey participants to rank scenarios according to how likely they are to accurately describe events over the coming decade. Most agree that urbanization will continue. People enjoy living in cities for myriad reasons and that is unlikely to change.

What that looks like is up for debate. The largest group posits that major cities will remain attractive as important centers of culture but will become less and less affordable (**Figure 8**). On the other hand, affordability and newfound mobility mean secondary and tertiary markets may grow at the expense of larger metropolitan areas. In this scenario, populations will trend toward greater density while simultaneously dispersing across a greater number of cities. Urbanization became a seemingly unstoppable force over the past century, but some survey participants are betting on post-urban scenarios. Further suburban sprawl is one possible outcome, while others suggest that cities may lose their vitality as greater numbers of people relocate to rural areas to escape hectic lifestyles.

Figure 8. Rank the following by how accurately you think they describe the coming decade

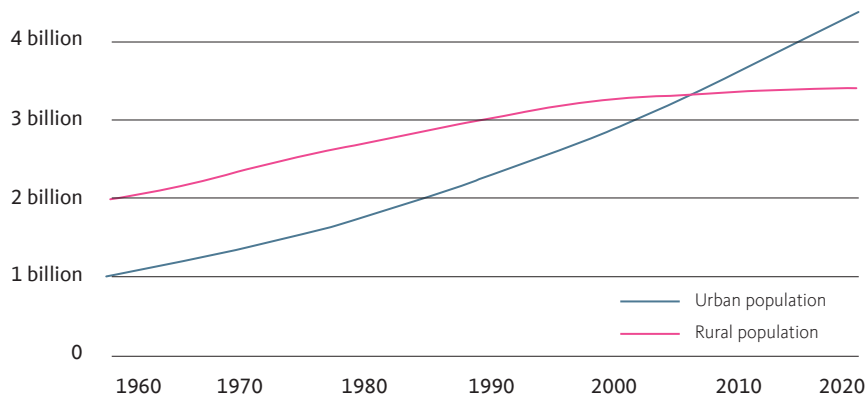
(1=Most Likely)



Source: 2022 SEI Survey of Infrastructure Managers and Investors

Urbanization is a well-established, long-term trend (**Figure 9**). Reversing it seems unlikely. More than 4 billion people already live in urban areas, and the United Nations predicts that 68% of the world’s population will live in cities by the year 2050. Managing this growth is especially challenging in poorer countries, where internal migration to urban areas is driven by the lack of opportunity and resources in rural areas. Better infrastructure is desperately needed. According to the UN Department of Economic and Social Affairs, “Many countries will face challenges in meeting the needs of their growing urban populations, including for housing, transportation, energy systems and other infrastructure, as well as for employment and basic services such as education and health care.”¹⁴

Figure 9. Number of people living in urban and rural areas globally



Source: World Bank based on data from the UN Population Division.

Note: Urban populations are defined based on the definition of urban areas by national statistical offices

Efficiently moving millions of people around crowded cities is a central challenge for urban planners, not least of all because of transport's carbon footprint. History can suggest solutions: Berlin is bringing back the electric tram lines that were removed when the city was separated by the wall during the Cold War. Bergen, a coastal city in Norway that depends heavily on maritime transport, is replacing diesel-powered ferries with battery-powered vessels. Bogota, the hilly capital of Colombia, now has cable cars that provide convenient access to the city center for residents of working-class neighborhoods on the surrounding mountainsides.

The New York Times featured these initiatives in an article entitled "Trams, Cable Cars, Electric Ferries: How Cities Are Rethinking Transit." Crucially, the author goes on to point out why this is so important: "Urban transportation is central to the effort to slow climate change. Home to more than half the world's population, cities account for more than two-thirds of global carbon dioxide emissions. And transportation is often the largest, and fastest-growing, source, making it imperative to not only encourage more people to get out of their cars and into mass transit, but also to make transit itself less polluting and more efficient."¹⁵

Environmental concerns play an ever-growing role in infrastructure planning, but they are increasingly joined by the careful consideration of the myriad other things that make cities attractive and livable. All cities have functional requirements, but some are vibrant in a way that others are not, encouraging people to stay and become active participants in the urban milieu.

One way to accomplish this is to reduce transport dependency by emphasizing walkability. C40, a global network of 96 cities, works with its members to create what they call "15-minute cities." The goal is to provide "equal access to core services and opportunities, with everyone able to meet their basic needs within a short walk or bike ride from home. It means ensuring that the activities that make urban life livable and enjoyable are available to all, not just concentrated in central or wealthy neighborhoods. This includes community-scale education and healthcare, essential retail, such as grocery shops and pharmacies, parks for recreation, working spaces and more."¹⁶

Buenos Aires is a vivid example of a large city working to introduce green spaces, fresh food markets, medical facilities, recycling points, and other amenities to each of its many neighborhoods. The municipal government is also enhancing walking and cycling infrastructure while simultaneously creating one of the world's largest car-free zones.¹⁷

Automobiles are such a ubiquitous part of modern life, that repurposing or destroying infrastructure meant for them might require a leap of faith. The transformative power of such moves is substantial. When San Francisco tore down the earthquake-damaged Embarcadero Freeway, the city's waterfront miraculously emerged as a favored destination for residents and visitors alike, with a renovated ferry terminal its crown jewel. Seattle accomplished a similar trick when it replaced the Alaska Way viaduct with a tunnel, reacquainting city dwellers with the waterfront and its world-class views.

Not all changes are as purposeful or positive. While some cities enjoy a lively cultural renaissance, others are being transformed to such an extent that they are virtually unrecognizable to long-time residents. Ontario, California was known primarily for its dairy farms. Thanks to its location, it is now a major logistics hub, the site of Amazon's largest warehouse and many others. Though playing an important role in the system that enables the convenient and inexpensive delivery of goods, the town is experiencing unpleasant side effects as the fabric of the local community is fraying, with the town deeply divided about what "progress" means—particularly as farmers get displaced, traffic increases and air quality steadily deteriorates.¹⁸

Infrastructure projects will naturally focus on servicing the needs of these population centers and connecting them when necessary. Cities that prove most adept at raising and spending infrastructure funding will attract new citizens and employers. What that looks like is largely a matter of vision. With various experiments in political devolution already underway and countless (historical and current) case studies highlighting the successes of cities from Venice to Shenzhen, it would not be surprising to see infrastructure play a pivotal role in the redrawing of the geopolitical map over the coming years.

Game changers.

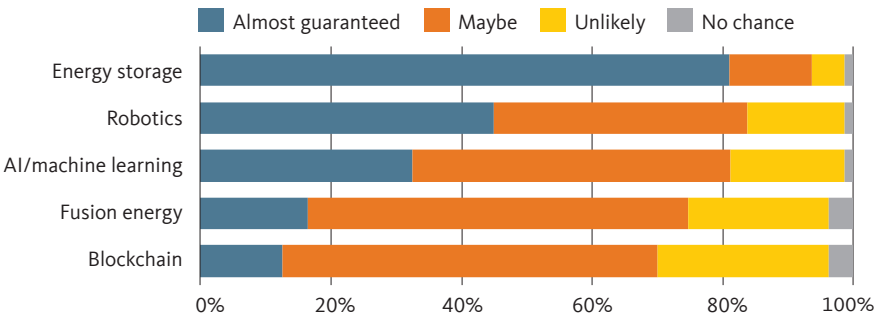
What does the infrastructure of tomorrow look like?

Radical new technologies periodically come along and render existing infrastructure obsolete. Think mobile telephony or containerization. This is likely to happen more regularly as the pace of innovation accelerates. Different and exciting approaches will add more risky investment opportunities to an asset class that has traditionally been risk averse. As a result, we are likely to see a broader spectrum of infrastructure investment opportunities going forward.

Potential game changers range from the proven to the speculative. Examples of the former include the wide array of drones already deployed to monitor infrastructure, collect data, and perform specific tasks. Promising but unproven technologies can be found in areas such as materials science. High-performance road surfaces made from recycled plastic have the potential to reduce problematic waste and greenhouse gas emissions while simultaneously improving durability and performance. Some experimental road surfaces utilize movement and vibration to generate power, while others include solar cells to light the way after dark.

Whether or not they allocate funds to leading-edge solutions, infrastructure investors have their opinions on which technologies are likely to shape infrastructure going forward. More than eight out of ten surveyed, for example, pinpoint energy storage as something that will almost certainly disrupt infrastructure development, financing, and investments over the coming decade (**Figure 10**).

Figure 10. Rate each of the following in terms of their capacity to radically disrupt infrastructure development, financing, and investments over the next decade.



Source: 2022 SEI Survey of Infrastructure Managers and Investors

Entrepreneurs and researchers are busily working to prove them right by scaling up energy storage technology. Storage capacity plays a central role in any conversation about renewable energy sources, which tend to be inconsistent. Batteries are not a viable solution at utility scale, necessitating other options. Pumped storage hydropower is not new, but it is emerging as a particularly good candidate for large-scale energy storage. Located in the Swiss Alps and operating since the summer of 2022, Nant de Drance points the way. Repurposing two existing reservoirs and costing an estimated \$2 billion, the plant utilizes variable speed turbines buried deep in the mountains to stabilize the power grid by supplying energy on demand. Its total capacity is equivalent to 400,000 electric vehicle batteries.¹⁹

Finnish researchers may have another solution: Sand. Using everyday sand in siloes, Markku Ylönen and Tommi Eronen created giant batteries that heat the sand to 500 degrees when electricity costs are low and store it near that temperature for months at a time, releasing heat to nearby homes and offices as needed.²⁰ The concept has limitations (e.g. it would be costly to reconvert heat to electricity), but it shows great promise as a simple, inexpensive solution to at least part of the energy storage conundrum.

While critical, energy storage is hardly the only game changer. Rapid advances in the field of robotics and artificial intelligence in recent years mean that many investors also see both as a likely source of disruption. With networks and sensors in place, smart infrastructure will increasingly be able to balance loads, control traffic, and optimize throughput.

More speculative examples of potential disruptors include fusion energy. By combining atoms rather than splitting them as in the more familiar process of atomic fission, fusion has for decades tantalized scientists as a potential source of limitless energy with no radioactive waste. Bridging the gap between theory and practice has proven incredibly difficult, leading many to dismiss fusion energy as a pipe dream. Periodic advances, however, spur renewed enthusiasm, and the latest round dangles the possibility of a working fusion reactor in the near future.²¹ The timing of commercial scale development is still a question mark, but at least some (16%) of investors and managers say fusion is almost guaranteed to disrupt the infrastructure market within the next ten years.

Investors are equally uncertain about the impact of blockchain. Despite being a proven technology, adoption is nascent and infrastructure applications might not be readily apparent. Standards and applications still need to be ironed out, but the energy intensive process of mining new coins is also proving to be a hurdle in widespread adoption. This is no abstract threat. Residents of upstate New York complain that bitcoin mining is raising the temperature of some of the nearby Finger Lakes, and Cambridge University estimates that bitcoin mining used more energy in 2021 than the entire country of Chile, a nation of almost 20 million.²² If it can be unchained from its reliance on traditional energy sources, blockchain is uniquely positioned to revolutionize the way infrastructure investments are made. If tokenization is ever applied to project finance in a meaningful way, direct ownership of unlisted infrastructure could extend far and wide to smaller investors, potentially including the retail segment.

Finding ingress points for new technologies during the initial planning stages and maintaining the flexibility to adapt to unforeseen technological changes, are crucial tactics in the battle to transform infrastructure.

The World Economic Forum eloquently summarizes the challenge of bringing new technology to bear when it comes to infrastructure: “While new technology is fast paced, highly active and continually evolving, infrastructure is a stable provider of supporting services, more focused on continuity, dependability, and stability. Innovations need to be given the opportunity to prove their value, and infrastructure systems must be designed with an eye towards potential future developments. Finding ingress points for new technologies during the initial stages of planning and maintaining the flexibility to adapt to unforeseen technological changes, are crucial tactics in the battle to transform infrastructure.”²³

There is a growing awareness that technological innovation can not only add value to new assets but also improve the sustainability profile of existing ones.

PwC points out that, “Infrastructure is relatively underinvested in advanced technologies compared to other capital-intensive industries.”²⁴ Infrastructure is simply too important and expensive to be saddled with innovative technology that is not reliable or purposeful. Many people, for example, are enamored with the idea of electric vertical take-off and landing (eVTOL) vehicles, commonly called “flying cars.” Hinting at how long this fascination has persisted, one of the more promising startups in the field is a Swedish company called Jetson, after a popular TV cartoon from the early 1960s.²⁵ Despite recent advances, flying cars are far from ready for prime time, meaning infrastructure planners will continue to focus on surface transport.

Disruption is difficult to predict, so it is worth examining some newer technologies already finding their way into infrastructure around the world. Many innovations are made possible because they offer planners and operators a hedge. GE Power, for example, partnered with Long Ridge to develop a 485 MW power plant designed to transition from burning primarily natural gas to 100% carbon-free hydrogen over the coming decade.²⁶

Other examples feature relatively simple and inexpensive ways to improve, augment, or leverage existing infrastructure. The City of Hillsboro in Oregon installed devices in its existing pipes that convert excess pressure to carbon-free electricity.²⁷

Data is enabling countless ways to improve infrastructure. As sensors became more affordable and computing power increased, the Internet of Things (aka IoT) was conceived to gather data and improve service efficiency on the fly. Industrial applications were quickly followed by its growing use in commercial and residential real estate. It is now finding its way into large-scale infrastructure projects such as highways, bridges, and dams. Some of this data is collected by drones, which are increasingly proving capable of doing even more. A marine drone known as the WasteShark collects litter and debris while monitoring water conditions as it navigates waterways autonomously using GPS and radar.²⁸

Smarter systems mean more predictive capability. The Arizona Department of Transportation rolled out an automated dust storm detection and warning system along a major highway subject to sudden and often deadly disruption. It uses “multiple intelligent transportation system technologies to detect events, warn drivers, and modify driver behavior using a dynamic variable speed limit system and dynamic message signs.”²⁹ Predictive analytics are also being employed to safely improve throughput at ports worldwide.

There is growing awareness that technological innovation can not only add value to new assets but also improve the sustainability profile of existing ones. Emerging technologies will almost certainly represent a growing part of infrastructure allocations, but it will take time. Venture capitalists may be well suited to navigating this world, but institutional investors remain cautious about immature business models in unpredictable competitive environments.

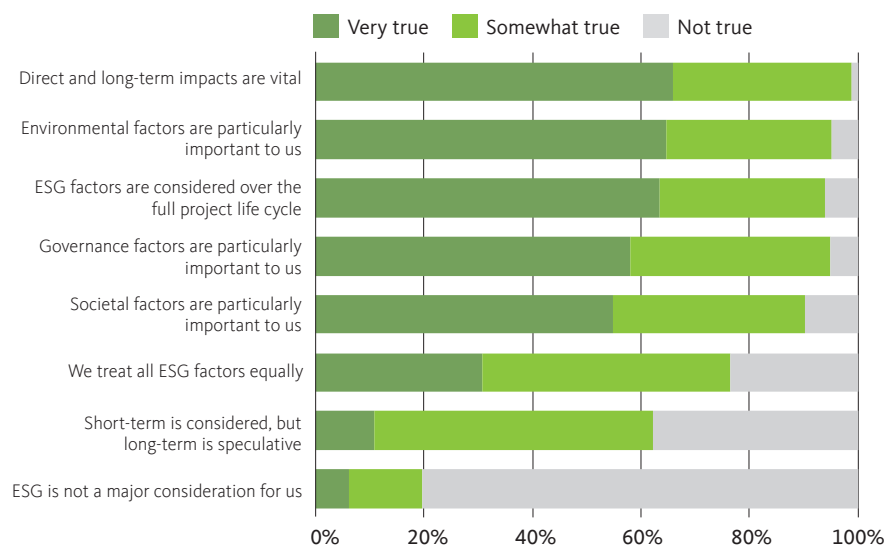
Sustainability.

Evaluating life-cycle costs and benefits

Infrastructure projects are designed and built for specific uses: Getting people from A to B, processing x numbers of containers, generating a certain number of megawatts per hour. These types of metrics are now scrutinized even more carefully in the context of environmental impact. Less easy to quantify are the effects on the well-being of citizens. Environmental considerations are crucial, but infrastructure projects also have an immediate impact (for better or worse) on the people that live and work nearby. Unexpected opportunities may emerge for communities previously underserved by transport options. Unforeseen risks might present themselves as the physical environment changes over time..

Our survey shows that fund managers and investors are keenly interested in both the direct and indirect impact of infrastructure projects on the surrounding environment and community (**Figure 11**). ESG frameworks are widely used, but they vary significantly in rigor and emphasis. Environmental

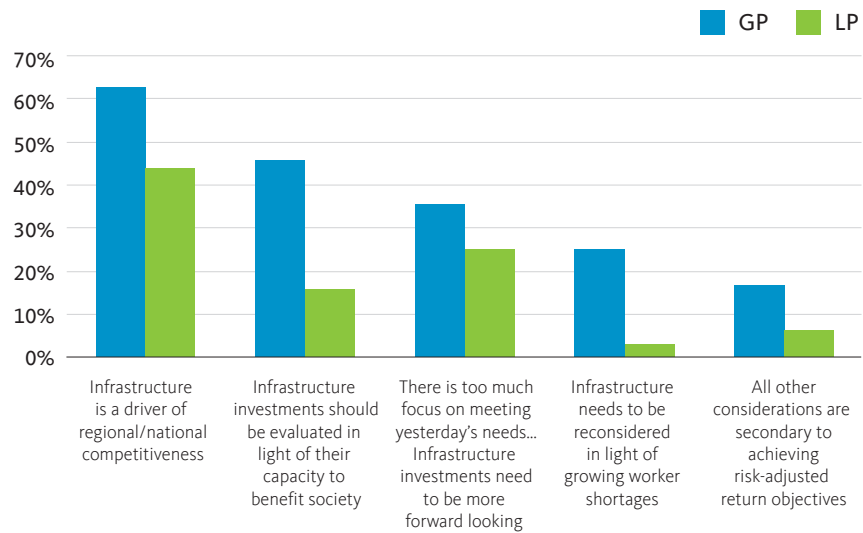
Figure 11. Recognizing that virtually all infrastructure projects have the potential to benefit and/or harm communities and ecosystems, how accurately do the following statements align with your view of investments in the context of ESG?



Source: 2022 SEI Survey of Infrastructure Managers and Investors

concerns, for example, are prioritized more often than societal ones. Short-term factors tend to be emphasized more often than long-term ones due to the greater certainty involved. Only a small minority of survey respondents say ESG considerations are not a major concern at their firm.

Figure 12. To what extent do you agree or disagree with the following? Differences on “Strongly agree”



Source: 2022 SEI Survey of Infrastructure Managers and Investors

Despite widespread agreement that sustainability is a core tenet, GPs and LPs are seemingly at odds with what that means. GPs, for example, are much more likely to say that investments should be evaluated for their capacity to benefit society. They are also more likely to insist on looking forward, agreeing that too much emphasis is generally placed on meeting yesterday’s needs (**Figure 12**). These discrepancies are particularly interesting since GPs often credit their investors with pushing them to prioritize sustainability. These responses may reveal genuine differences of opinion, but they may also be highlighting the need for more standardized language, objectives, metrics, and tools around ESG and sustainability.

There have been many attempts to document or even codify the role of sustainability in development. The United Nations and the Inter-American Development Bank among others have adopted frameworks for this very purpose. The World Economic Forum chose a meta-approach, molding the two aforementioned models into a set of six principles:³⁰

- 1.** Access and benefit-sharing
- 2.** Environmental and climate resilience
- 3.** Social engagement and acceptability
- 4.** Economic and institutional effectiveness
- 5.** Futureproofing over life cycle
- 6.** Critical mass potential through replicability

Aiming to enhance the decision-making ability of investors, owners, and policymakers, the WEF suggests that these qualities should permeate the development process of any sustainable infrastructure project. In practice, this means the needs of all stakeholders need to be considered, including regulators, scientists, engineers, environmental and social experts, construction firms, lenders, investors, and the wider community. Goals and desired outcomes need to be crafted in the context of sustainability and resilience drivers. Cost benefit analysis also needs to incorporate sustainability and resilience considerations, which need to be considered at every stage of a project life cycle, starting at the very beginning with strategy and design.

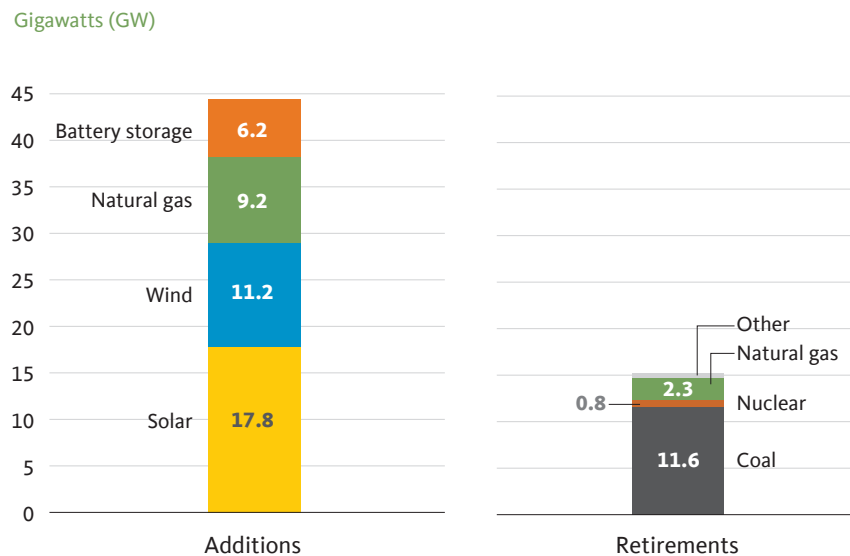
While some investors remain predominantly focused on finding the best risk-adjusted returns from their investments, others are taking sustainability considerations to heart. Andrea Cornetti notes that her firm Azimut has a technical team assisting in the evaluation of every project from two points of view. “First, we evaluate the alignment with our business plan. And then we evaluate every single point from an ESG point of view.”

Hamish Mackenzie, Head of Infrastructure at DWS, expands on the growing relationship between ESG and infrastructure by saying, “The long lifespan of infrastructure assets, the central role of infrastructure in economies and society, and its impact on the environment, decarbonization and communities, mean that infrastructure plays a pivotal role for ESG. Equally, ESG can present risks across the infrastructure investment lifecycle that need to be identified, mitigated, and managed. The movement of capital in line with the sustainability agenda is clearly gathering pace.”

More thorough ESG considerations can also reveal factors with the potential to significantly alter the calculus of projects that previously may have seemed altruistic at best. Jed Freedlander, Head of Business Development & Managing Partner at Phoenix Infrastructure, offers concrete evidence when he says, “Rural broadband (connecting underserved areas) helps you do things like monitor crops and monitor rainfall...land subsidence, and aquifer depletion.”

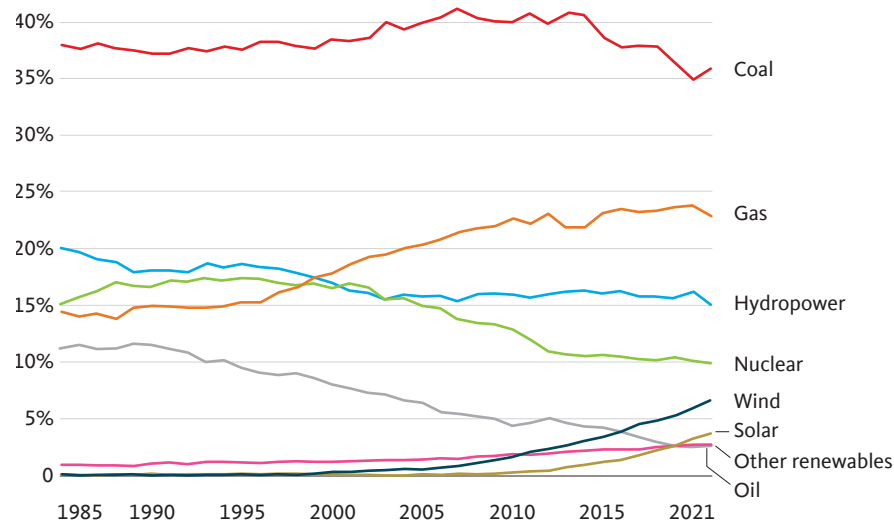
Progress has been mixed. Renewable energy, for example, may represent the most straightforward example of sustainable infrastructure, but it takes time to replace the massive installed capacity relying on traditional fuels. Additions of renewable sources are picking up pace, while dirty sources like coal make up the bulk of retired capacity (**Figure 13**). Long powered by coal, Australia now derives one third of its energy from wind alone.³¹ Globally, solar energy capacity is nearing 1 terawatt (or 1000 gigawatts), with 250 gigawatts of capacity expected to be added in 2022 alone. Solar installations are projected to see sustained double-digit growth through 2025 at least.³²

Figure 13. Planned additions and retirements to U.S. power grid capacity in 2022



Source: U.S. Energy Information Administration, Preliminary Monthly Electric Generator Inventory, June 2022.

Figure 14. Global share of electricity production by source



Source: Our World in Data based on BP Statistical Review of World Energy

Despite this massive investment, meaningful change takes time. Utility-scale wind and solar power exploded onto the scene in recent years, but more than a third of the world's electricity is still generated by burning coal (**Figure 14**).

The slow pace of change is due to myriad factors, including project-specific risks that prevent consensus among stakeholders. High costs are sometimes used as a wedge to further divide opinions in situations where climate change and sustainability may already be divisive political issues. However, commercial viability has a knack for bridging the divide. There may be no greater example of this than the 700+ mile power line being proposed to carry energy from Wyoming to California.

The source of this energy would be a 3,000 megawatt wind farm comprised of 1,000 turbines on land owned by a fossil fuel magnate who contributes generously to conservative causes and politicians. His customers would be millions of the largely liberal inhabitants of coastal California.”³³ Commercial opportunities, it would seem, can transcend even the most contentious politics.

There is growing consensus that infrastructure has a vital role to play in decarbonizing the global economy. Policy priorities are not always matched by budgetary realities, and the private sector is expected to take up the slack. With opportunities in wind farms, grid hardening, smart roads, upgraded pipelines, and myriad other green initiatives, investors reasonably expect decades of tailwinds.

What investors want.

Preferences and concerns evolving alongside a changing world

Until recently, infrastructure was not widely identified as a discrete asset class. Viewed as a subset of “real” assets, portfolio allocations typically consisted of direct investments in specific projects, municipal bonds (in the U.S.), real estate funds, or shares of heavy industrial firms. Even other real assets such as real estate and natural resources were previously presented by research firms such as Preqin as a subset of the broader private equity market.

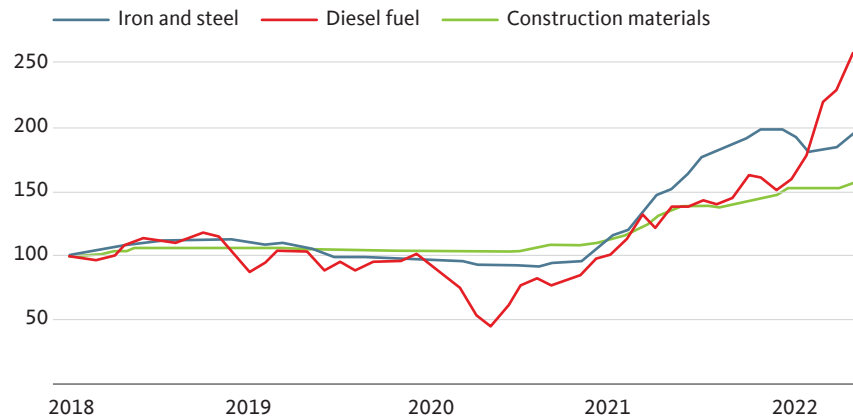
The growing size of the market and elevated level of public discourse about infrastructure brought it into focus as an investment category worthy of consideration on its own merits. Investors now have a wide array of vehicles open to them, along with a variety of unique factors to consider as they evaluate their options. Public policy and standards, for example, are critically important when considering the attractiveness of projects. Reliability and resilience must be analyzed in the context of changing environmental conditions. Life cycle cost analysis is likely to span decades.

None of this is news to seasoned infrastructure managers or investors, but they are increasingly joined by newcomers, including retail investors eager to find investments less correlated to the broader market and a place to achieve above-broad market returns.

Surging enthusiasm is buoyed by infrastructure’s reputation as a good counter to inflation. This remains true to a large degree, but infrastructure is not immune. The soaring cost of materials and fuel in recent years has diluted private funds and public budgets. Higher costs mean fewer projects (**Figure 15**). Commercial mitigation is standard practice, and investors like to work with contractors who can provide fixed prices, dates, and deliverables. Whether or not contractual terms can actually be honored is a separate issue, causing more financiers to try and diversify their suppliers, adding flexibility to their transactions.

Figure 15. Infrastructure costs rising in 2022

Producer price index (January 2018 baseline)



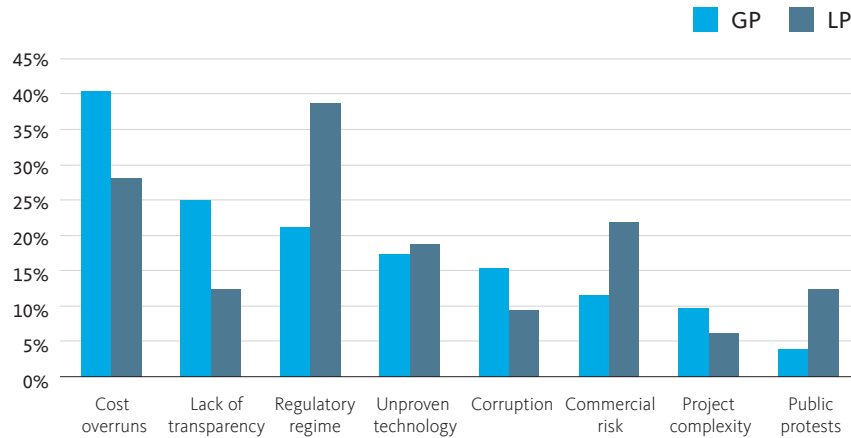
Source: Federal Reserve Bank of St. Louis

Ironically, for an asset class traditionally associated with heavy industry, infrastructure is also favored by today's investors for its ESG qualities. Environmental impact is a growing concern, but there are also commercial motivations, and investors are keenly tracking the monetization of carbon reduction.

Institutional investors are uniquely positioned to make a difference. Rather than simply screening out investments based on ESG factors, asset owners can work with portfolio companies to engage with community stakeholders and secure results in everyone's best interest. Tools such as theGRESB Infrastructure Assessment are emerging to help guide the way. Systematic reporting, objective scoring, and peer benchmarking empower investors and fund managers alike to better understand the performance of infrastructure assets from an ESG perspective.³⁴

Infrastructure's unique merits are matched by some distinct risks. Given the focus on large, complex, and expensive projects, cost overruns are a particular concern (**Figure 16**). More directly involved with the intricacies of individual transactions, GPs pinpoint cost overruns as their single biggest concern, followed by a lack of transparency. LPs are more likely to identify regulatory regimes as a concern and are notably more sensitive to commercial risk and any unwelcome reputational risk stemming from public protests.

Figure 16. How much of a concern is each of the following risk factors when it comes to infrastructure investments?

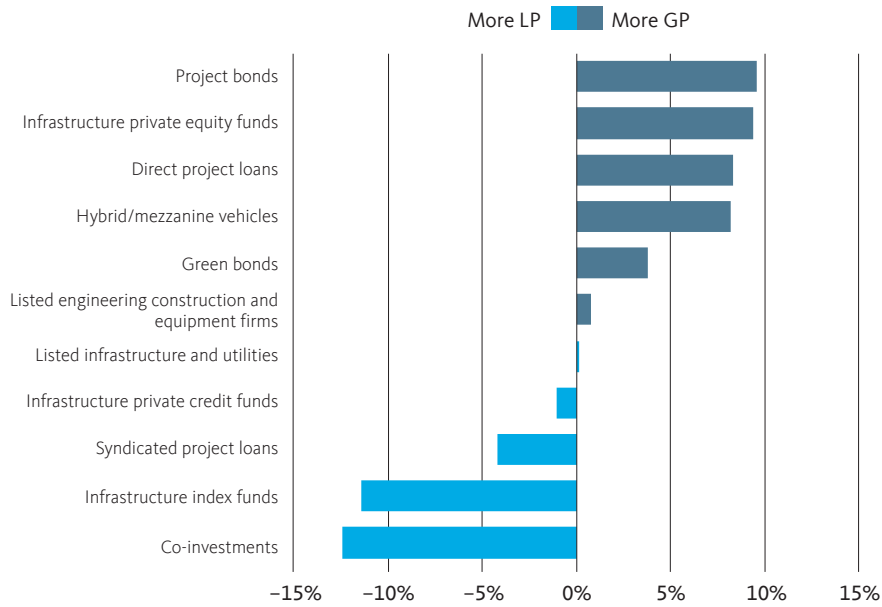
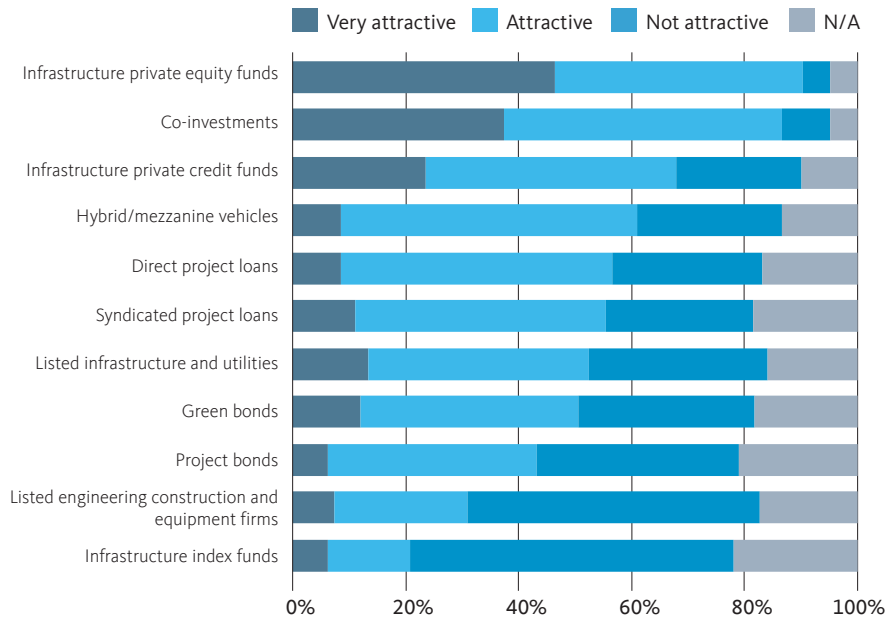


Source: 2022 SEI Survey of Infrastructure Managers and Investors

A *Wall Street Journal* article outlining proposals for two offshore wind farms off the coast of California highlights the potent combination of regulatory hurdles and public protest that delay and threaten even the most well-intentioned infrastructure projects. Despite being located 20 miles offshore and promising to generate enough electricity to power 1.5 million homes, both projects face an uphill battle against commercial fisherman, environmentalists, the shipping industry, and others. Just because a large infrastructure project isn't visible does not mean it won't have an impact, and objections are facilitated by complex, multi-jurisdiction, regulatory regimes.³⁵

Investors have more options than ever before as they consider the unique risk-reward dynamics for an asset class that is poised to move from the fringe to center stage. Exposure to infrastructure can be added to portfolios in myriad ways, ranging from private markets to various types of listed securities and funds. Among institutional investors, specialized private equity funds and co-investments are the most popular types of investments (**Figure 17**). Private credit funds trail closely behind. LPs and GPs largely concur on all of these, but they part ways when it comes to utilities, which LPs are far more likely than GPs to find attractive. Without the built-in

Figure 17. How much of a concern is each of the following risk factors when it comes to infrastructure investments?

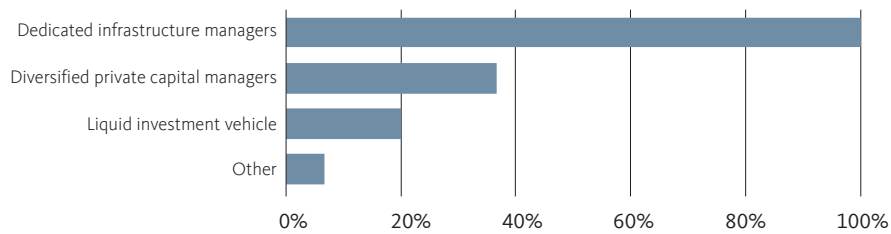


Source: 2022 SEI Survey of Infrastructure Managers and Investors

benefit of diversification, project loans and bonds are much more likely to be targeted by GPs. Listed shares of companies servicing the sector are, along with infrastructure index funds, more likely to appeal to LPs and hardly merit consideration from GPs. Their reasoning is simple: While most listed firms have competitors, direct investments often finance projects with local monopolies that are insulated from competitive pressure.

In an asset management industry where convergence and diversification have become the norm, infrastructure investing is notable for its high level of specialization. 100% of LPs in the survey report working with managers who are dedicated to infrastructure investing (**Figure 18**). Approximately one out of three also invest with diversified private capital managers, while only one out of five utilize liquid investment vehicles.

Figure 18. With what type of managers do you make infrastructure investments? (LPs only)



Source: 2022 SEI Survey of Infrastructure Managers and Investors

The attractiveness of infrastructure investments predates investors' recent preoccupation with ESG and inflation. Investors typically seek them out for stable long-term returns and predictable income streams. Low correlation with the broader market is also appealing, as is the prospect of benefiting society.

The global push toward decarbonization and net zero is a significant tail wind. Technological innovation is helping boost performance. Even factors threatening overall economic performance such as inflation and supply chain disruptions are likely to support further infrastructure investment. Furthermore, there are few investments that can legitimately claim to address the most critical issues facing humanity. As new forms of financing join the mainstream, innovative technologies are introduced, and more investors believe that societal benefits are not mutually exclusive from their other objectives, infrastructure will continue its journey from being viewed as a niche asset class to one of the most important.

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